

CRISTAE MEMBRANE



CRISTAE MEMBRANE

**MITOCHONDRION
INNER MEMBRANE**

CRISTAE MEMBRANE



CRISTAE
MEMBRANE
MITOCHONDRION
INNER MEMBRANE

SITE: ETC

CRISTAE
MEMBRANE

**CRISTAE
MEMBRANE**

**MITOCHONDRION
INNER MEMBRANE**

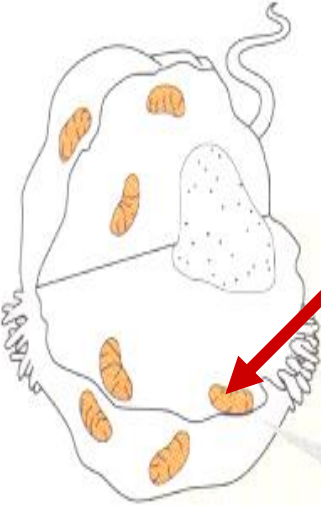
**SITE: ETC
DERIVES ATP**

**CRISTAE
MEMBRANE**



MITOCHONDRION ULTRASTRUCTURE

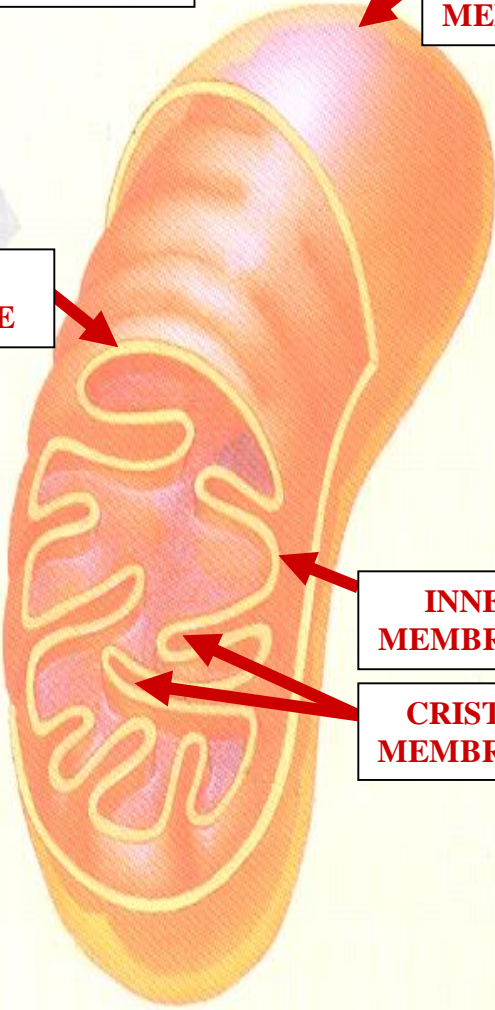
ETC



MITOCHONDRION

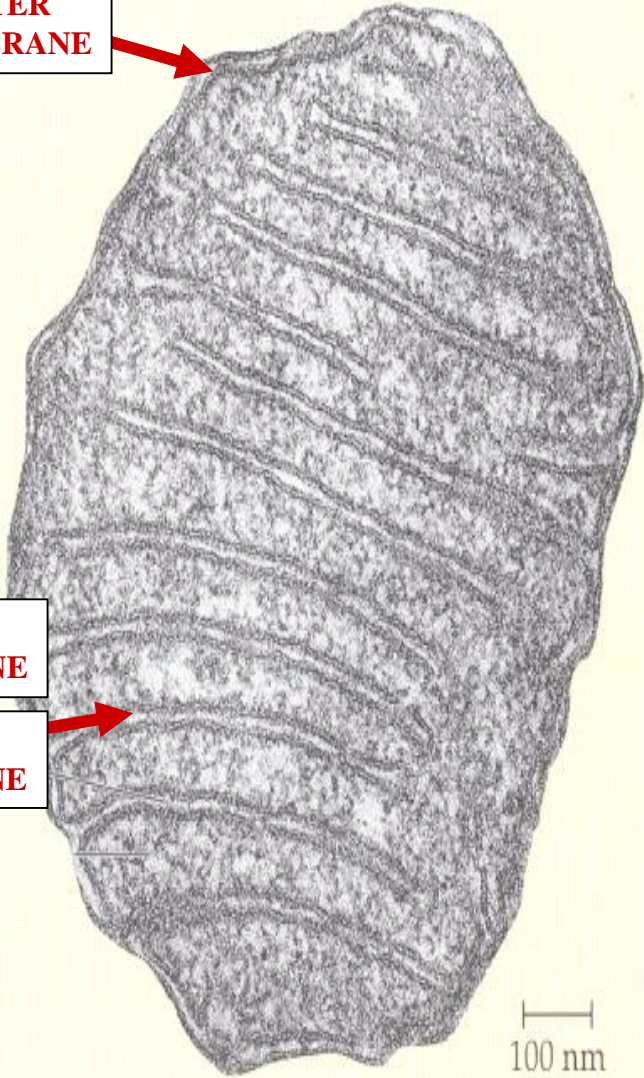
OUTER
MEMBRANE

INNER
MEMBRANE



INNER
MEMBRANE

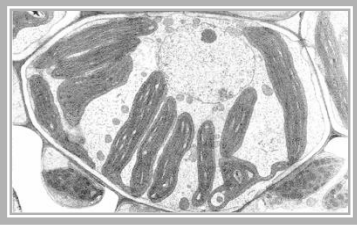
CRISTAE
MEMBRANE



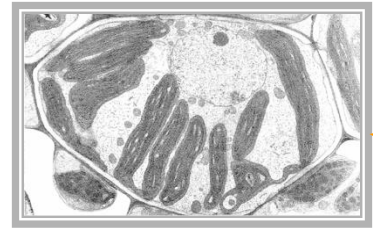
100 nm



ELECTRON TRANSPORT CHAIN



AEROBIC RESPIRATION



C



CELL

GLYCOLYSIS

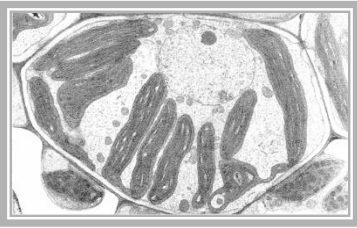
MITOCHONDRION

KREBS CYCLE

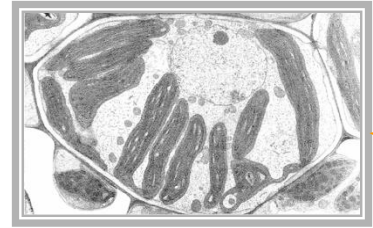
ETC

CRISTAE





AEROBIC RESPIRATION



I



CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

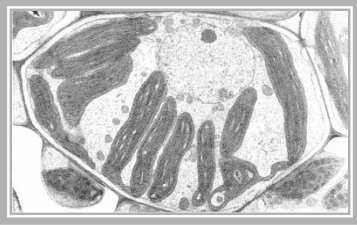
ETC

CRISTAE

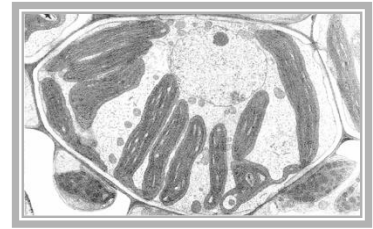
**CHEM EGY
RELEASED**

EGY





AEROBIC RESPIRATION



A

CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

ETC

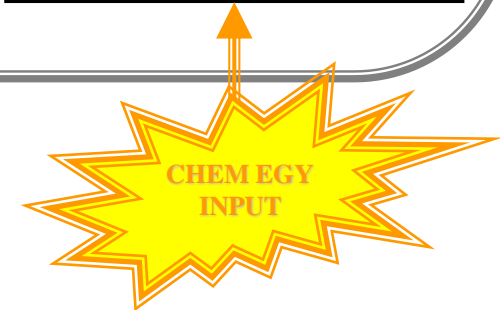
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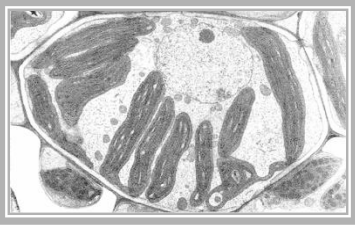
**CHEM EGY
RELEASED**

P + ADP

**CHEM EGY
INPUT**

EGY





AEROBIC RESPIRATION



P

CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

ETC

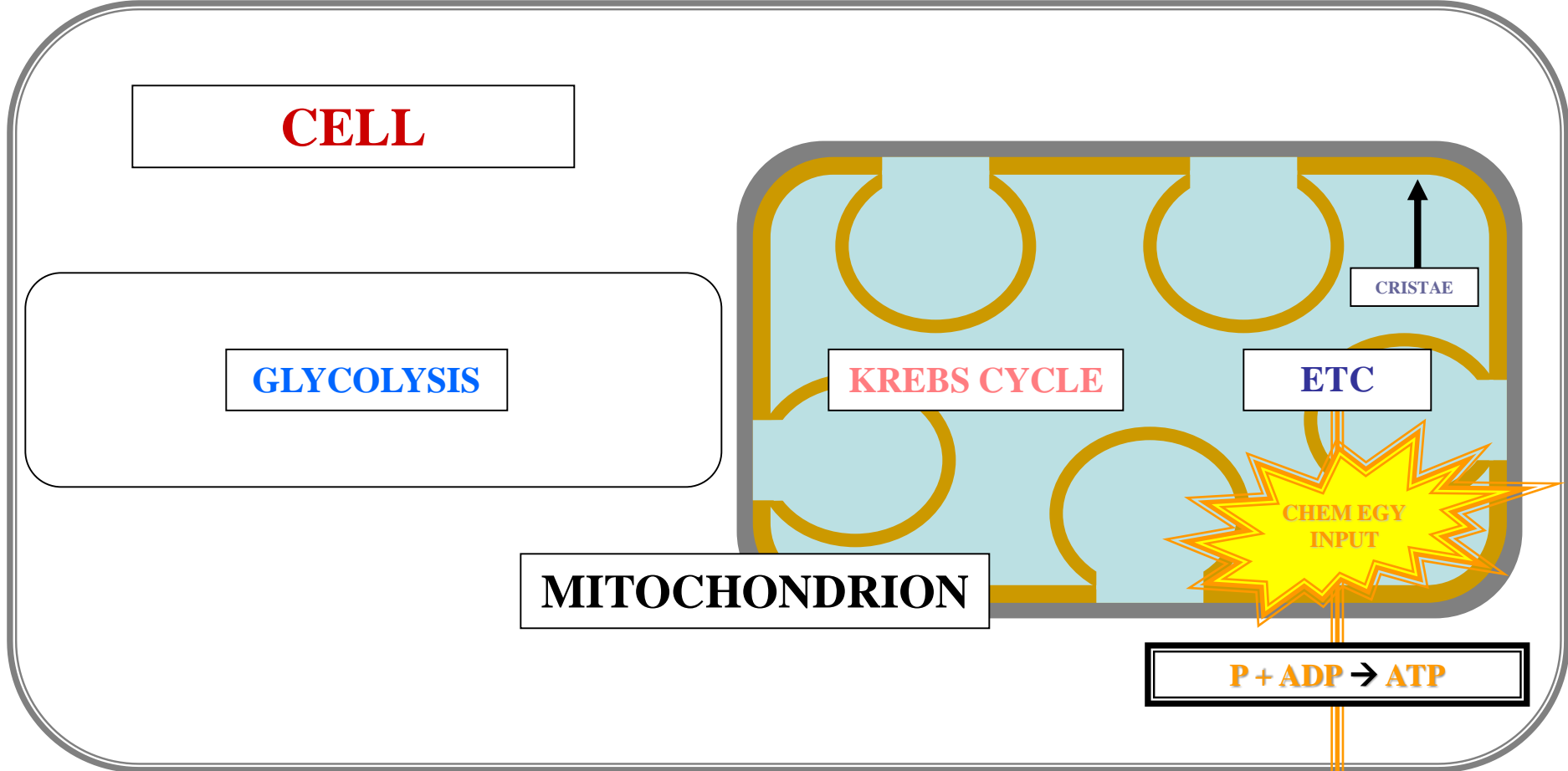
CRISTAE

CHEM EGY INPUT

P + ADP → ATP

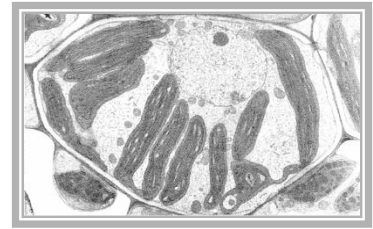
ATP

EGY





AEROBIC RESPIRATION



F

CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

ETC

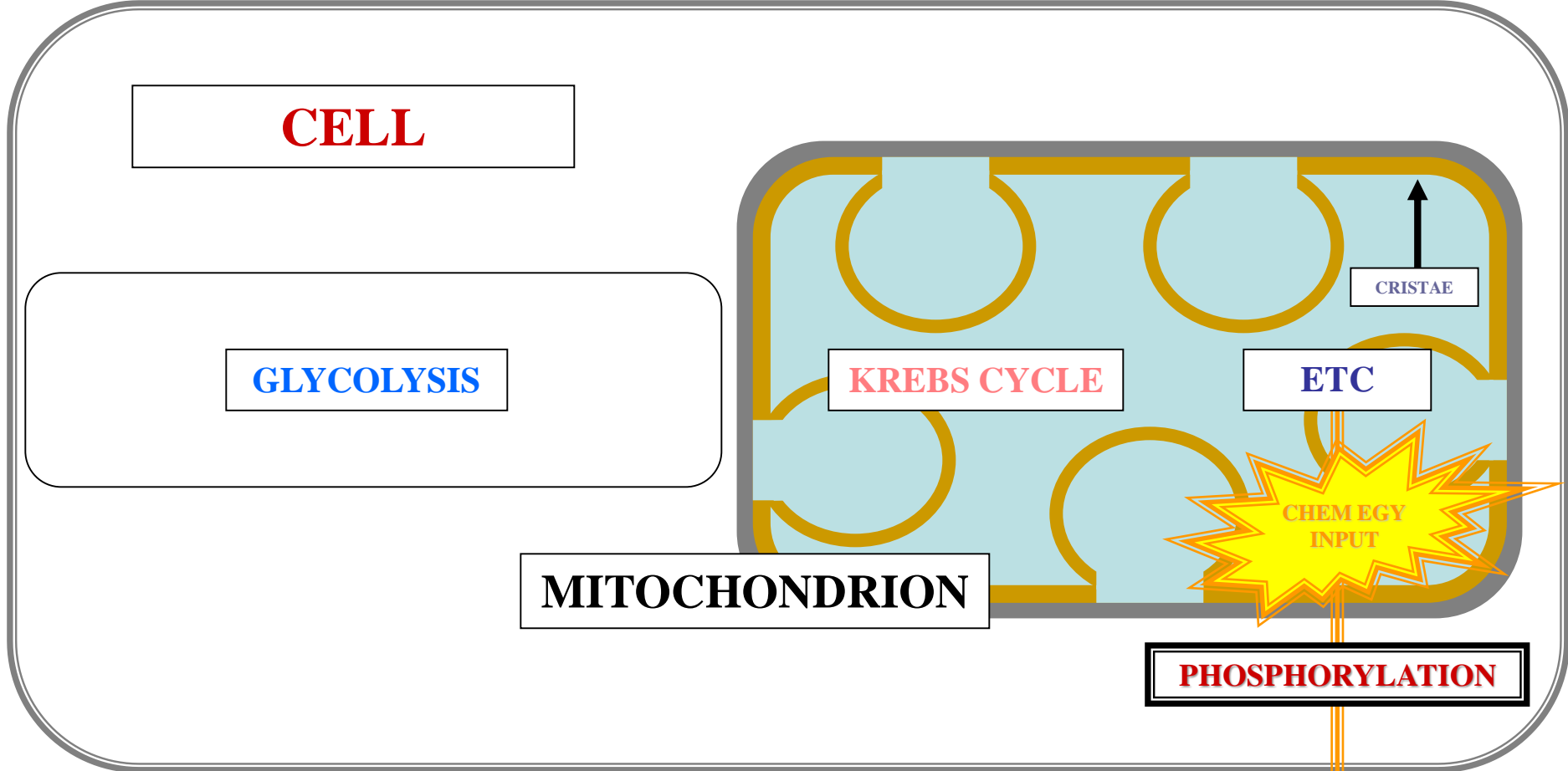
CRISTAE

**CHEM EGY
INPUT**

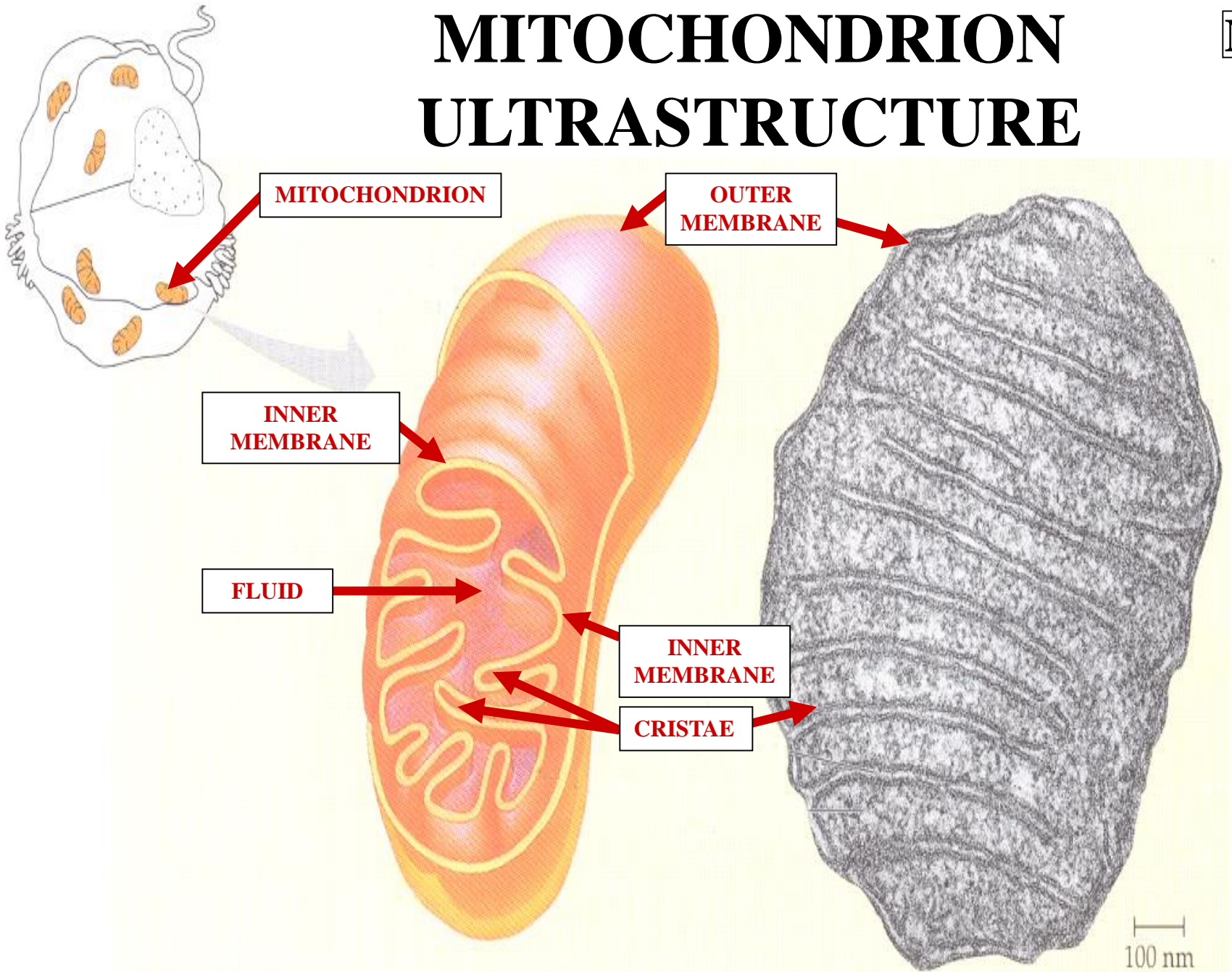
PHOSPHORYLATION

ATP

EGY



MITOCHONDRION ULTRASTRUCTURE



MATRIX



MATRIX

**MITOCHONDRION
INNER FLUID**

MATRIX



MATRIX

**MITOCHONDRION
INNER FLUID**

SITE: KREBS CYCLE

MATRIX



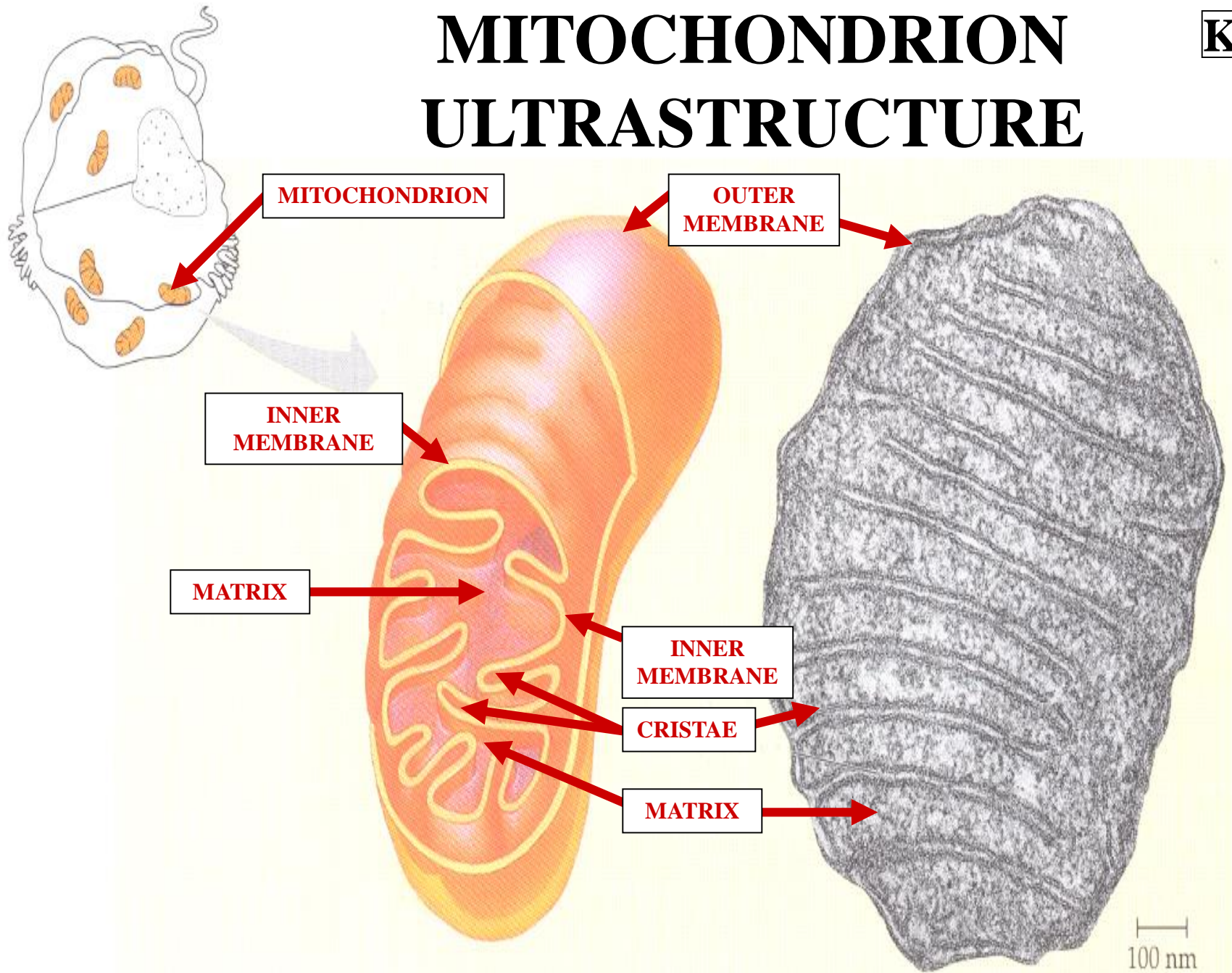
MATRIX

**MITOCHONDRION
INNER FLUID**

**SITE: KREBS CYCLE
DERIVES ATP**

MATRIX

MITOCHONDRION ULTRASTRUCTURE

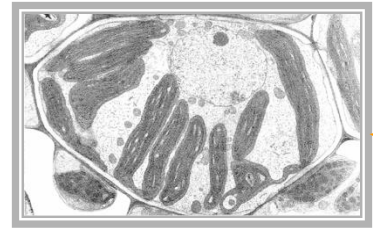




KREBS CYCLE



AEROBIC RESPIRATION



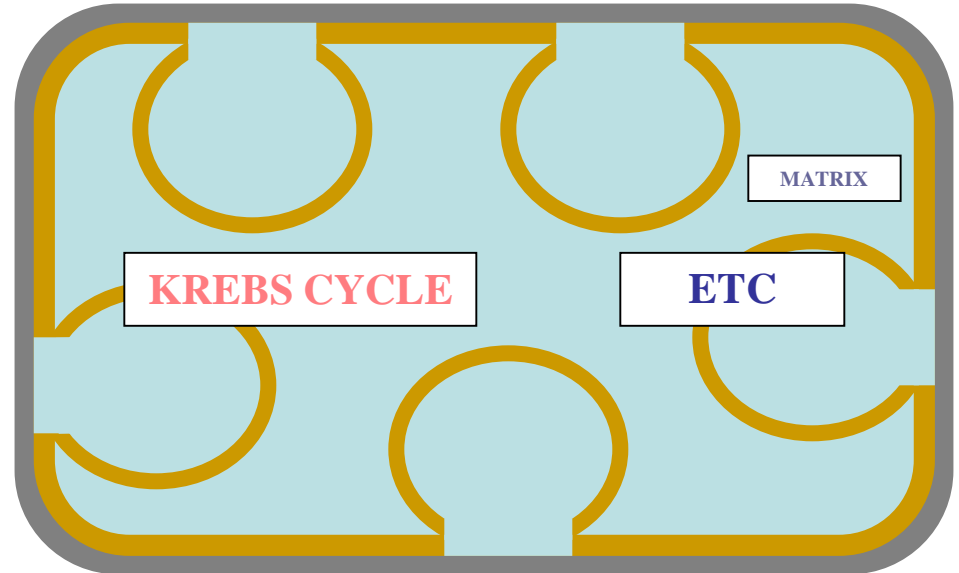
C

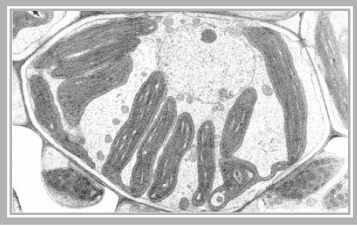


CELL

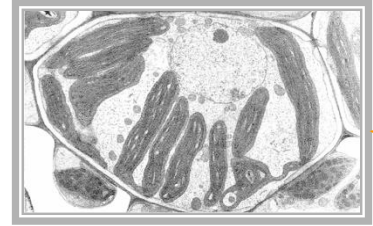
GLYCOLYSIS

MITOCHONDRION





AEROBIC RESPIRATION



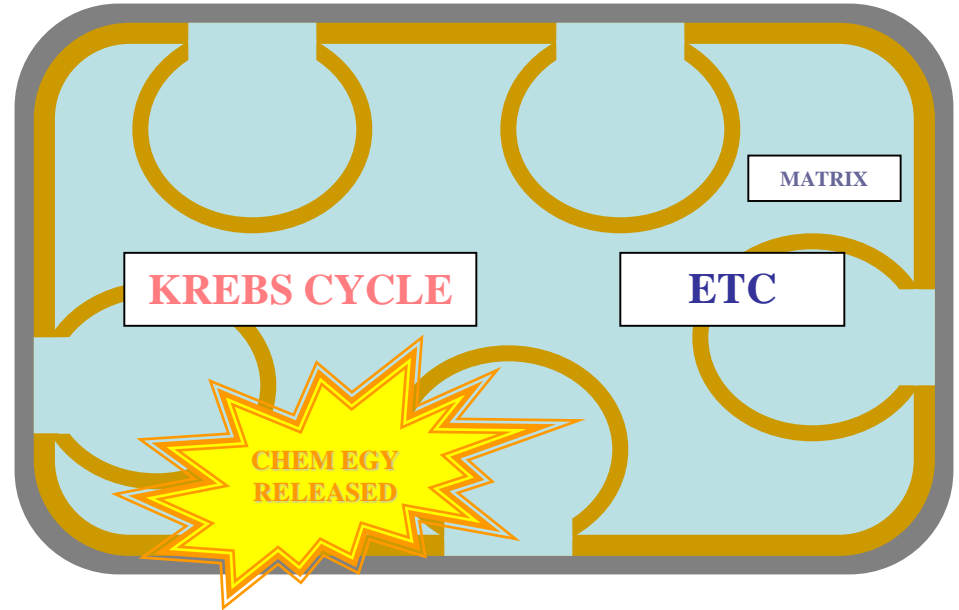
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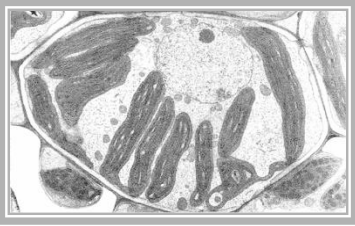


CELL

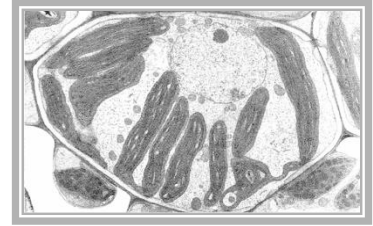
GLYCOLYSIS

MITOCHONDRION





AEROBIC RESPIRATION

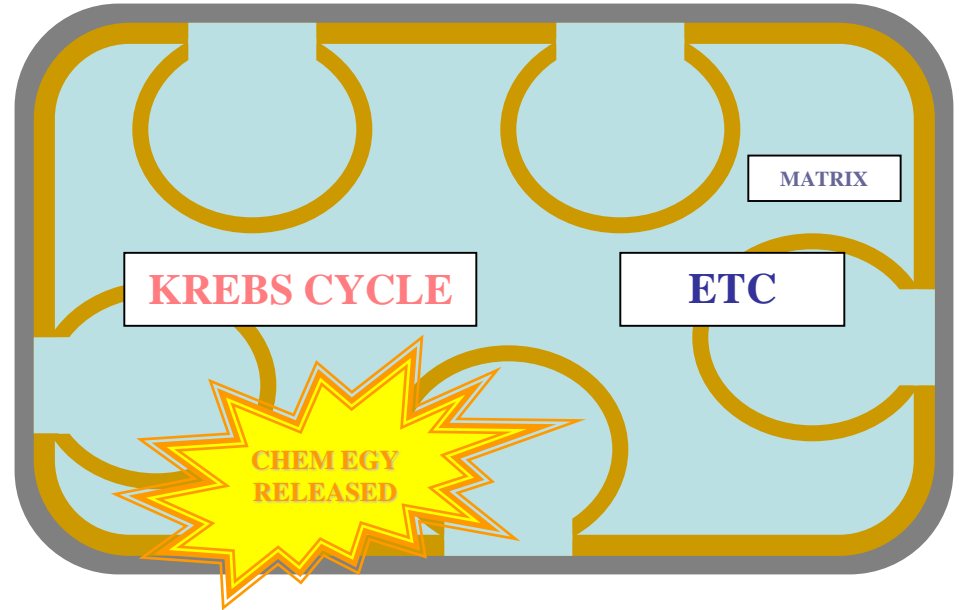


A

CELL

GLYCOLYSIS

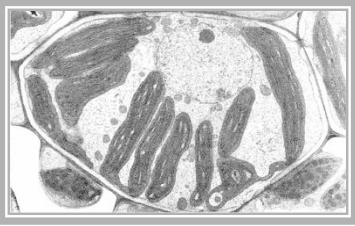
MITOCHONDRION



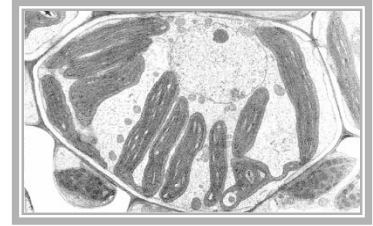
P + ADP

CHEM EGY INPUT

EGY



AEROBIC RESPIRATION

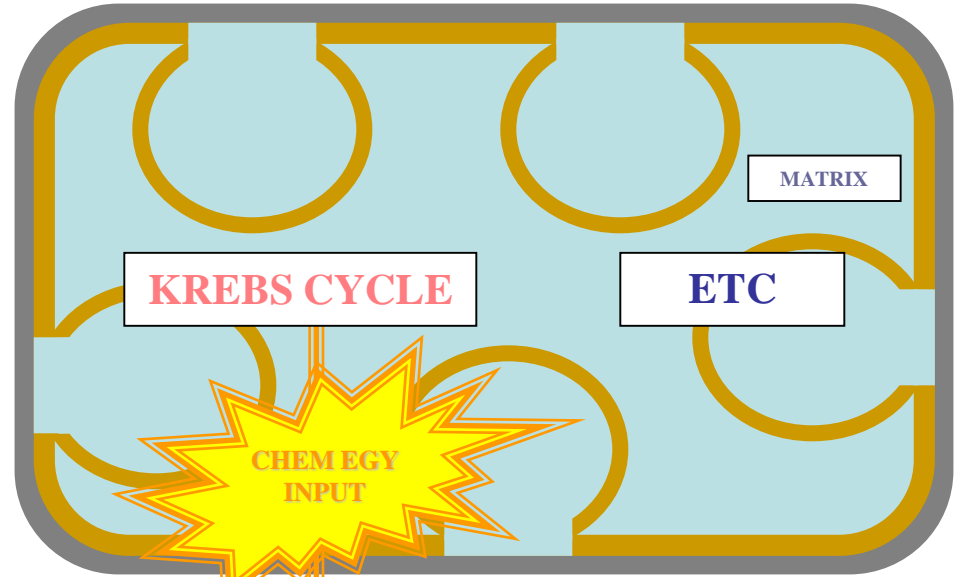


P

CELL

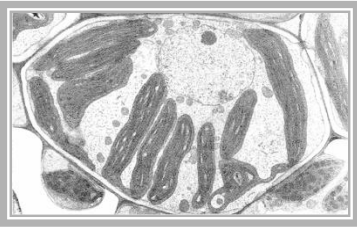
GLYCOLYSIS

MITOCHONDRION

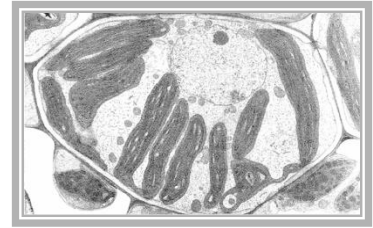


ATP

EGY



AEROBIC RESPIRATION



A

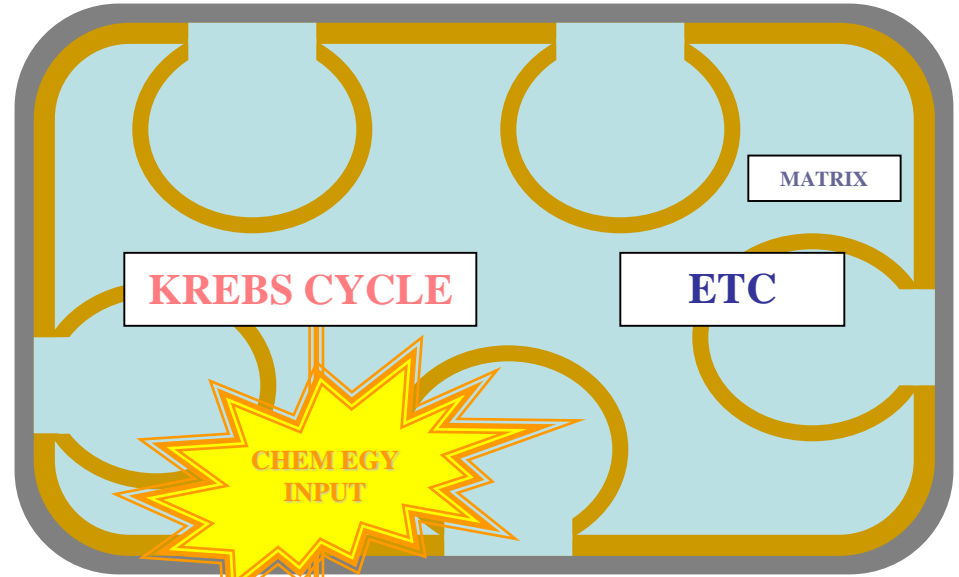
A

+

CELL

GLYCOLYSIS

MITOCHONDRION

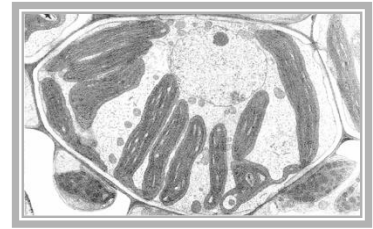
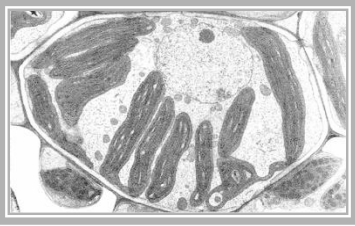


PHOSPHORYLATION

ATP

EGY

AEROBIC RESPIRATION



CELL

GLYCOLYSIS

MITOCHONDRION

KREBS CYCLE

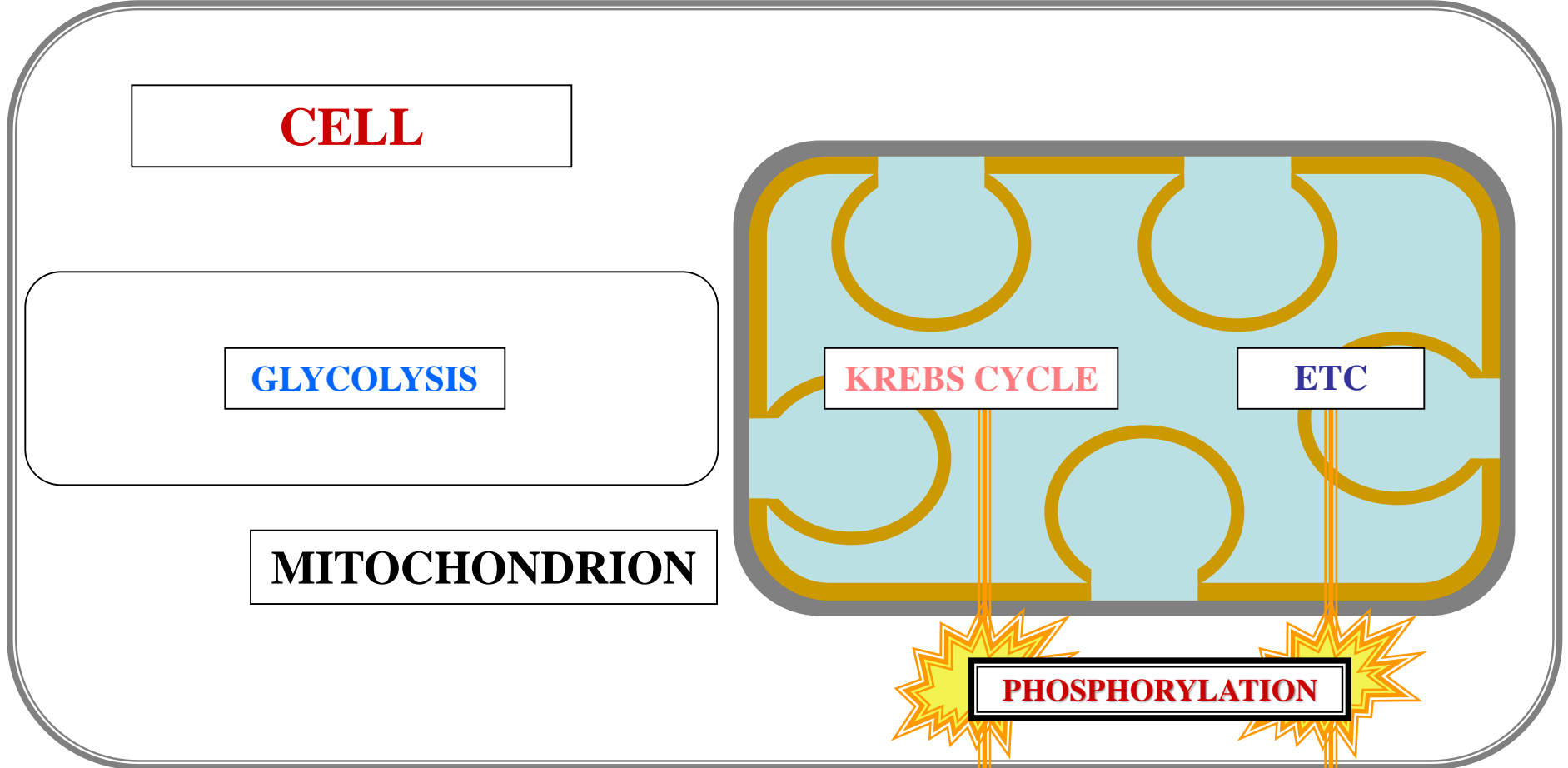
ETC

PHOSPHORYLATION

ATP

ATP

EGY



CELL METABOLISM

C



ATP



BIOCHEMICAL REACTION

CELL METABOLISM

EN

?



**CHEMICAL
ENERGY**



**ATP DELIVERS CHEM-EGY
TO
BIOCHEMICAL REACTIONS**

CELL METABOLISM



**CHEMICAL
ENERGY**



**ATP DELIVERS CHEM-EGY
TO ENDERGONIC
BIOCHEMICAL REACTIONS**

CELL METABOLISM

A yellow starburst graphic with a jagged, multi-pointed border, containing the text 'CHEMICAL ENERGY'. An arrow points downwards from the bottom center of the starburst towards the chemical reaction below.

**CHEMICAL
ENERGY**



**ATP DELIVERS CHEM-EGY
TO DRIVE ENDERGONIC
BIOCHEMICAL REACTIONS
TO A PRODUCT**



***EFFICIENT
CELL
METABOLISM***

An electron micrograph showing a cross-section of a cell. The image displays various organelles, including a large nucleus with a prominent nucleolus, rough endoplasmic reticulum, and several mitochondria with visible internal folds (cristae). A red letter 'E' is enclosed in a small white box in the upper right corner, with a red arrow pointing downwards towards a specific structure within the cell.

E
↓

***ORGANIZATION
INCREASES***

An electron micrograph showing a cross-section of a cell. The cell contains various organelles, including a large nucleus with a prominent nucleolus, several mitochondria with visible internal folds (cristae), and a network of endoplasmic reticulum. The text "ENTROPY DECREASES" is overlaid in a large, bold, red, italicized serif font across the center of the image.

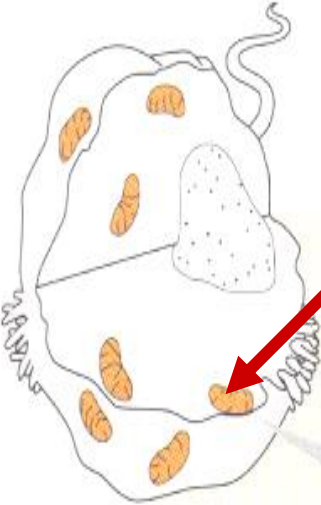
***ENTROPY
DECREASES***



HOMEOSTASIS



MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

INNER
MEMBRANE

ATP

INNER
MEMBRANE

CRISTAE

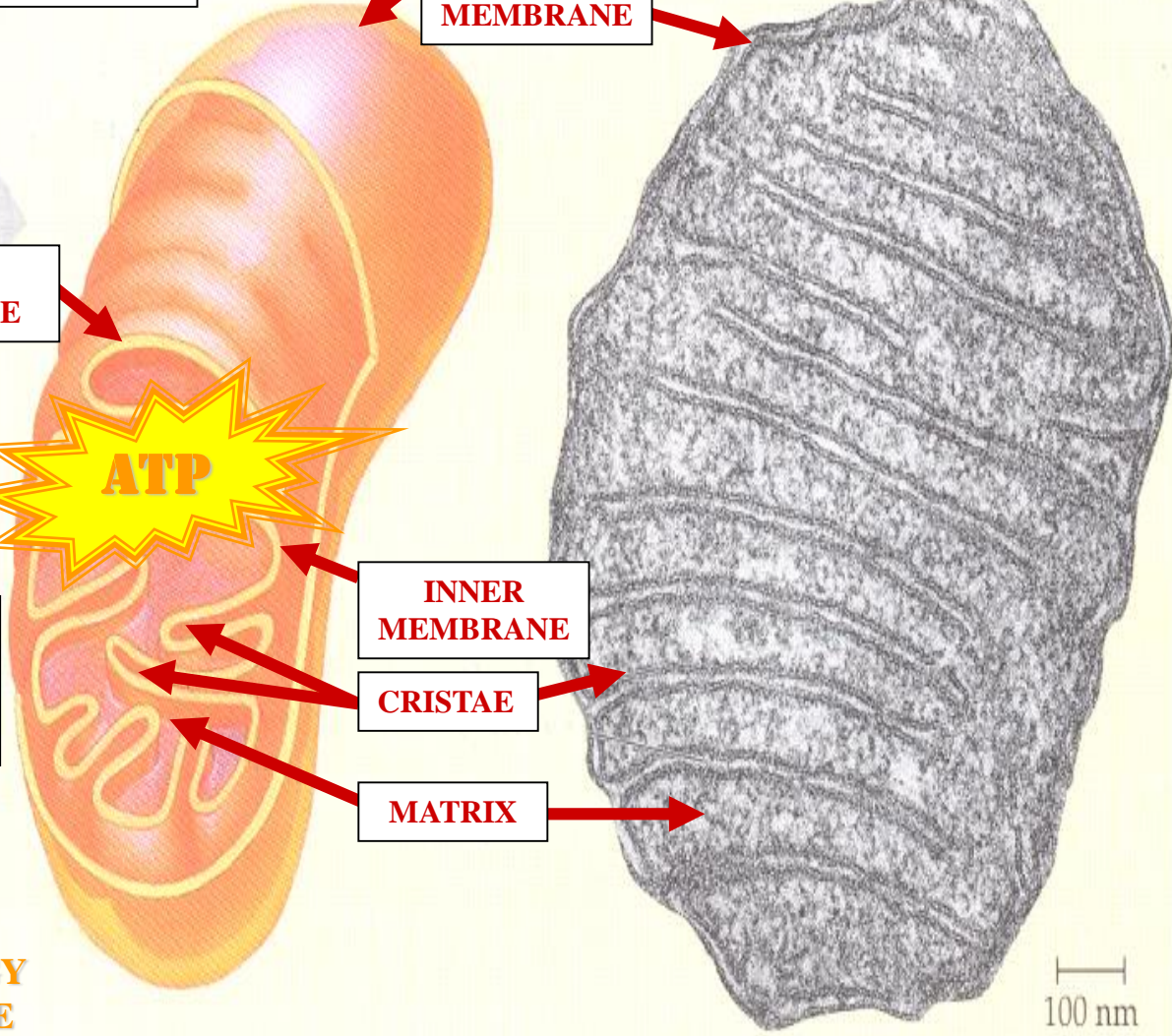
MATRIX

?

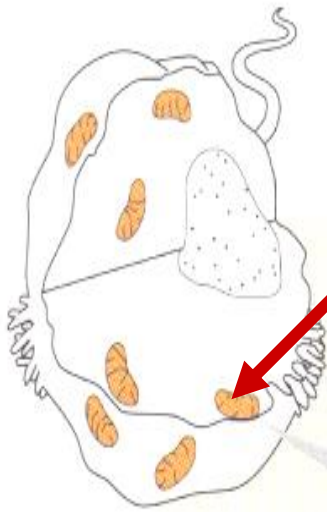
ATP

= BIO ENERGY
MOLECULE

100 nm



MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

INNER
MEMBRANE



CELL
"POWER-HOUSE"

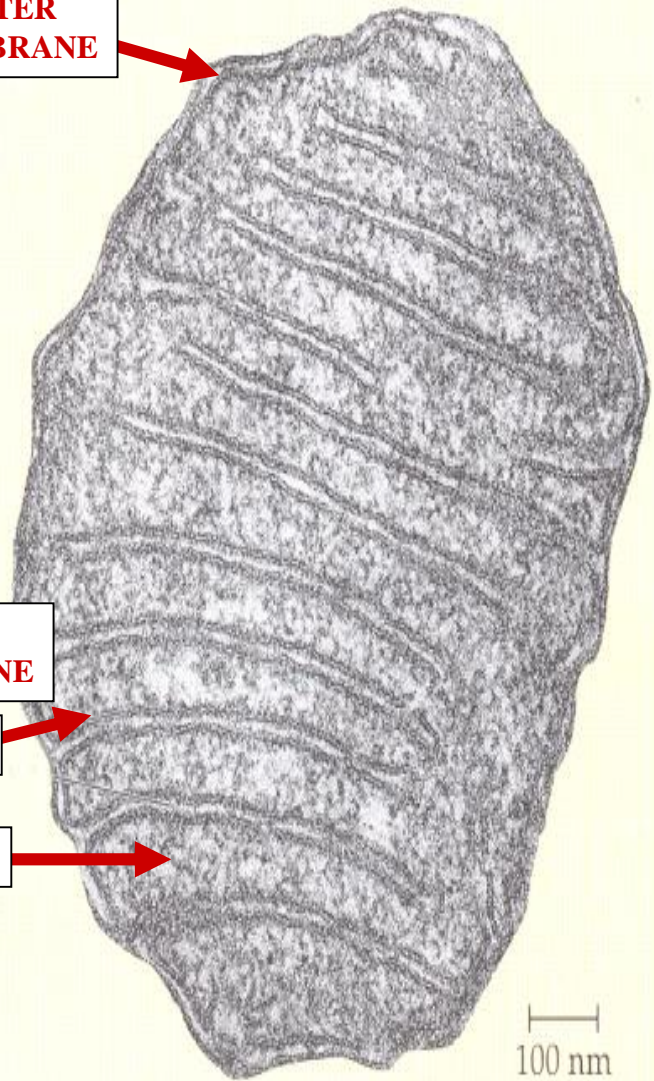
INNER
MEMBRANE

CRISTAE

MATRIX

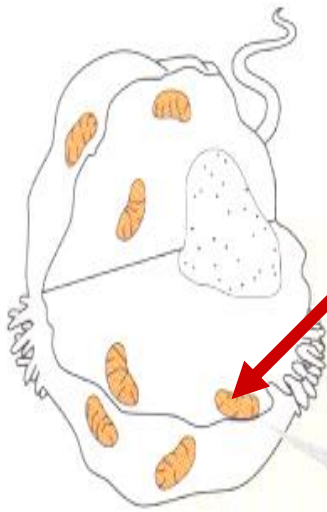
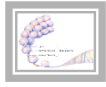


= BIO ENERGY
MOLECULE



100 nm

MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

INNER
MEMBRANE

DNA



**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

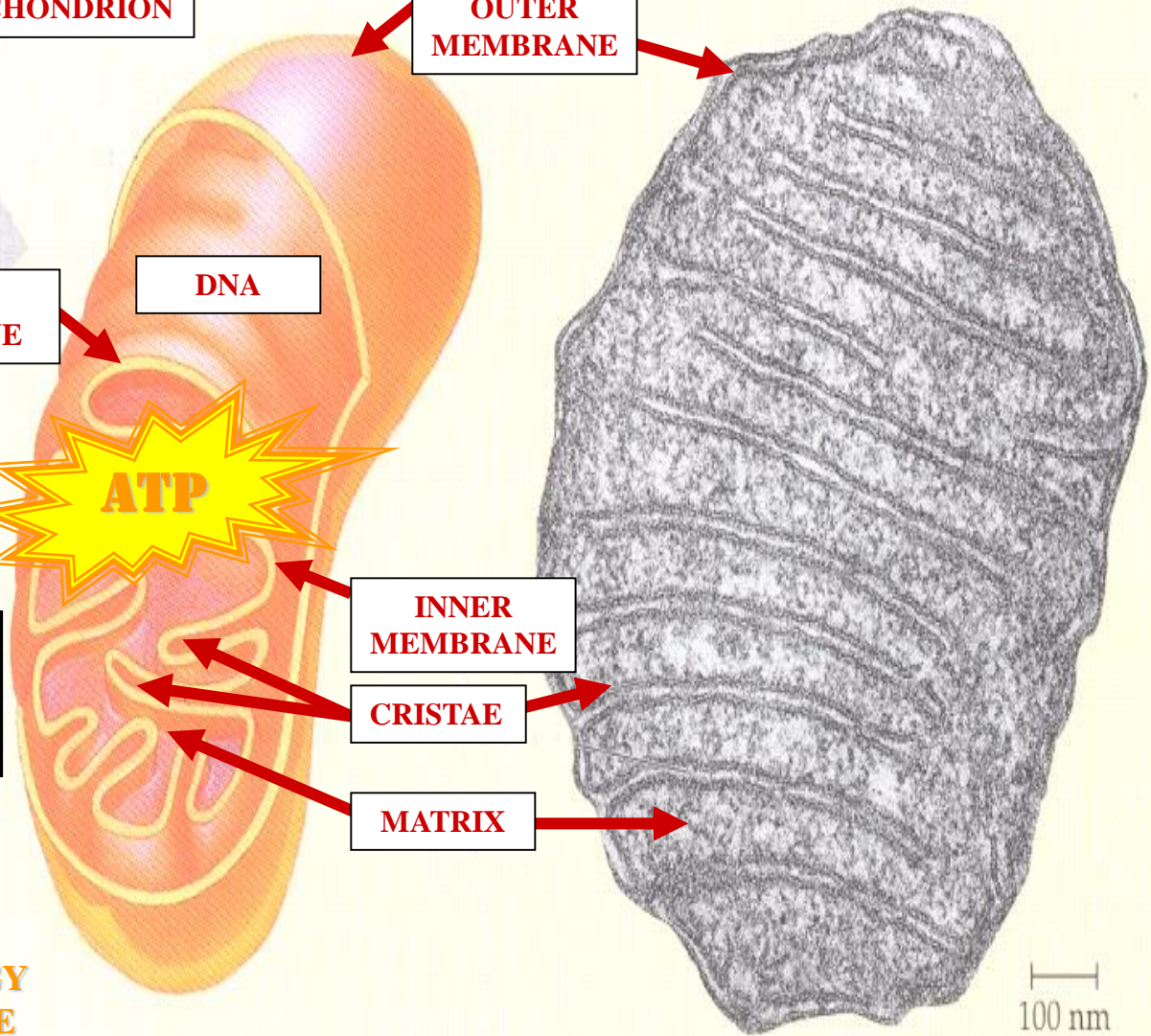
CRISTAE

MATRIX



= BIO ENERGY
MOLECULE

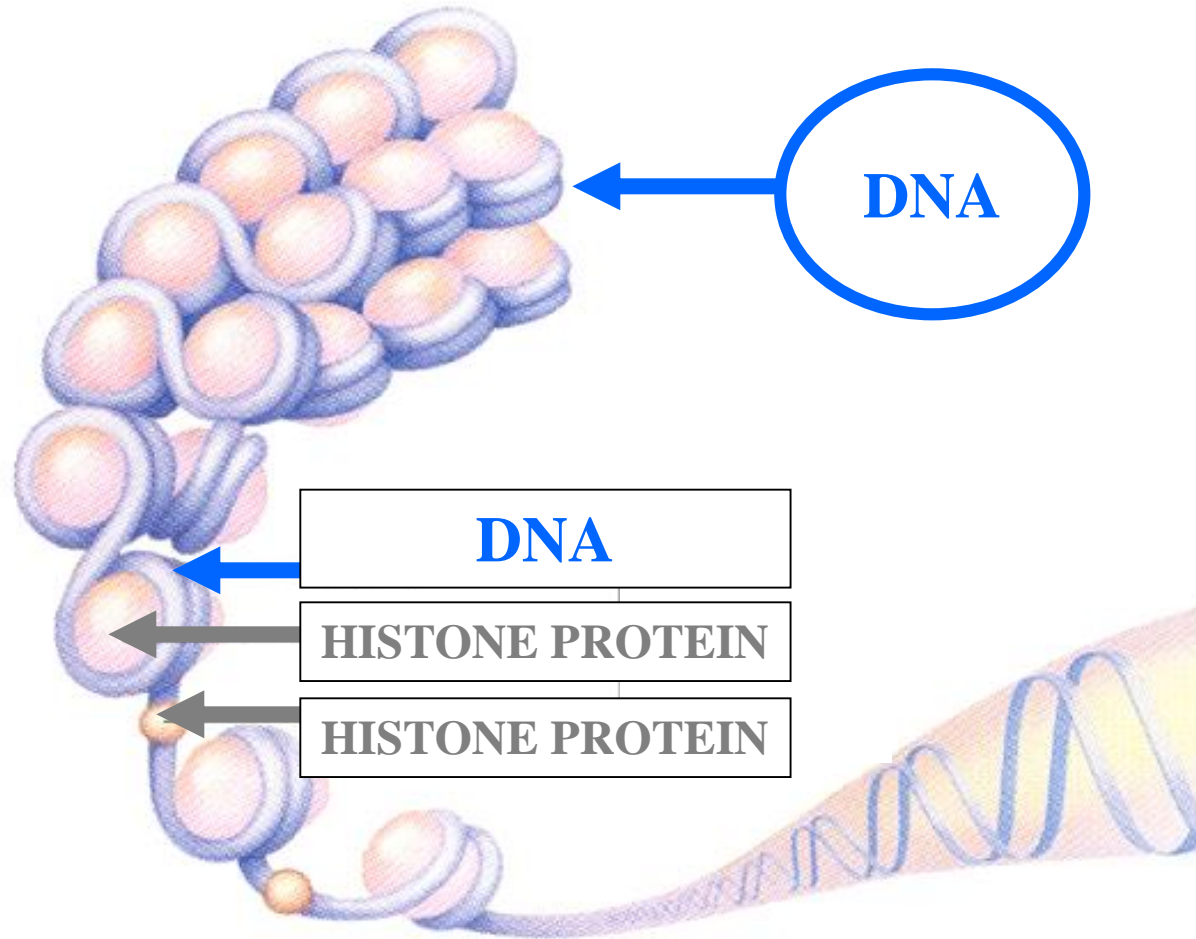
100 nm



MITOCHONDRION DNA

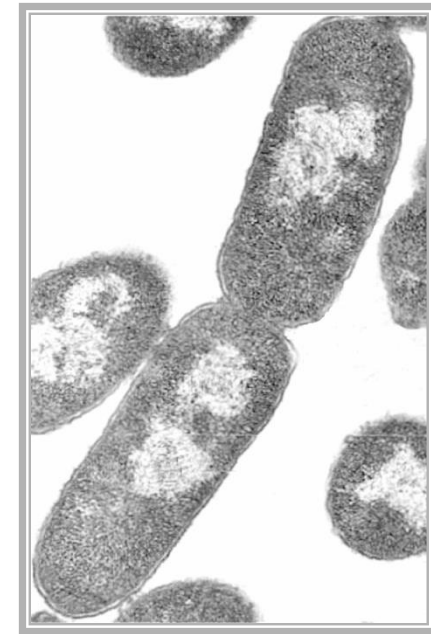
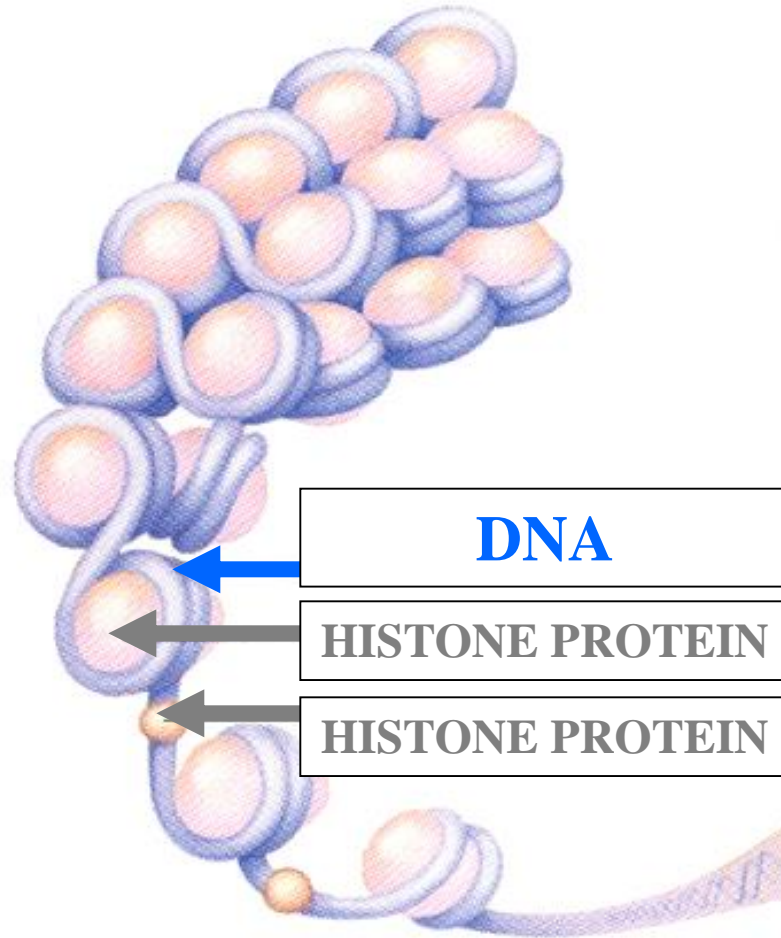


P



MITOCHONDRION DNA: HISTONE PROTEINS ABSENT

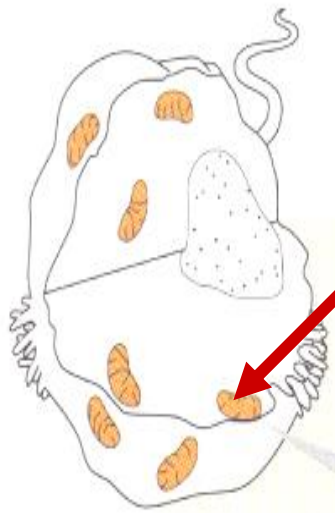
MITOCHONDRION DNA



PROKARYOTE-LIKE

MITOCHONDRION DNA: HISTONE PROTEINS ABSENT

MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

PROKARYOTE-LIKE DNA

INNER
MEMBRANE

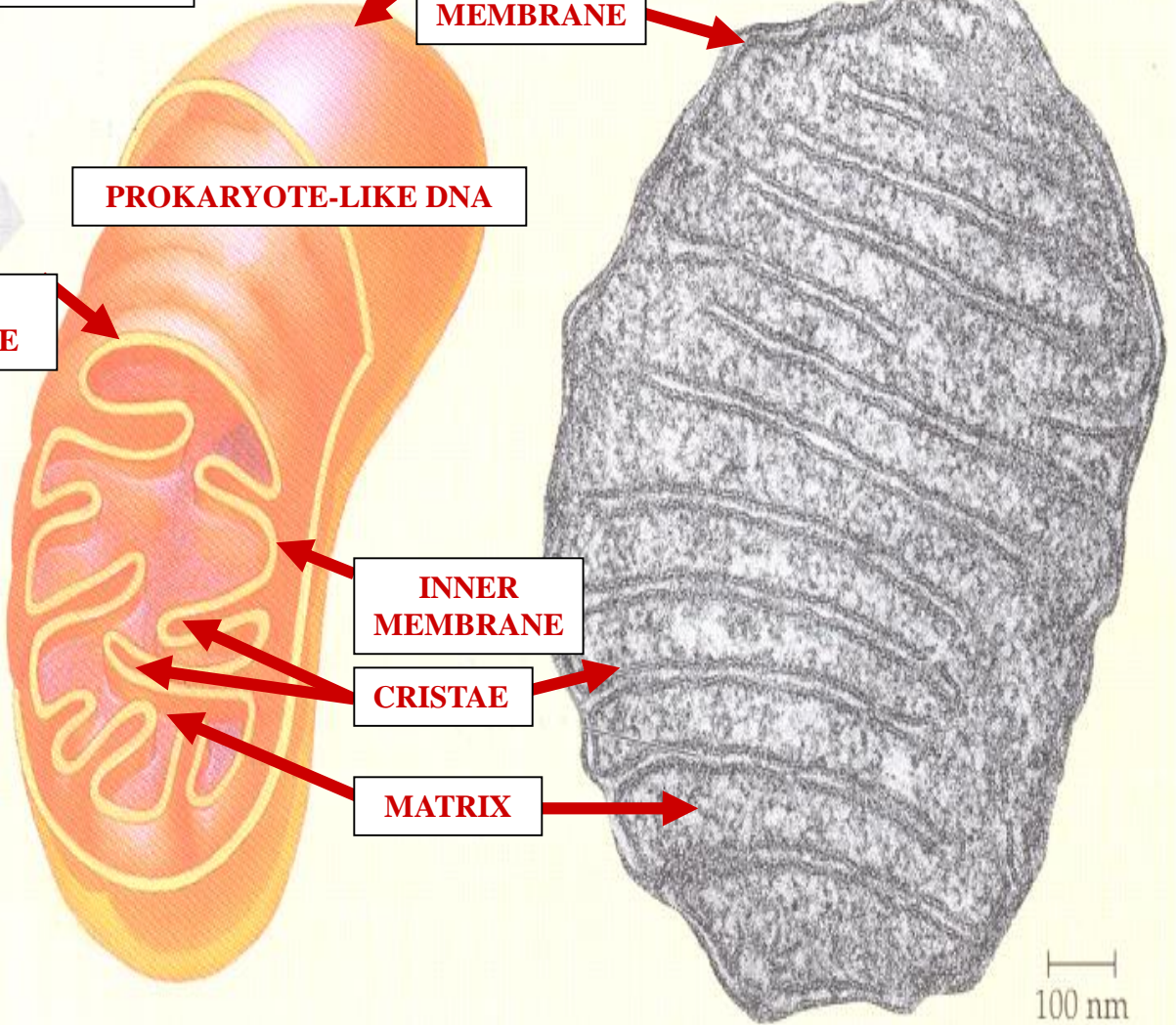
**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

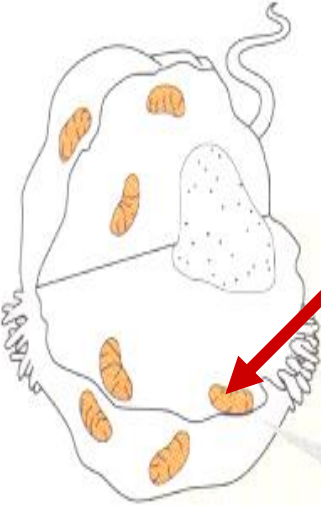
CRISTAE

MATRIX

100 nm



MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

PROKARYOTE-LIKE DNA

INNER
MEMBRANE

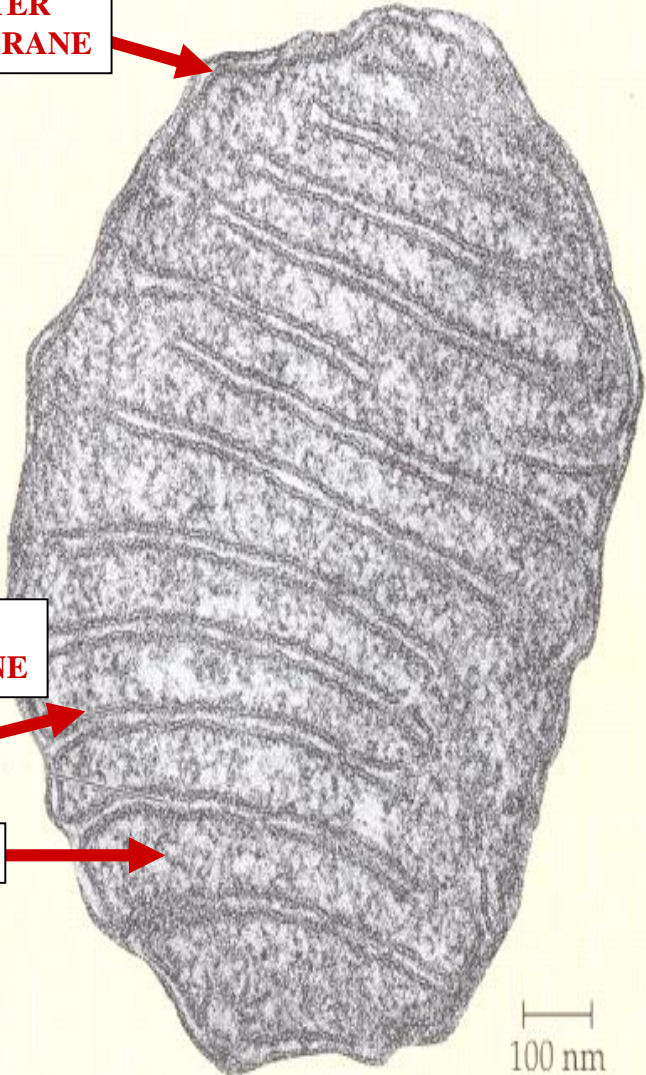
RIBOSOMES

**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

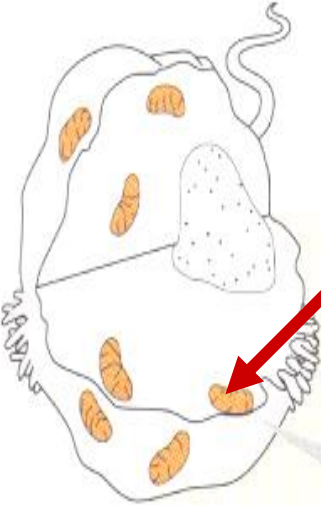
CRISTAE

MATRIX



100 nm

MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

PROKARYOTE-LIKE DNA

INNER
MEMBRANE

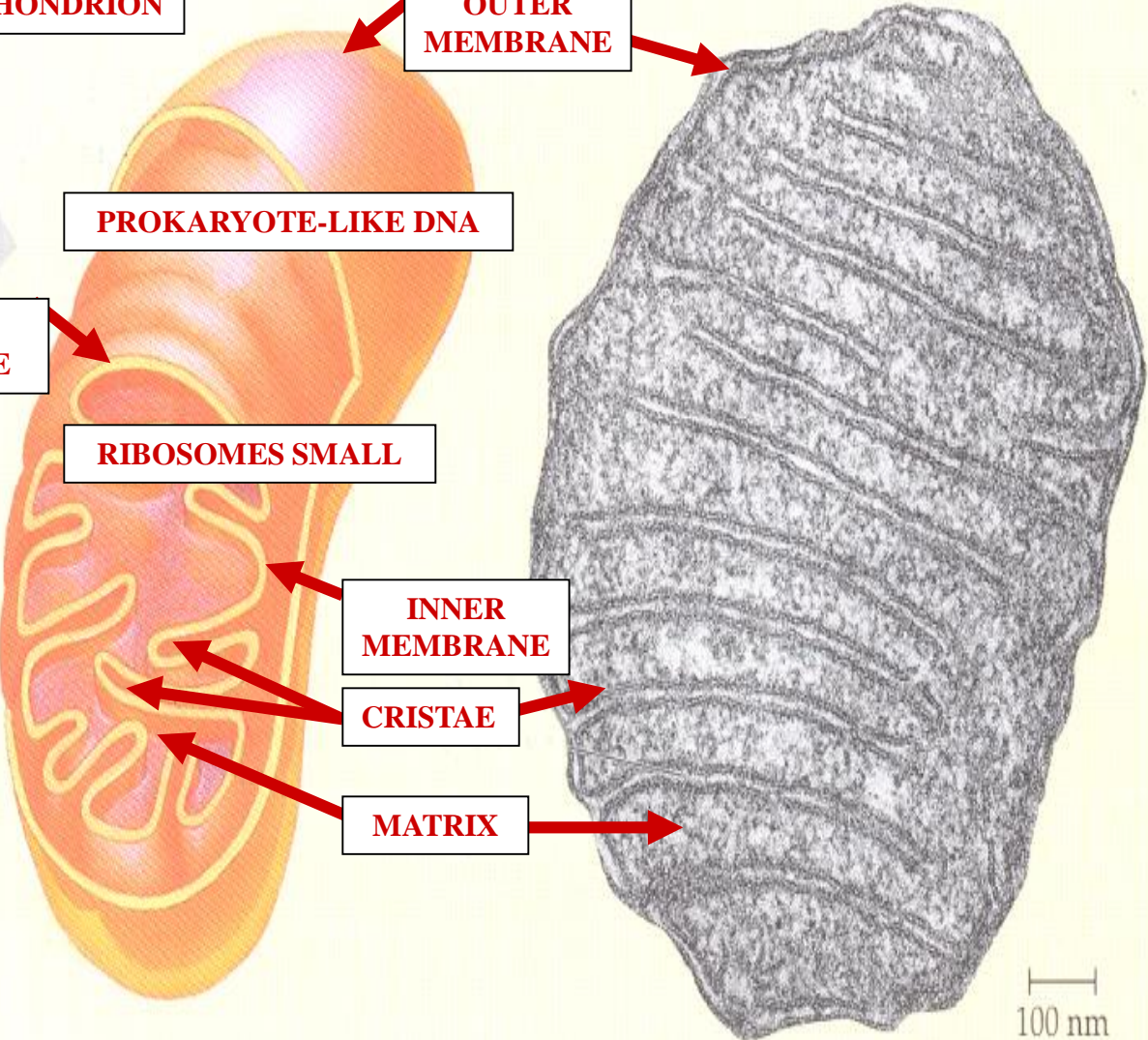
RIBOSOMES SMALL

**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

CRISTAE

MATRIX



100 nm

MITOCHONDRION RIBOSOME SMALL



P

3 RNAs & 54 PROTEINS

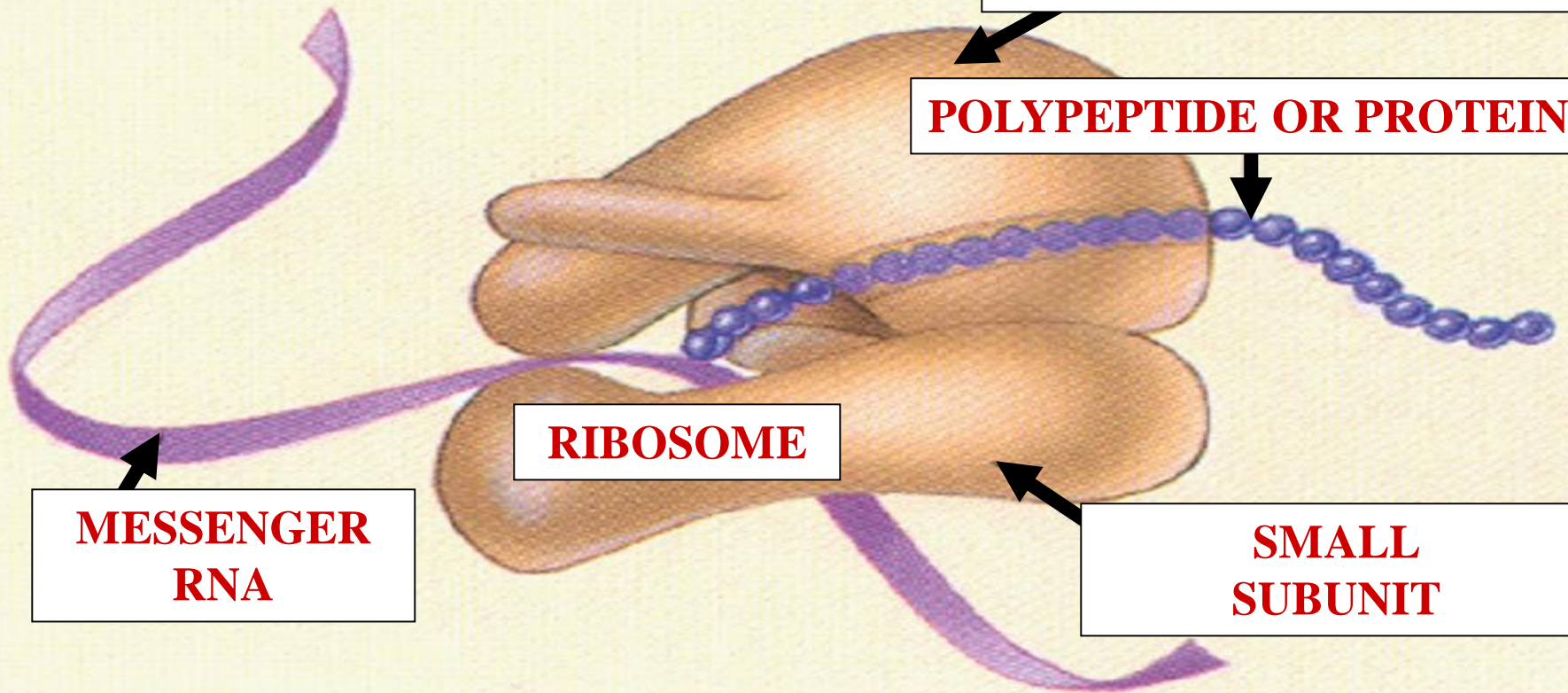
**LARGE
SUBUNIT**

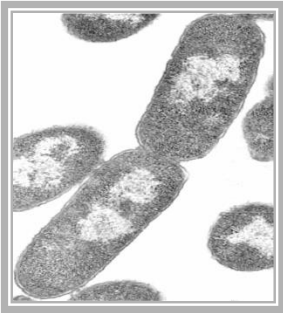
POLYPEPTIDE OR PROTEIN

RIBOSOME

**MESSENGER
RNA**

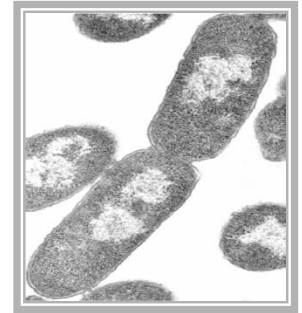
**SMALL
SUBUNIT**





PROKARYOTE-LIKE

MITOCHONDRION RIBOSOME SMALL



PROKARYOTE-LIKE



3 RNAs & 54 PROTEINS

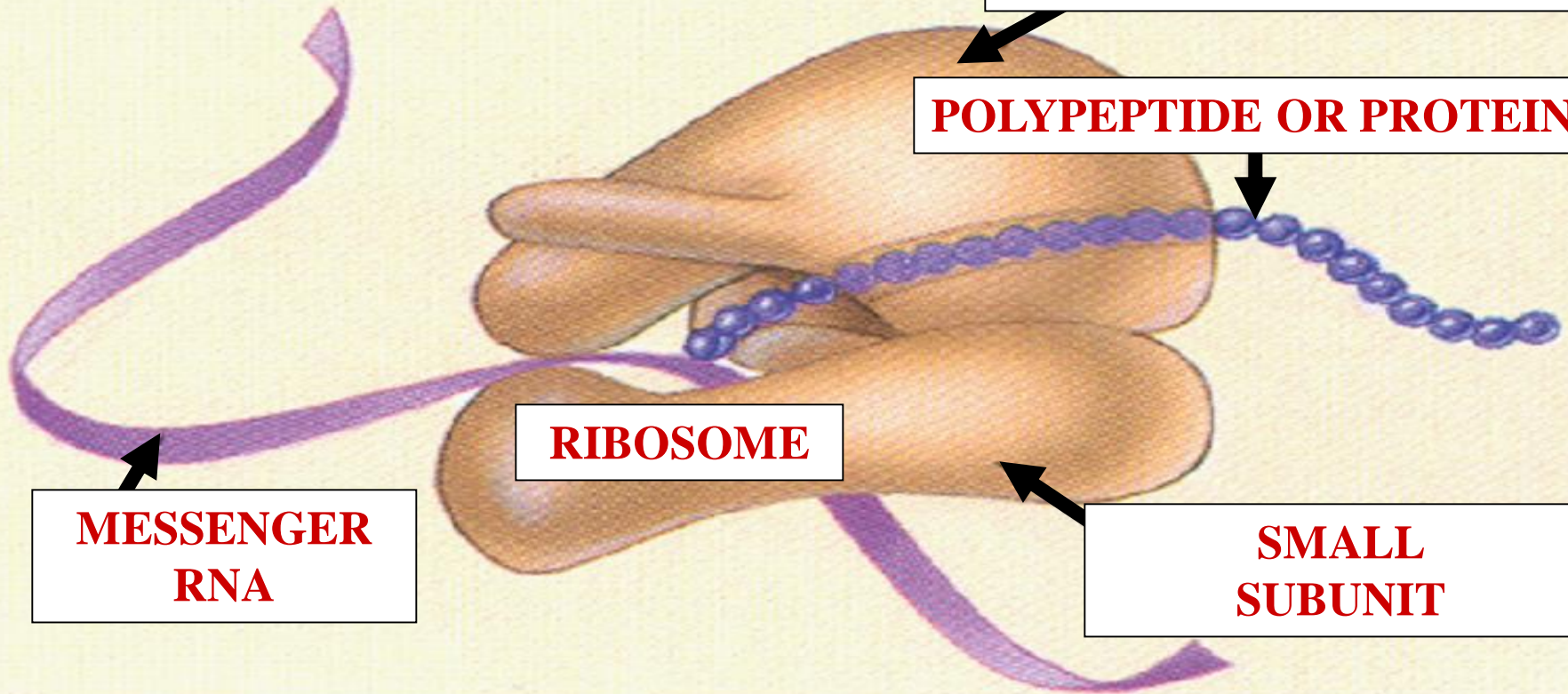
**LARGE
SUBUNIT**

POLYPEPTIDE OR PROTEIN

RIBOSOME

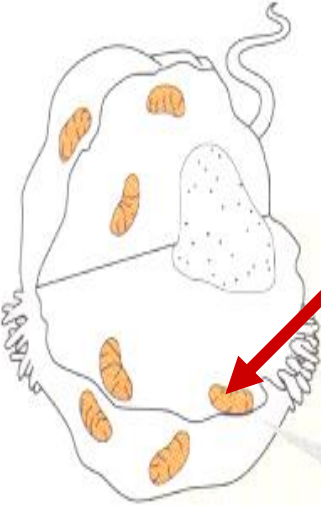
**MESSENGER
RNA**

**SMALL
SUBUNIT**





MITOCHONDRION ULTRASTRUCTURE



MITOCHONDRION

OUTER
MEMBRANE

PROKARYOTE-LIKE DNA

INNER
MEMBRANE

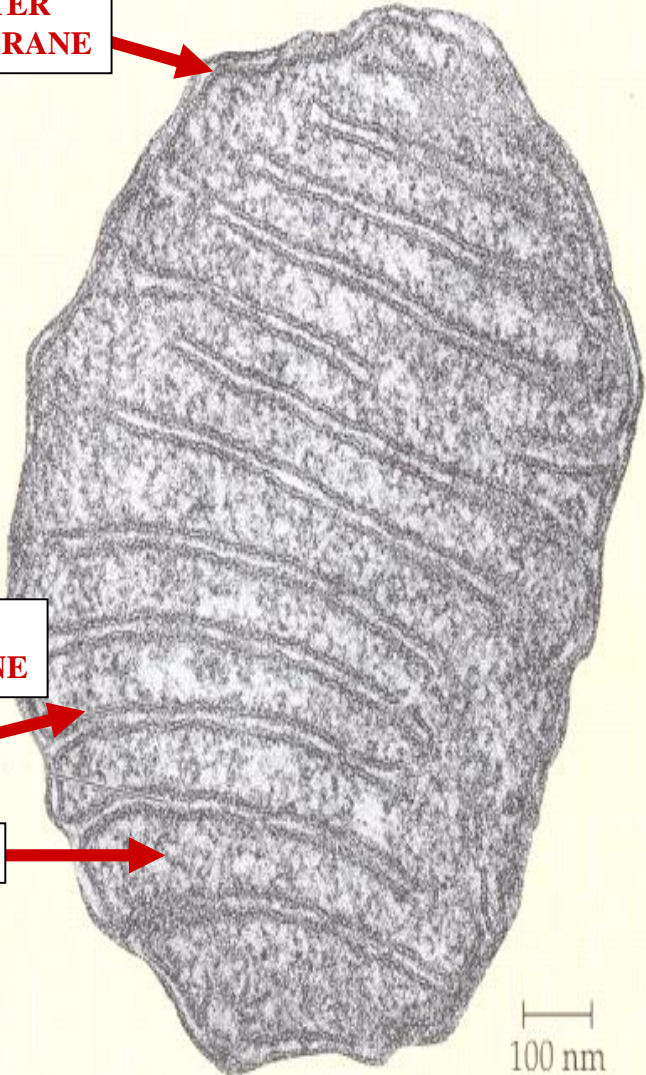
PROKARYOTE-LIKE RIBOSOMES

**CELL
"POWER-HOUSE"**

INNER
MEMBRANE

CRISTAE

MATRIX



100 nm



MITOCHONDRION EVOLUTION

MITOCHONDRION

PROKARYOTE-LIKE DNA

PROKARYOTE-LIKE RIBOSOMES

MITOCHONDRION EVOLUTION



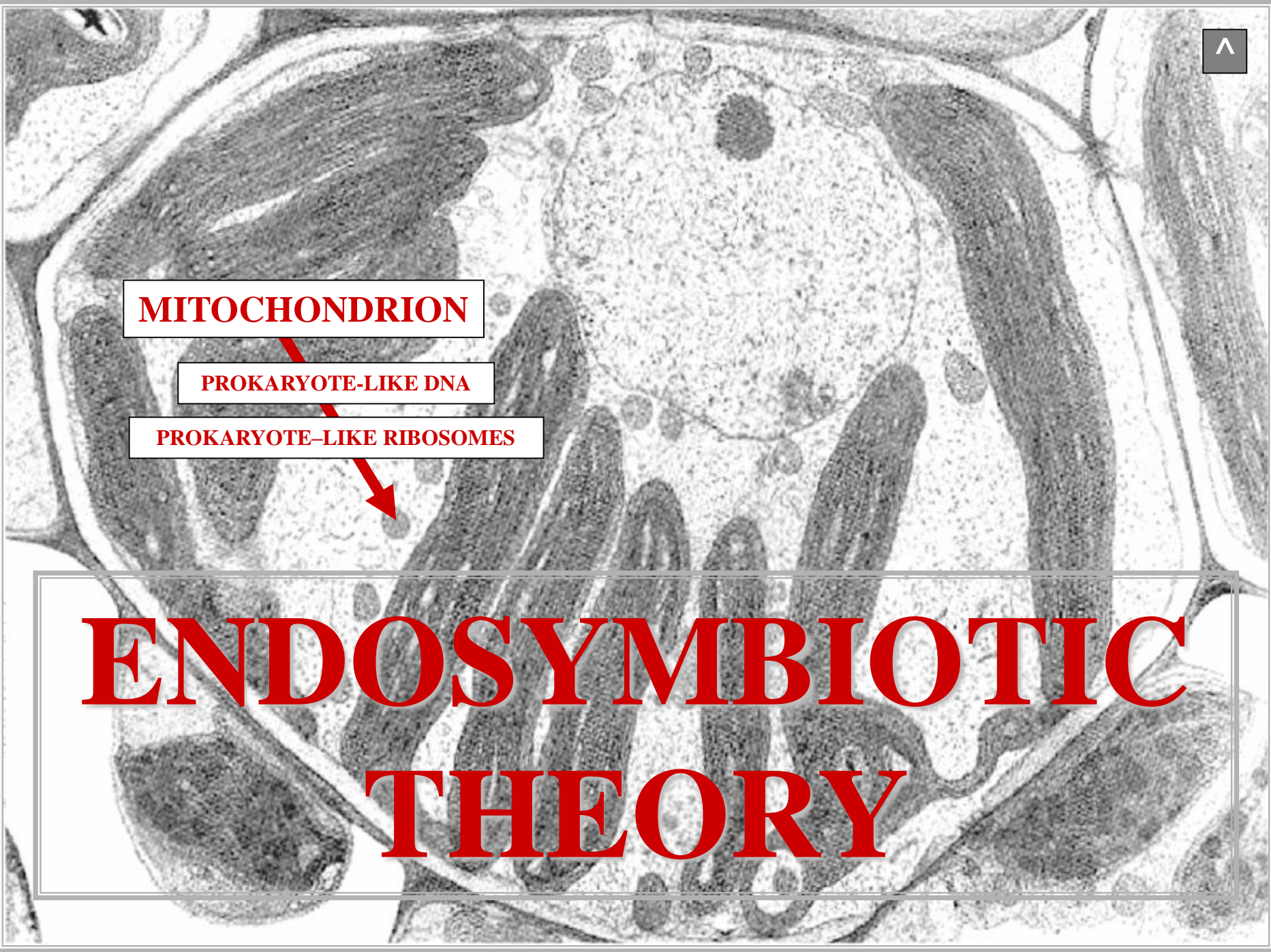
MITOCHONDRION

PROKARYOTE-LIKE DNA

PROKARYOTE-LIKE RIBOSOMES



ENDOSYMBIOTIC THEORY



NUCLEUS

NUCLEUS



NUCLEUS

KNOWN MOST EUKARYOTES

NUCLEUS



NUCLEUS

KNOWN MOST EUKARYOTES

CHROMOSOME LOCATION

NUCLEUS



NUCLEUS

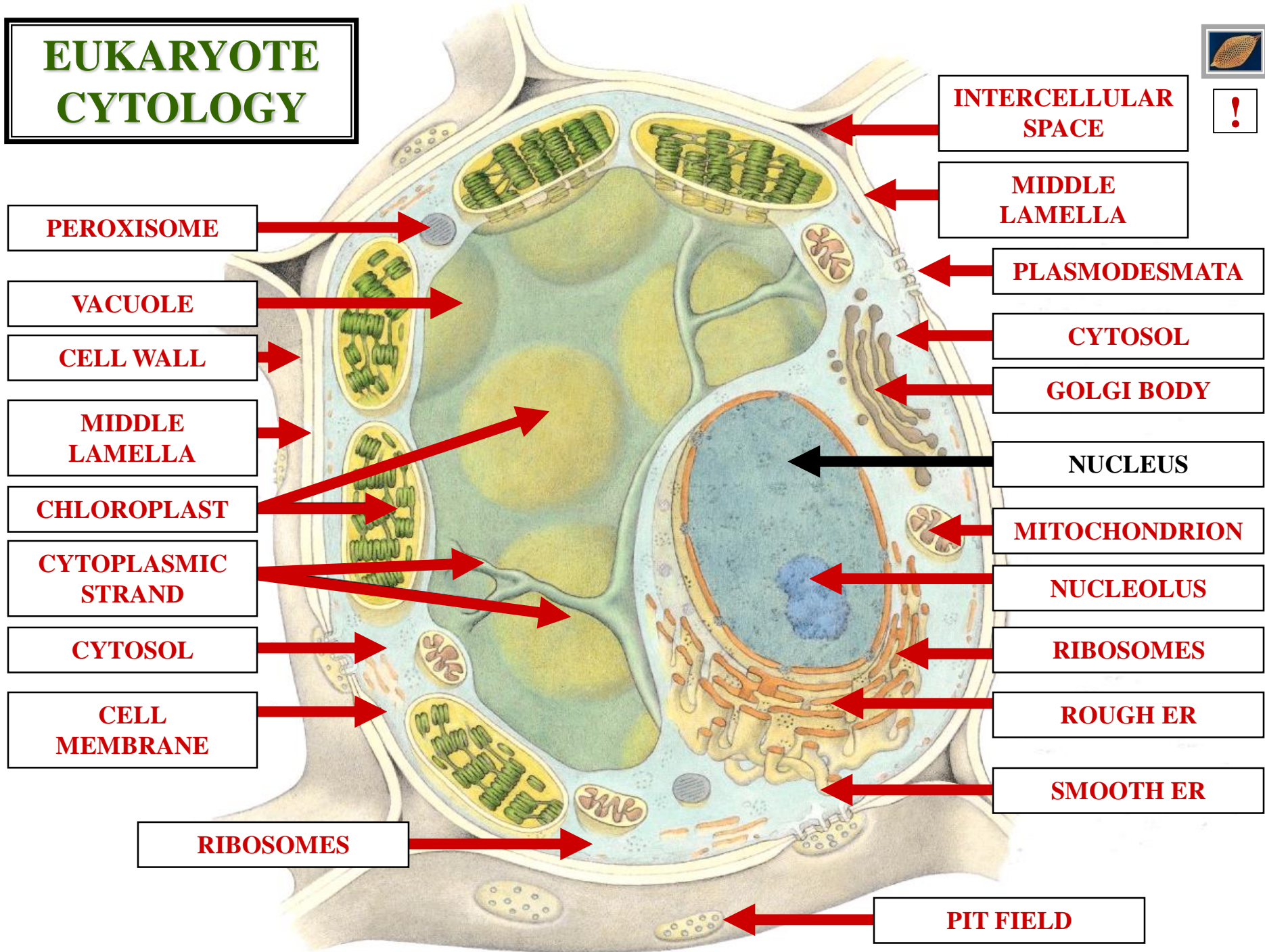
KNOWN MOST EUKARYOTES

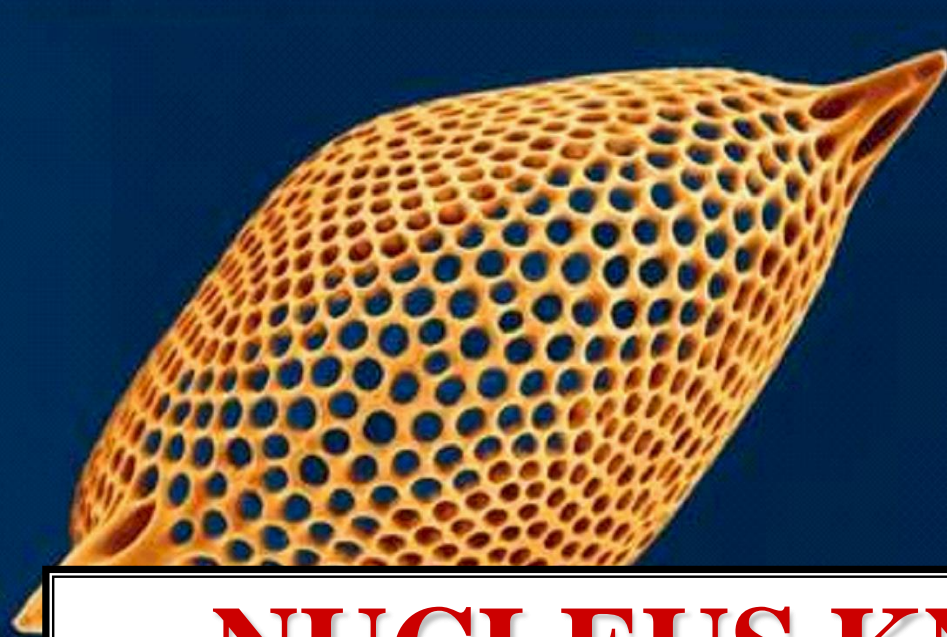
CHROMOSOME LOCATION

REGULATES
CELL METABOLISM

NUCLEUS

EUKARYOTE CYTOLOGY



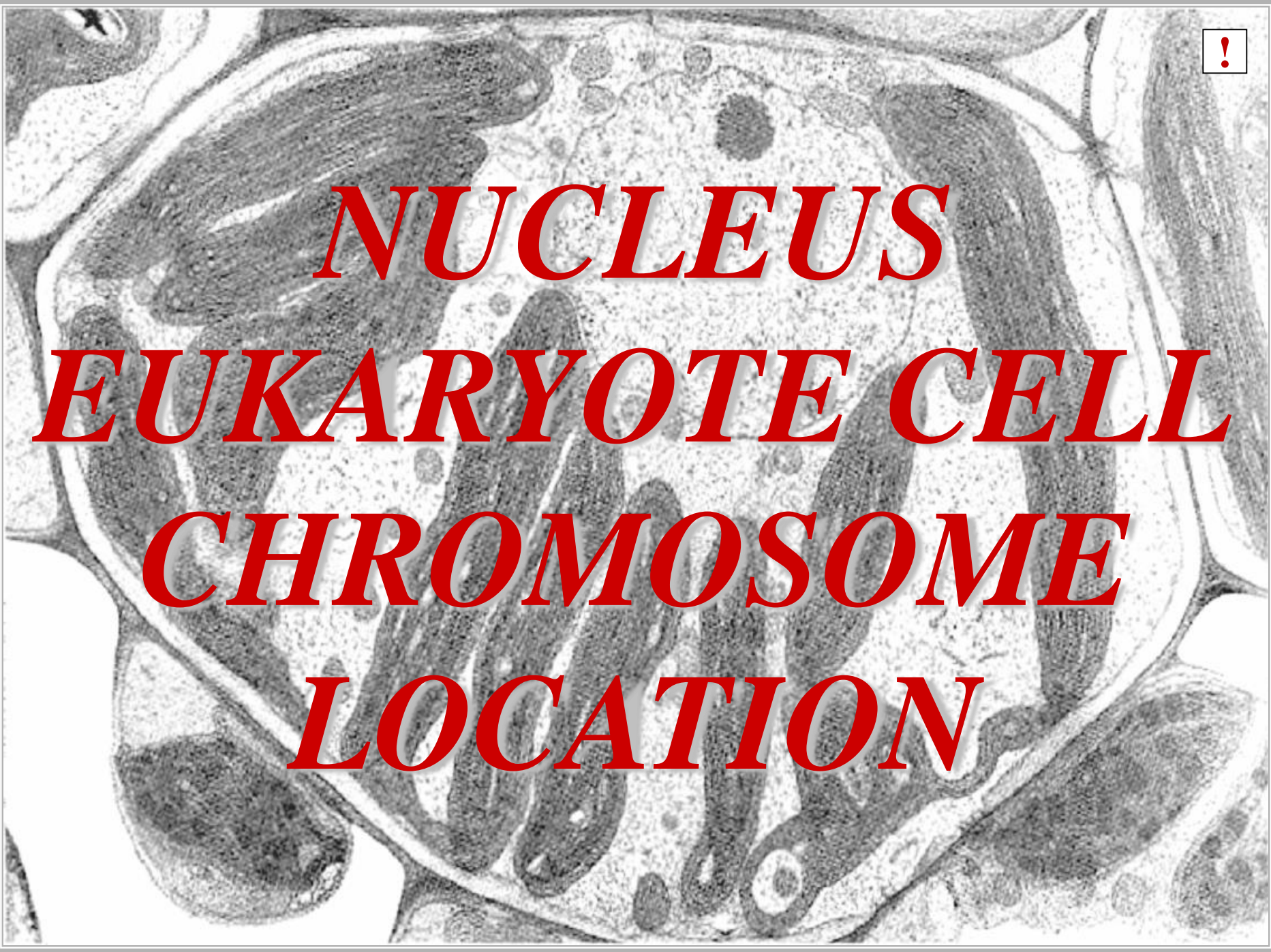


NUCLEUS KNOWN MOST EUKARYOTES



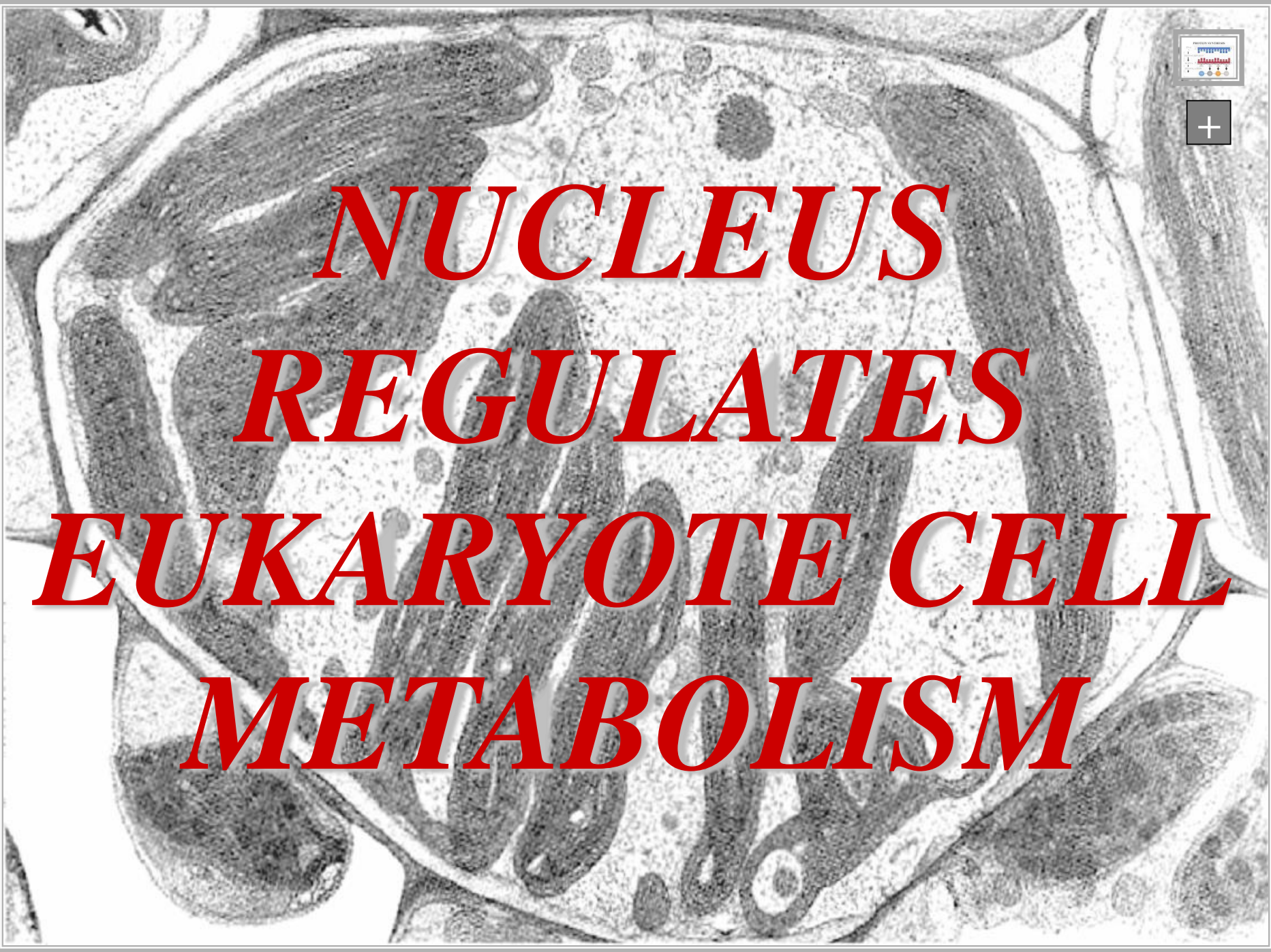


NUCLEUS
EUKARYOTE CELL
CHROMOSOME
LOCATION

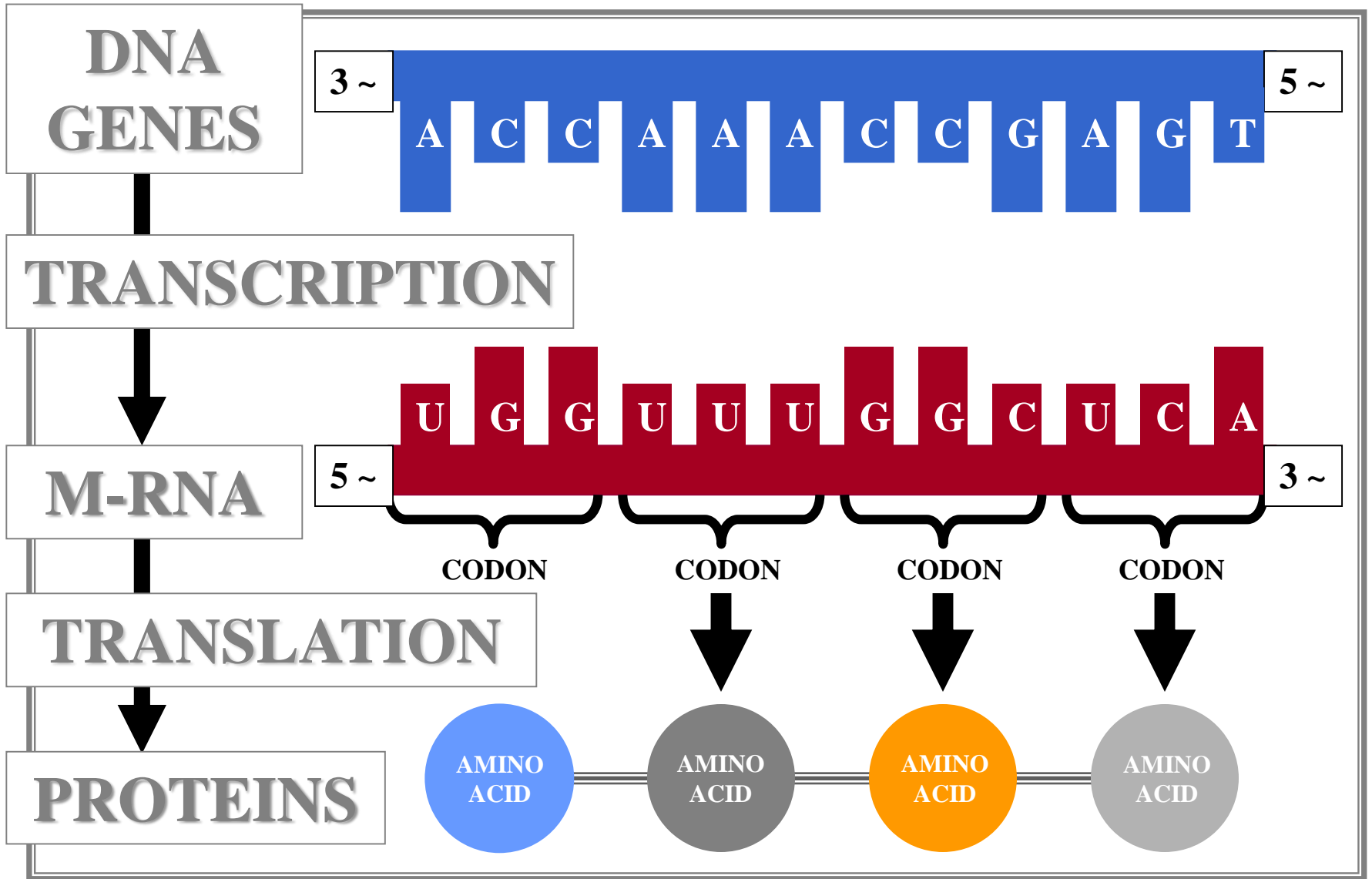




***NUCLEUS
REGULATES
EUKARYOTE CELL
METABOLISM***



PROTEIN/ENZYME SYNTHESIS



METABOLISM

GLUCOSE

METABOLISM

HEXOKINASE

+

ATP

EGY

ADP

GLUCOSE-6-PHOSPHATE

ENZYMES
VITAL TO METABOLISM

PHOSPHOGLUCOISOMERASE

ENZYMES
VITAL TO METABOLISM

FRUCTOSE-6-PHOSPHATE

PHOSPHOFRUCTOKINASE

ATP

EGY

ADP

FRUCTOSE-1-6-PHOSPHATE



FRUCTOSE-1-6-PHOSPHATE

ENZYMES
VITAL TO METABOLISM

ENZYMES
VITAL TO METABOLISM

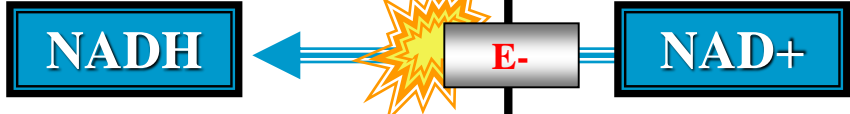
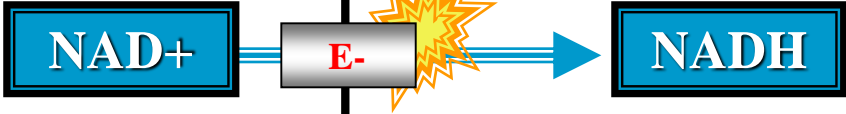
ALDOLASE
ISOMERASE

PHOSPHOGLYCERALDEHYDE - PGAL

PHOSPHOGLYCERALDEHYDE - PGAL

TRI-PHOSPHATE DEHYDROGENASE

TRI-PHOSPHATE DEHYDROGENASE



1-3-BISPHOSPHOGLYCERATE

1-3-BISPHOSPHOGLYCERATE

PHOSPHOGLYCEROKINASE

PHOSPHOGLYCEROKINASE



3-PHOSPHOGLYCERATE - PGA

3-PHOSPHOGLYCERATE - PGA



3-PHOSPHOGLYCERATE - PGA

ENOLASE

3-PHOSPHOENOLPYRUVATE

PYRUVATE KINASE



PYRUVATE

ENZYMES
VITAL TO METABOLISM

3-PHOSPHOGLYCERATE - PGA

ENOLASE

3-PHOSPHOENOLPYRUVATE

PYRUVATE KINASE



PYRUVATE

ENZYMES
VITAL TO METABOLISM

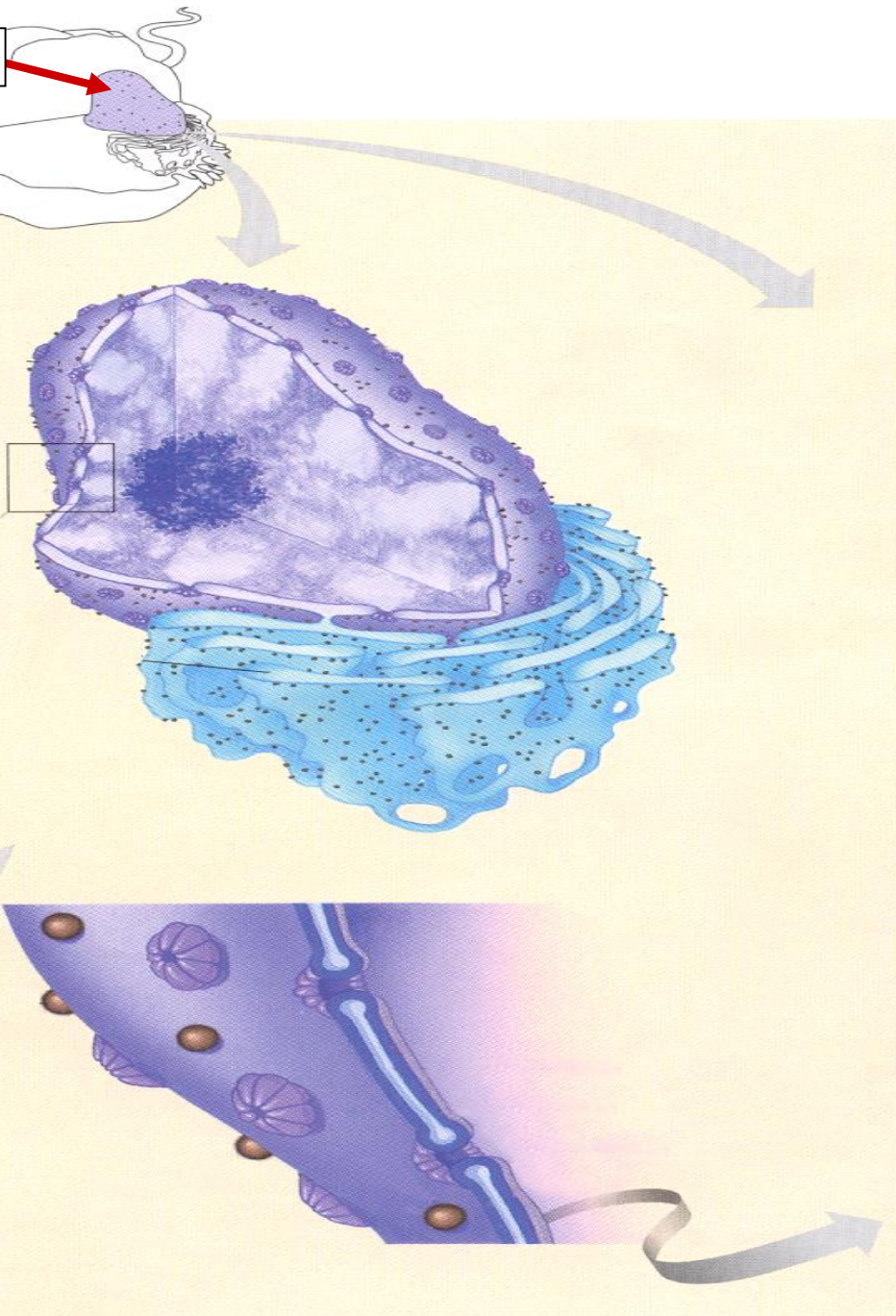
NUCLEUS REGULATES ENZYME SYNTHESIS

NUCLEUS REGULATES CELL METABOLISM

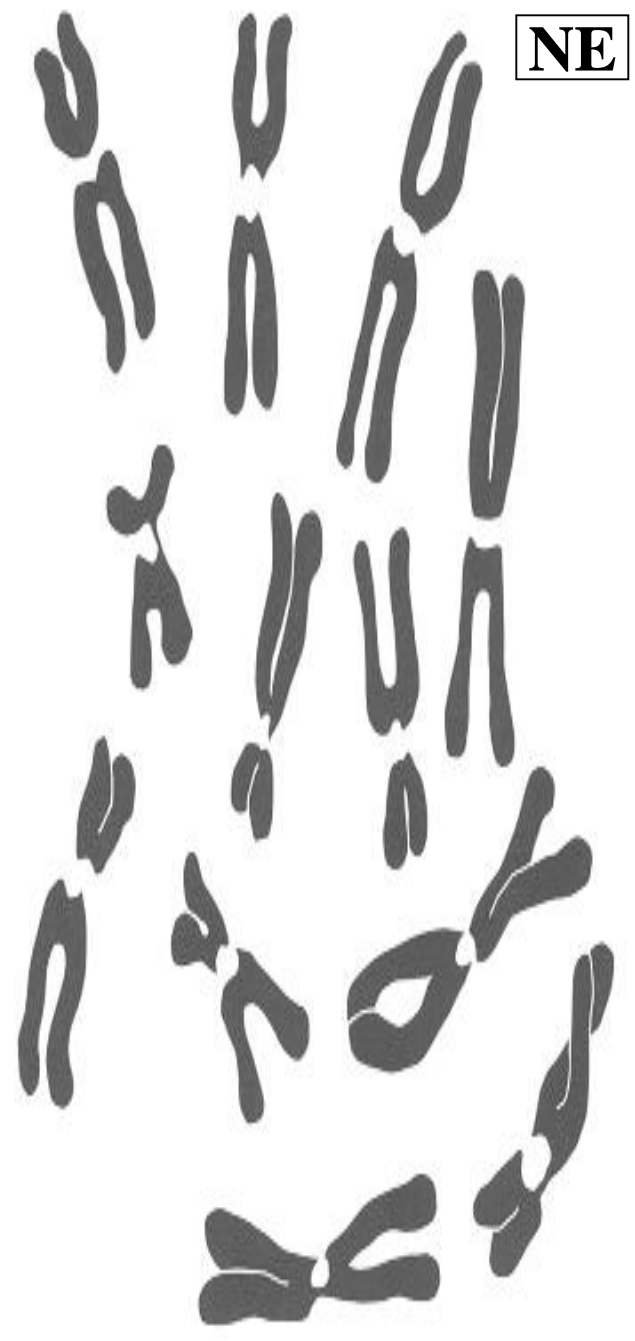


NUCLEUS ULTRASTRUCTURE

NUCLEUS



NE



NUCLEAR ENVELOPE

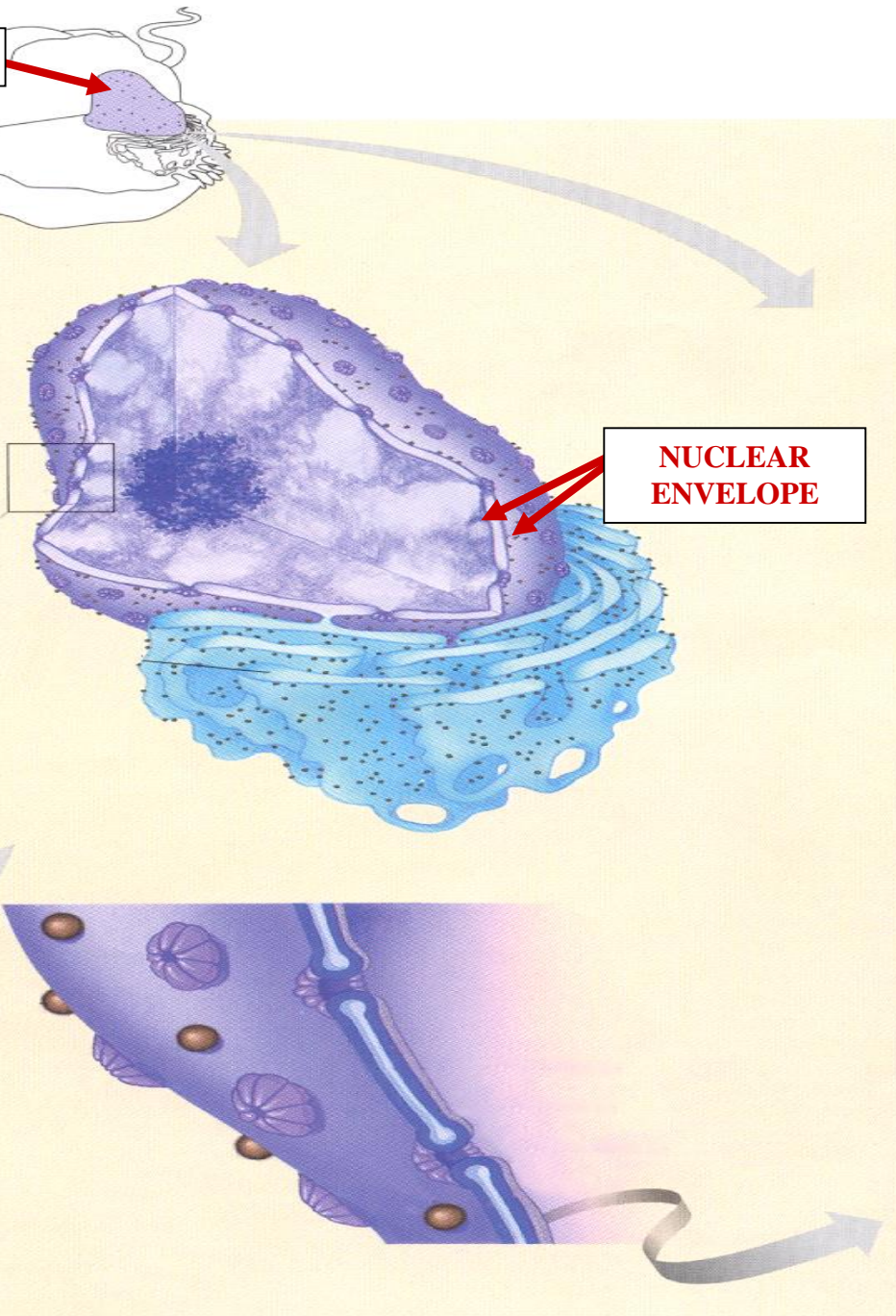


NUCLEAR ENVELOPE

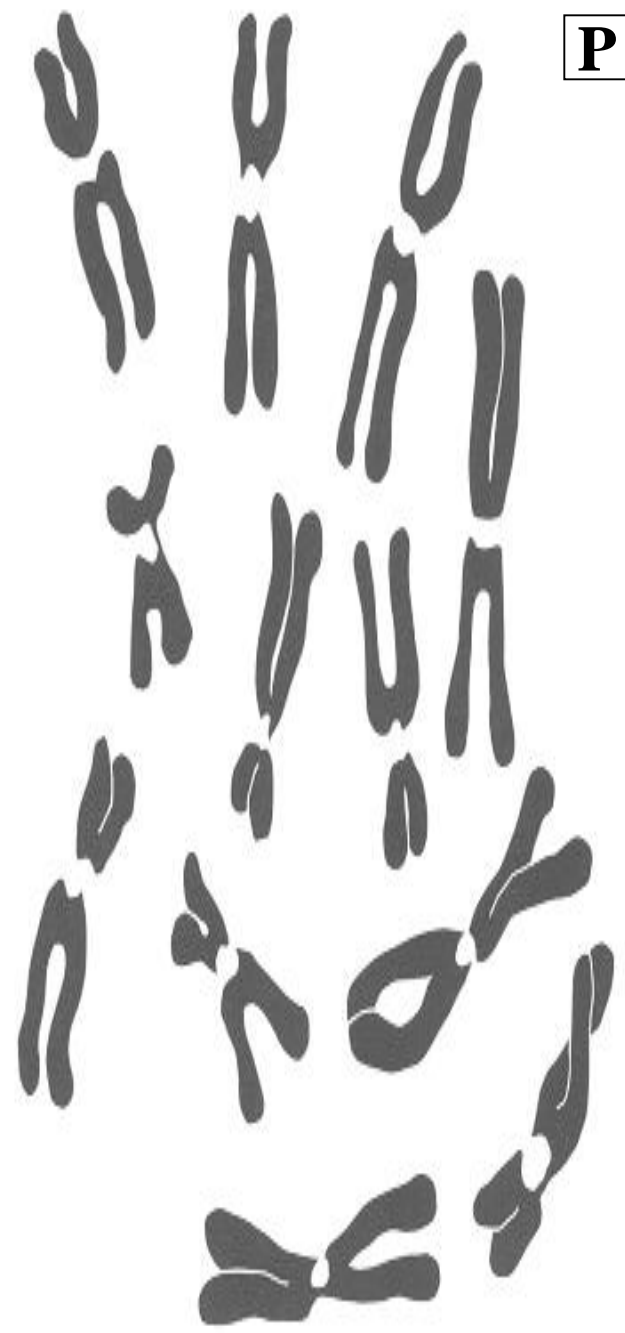
NUCLEUS
DOUBLE MEMBRANE

NUCLEAR ENVELOPE

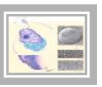
NUCLEUS



P



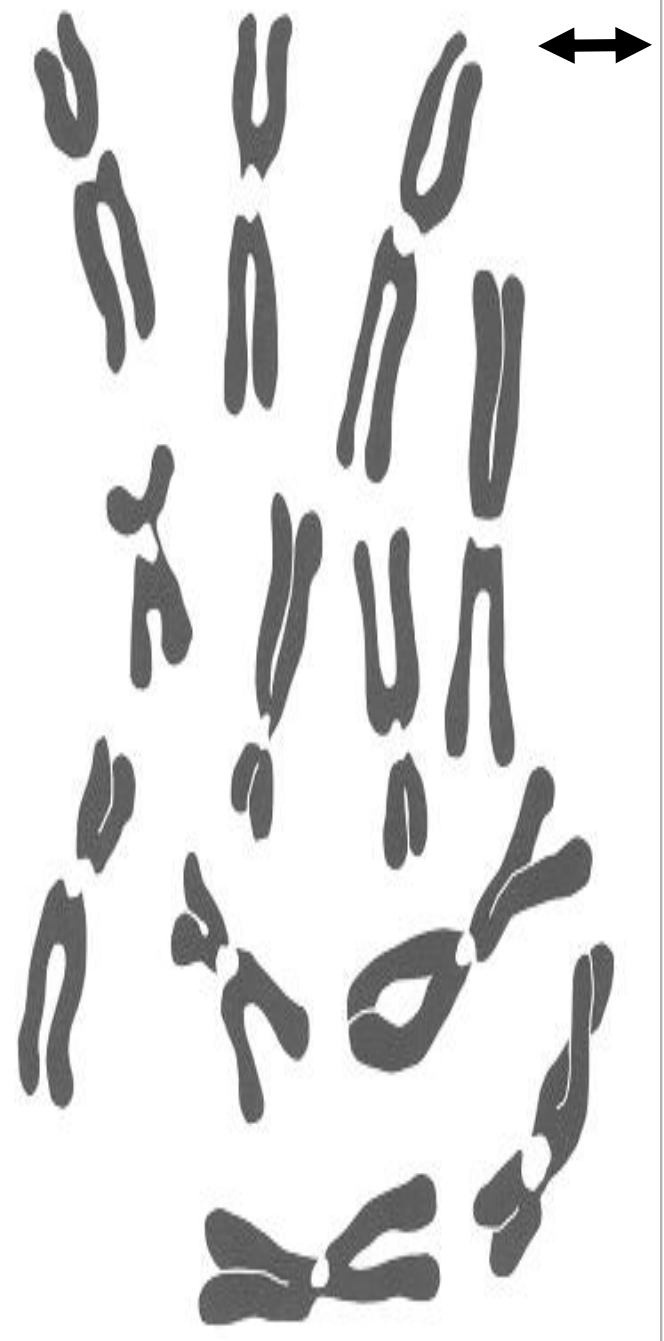
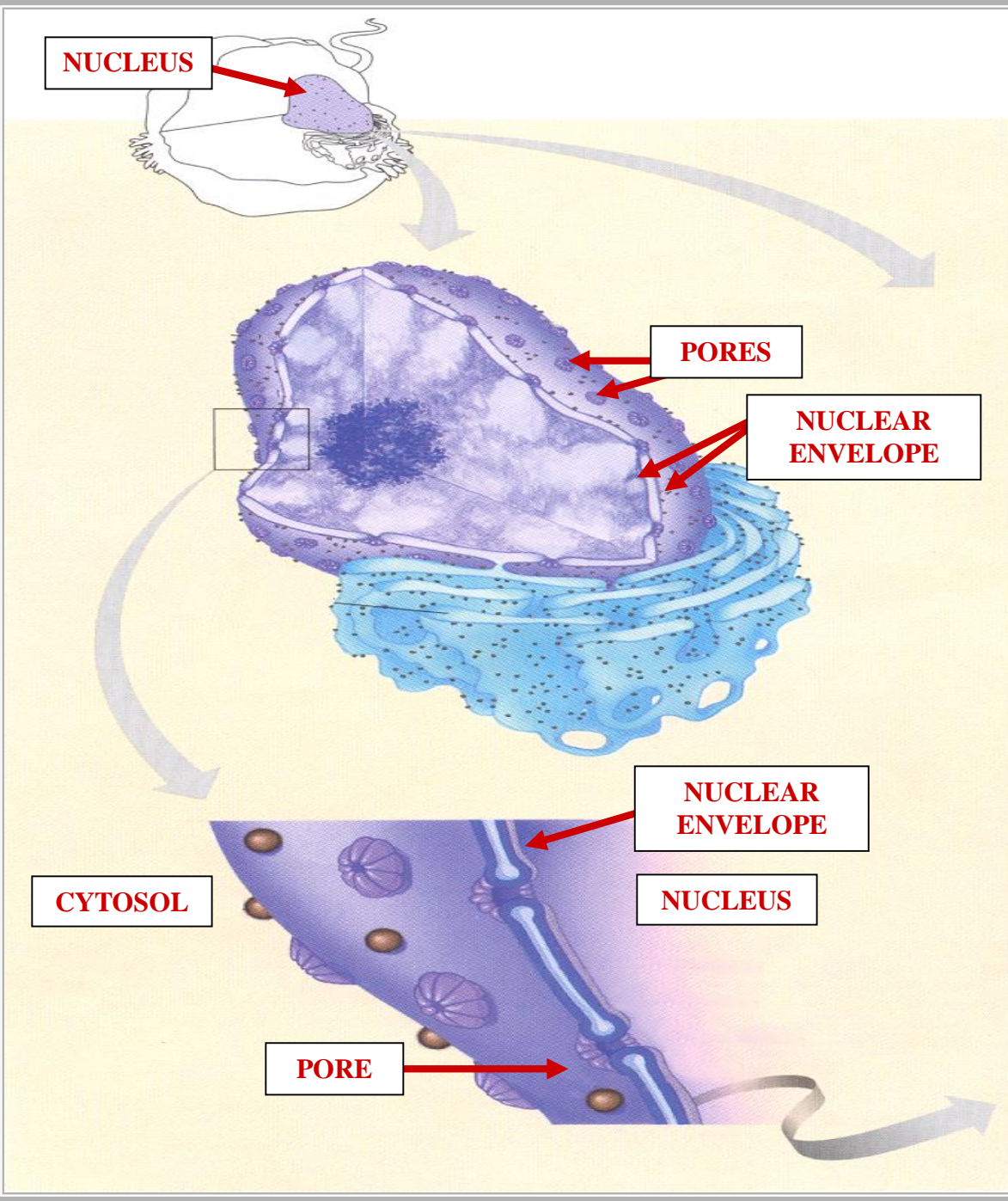
**NUCLEAR
ENVELOPE
PORES**

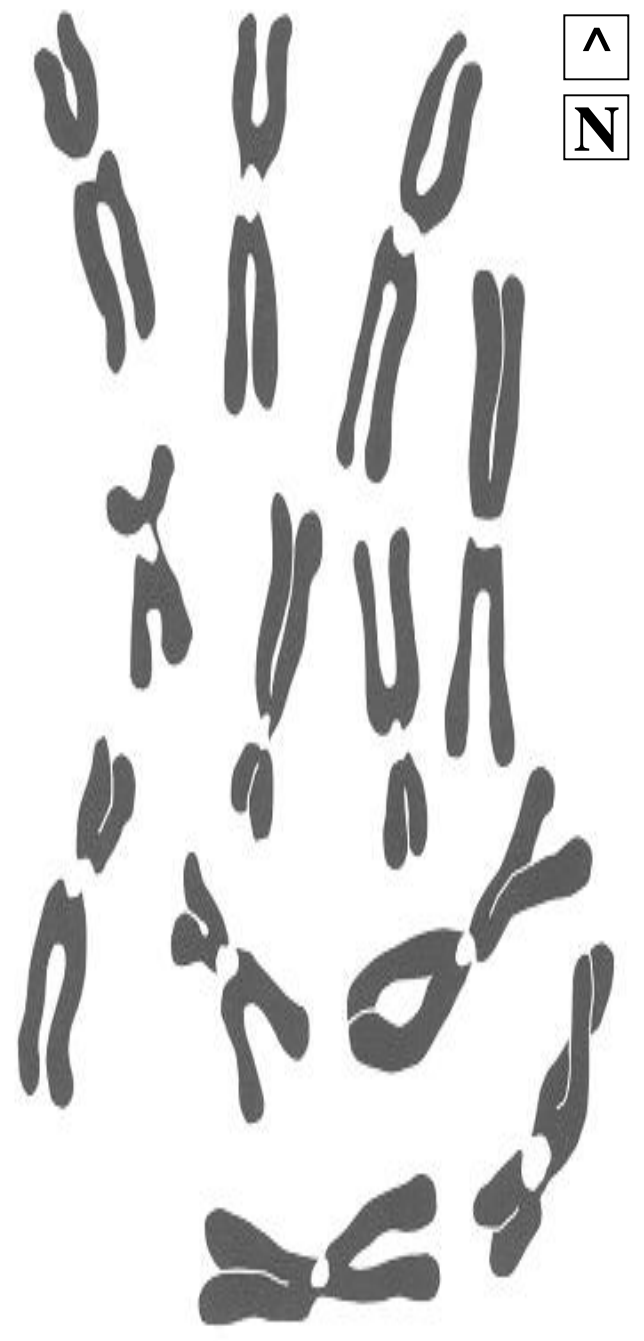
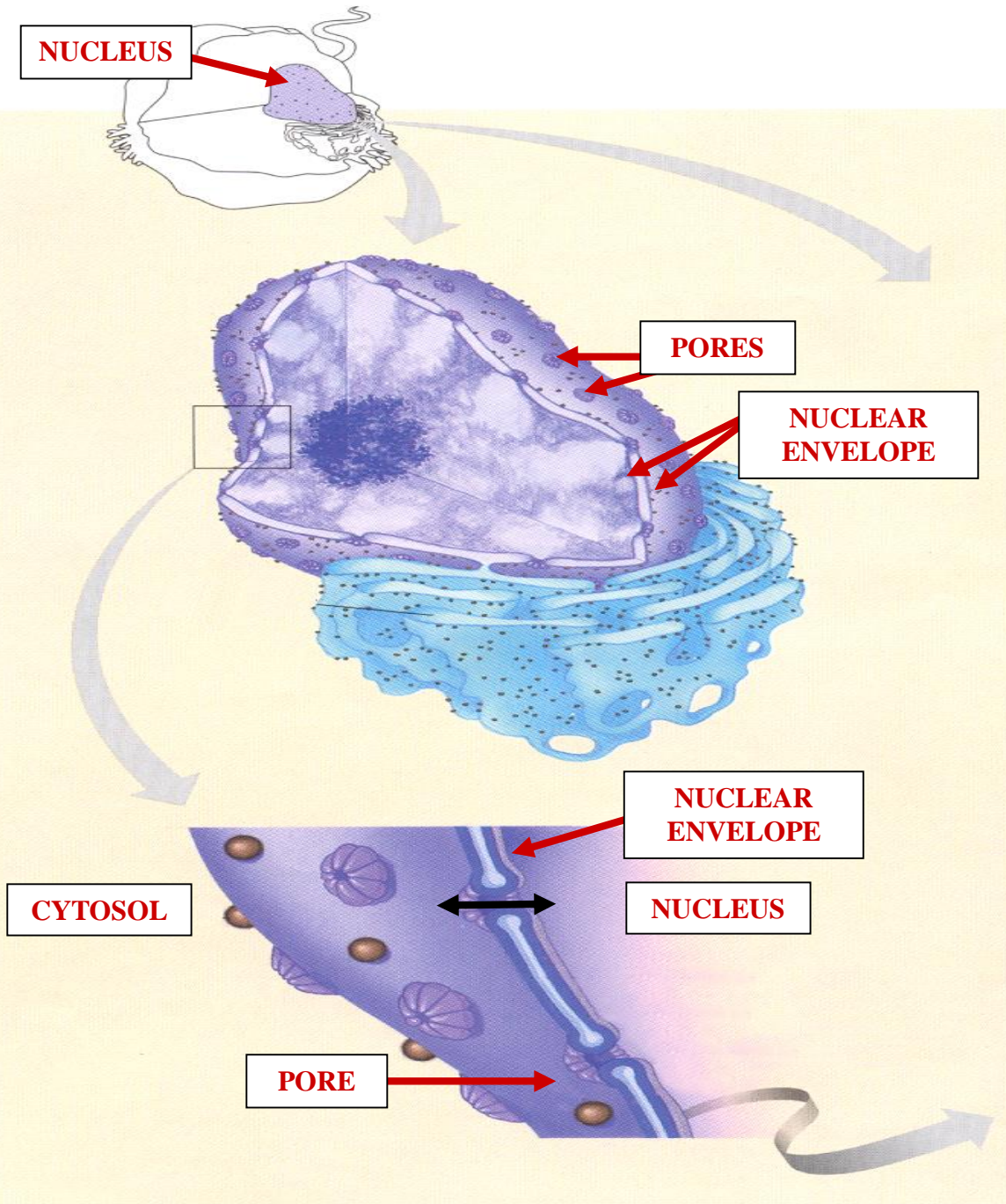


NUCLEAR ENVELOPE PORES

**COMMUNICATION
CONDUITS BETWEEN
NUCLEUS & CYTOSOL**

NUCLEAR ENVELOPE PORES





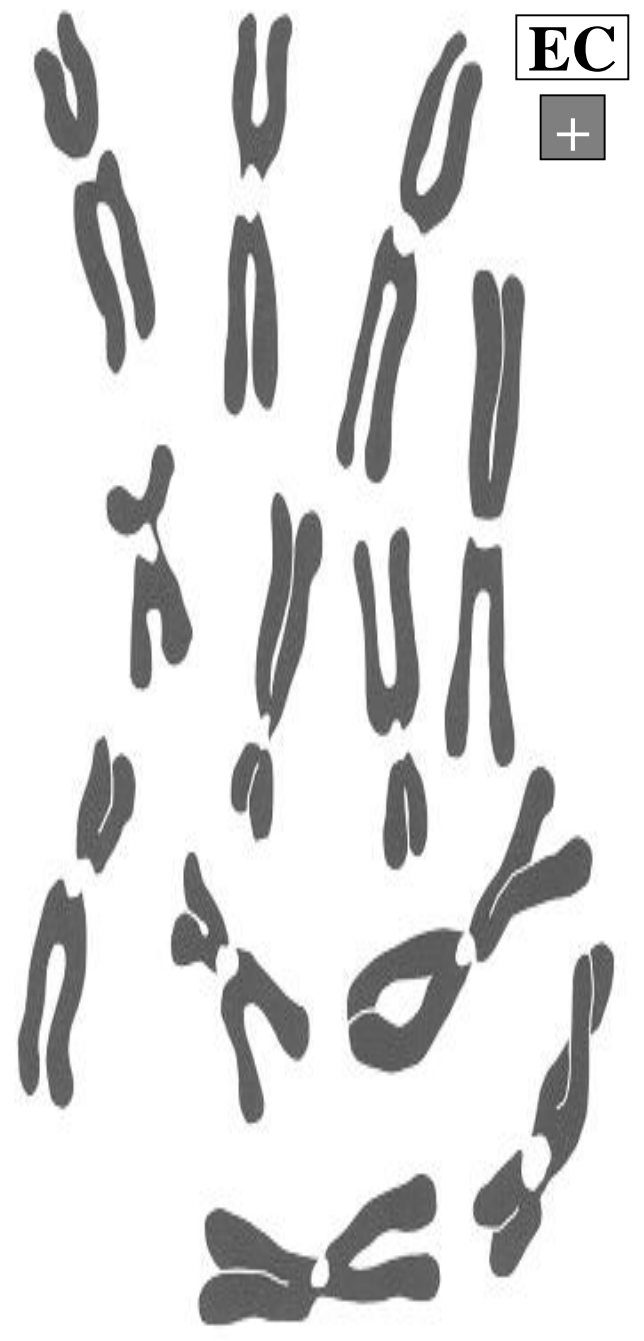
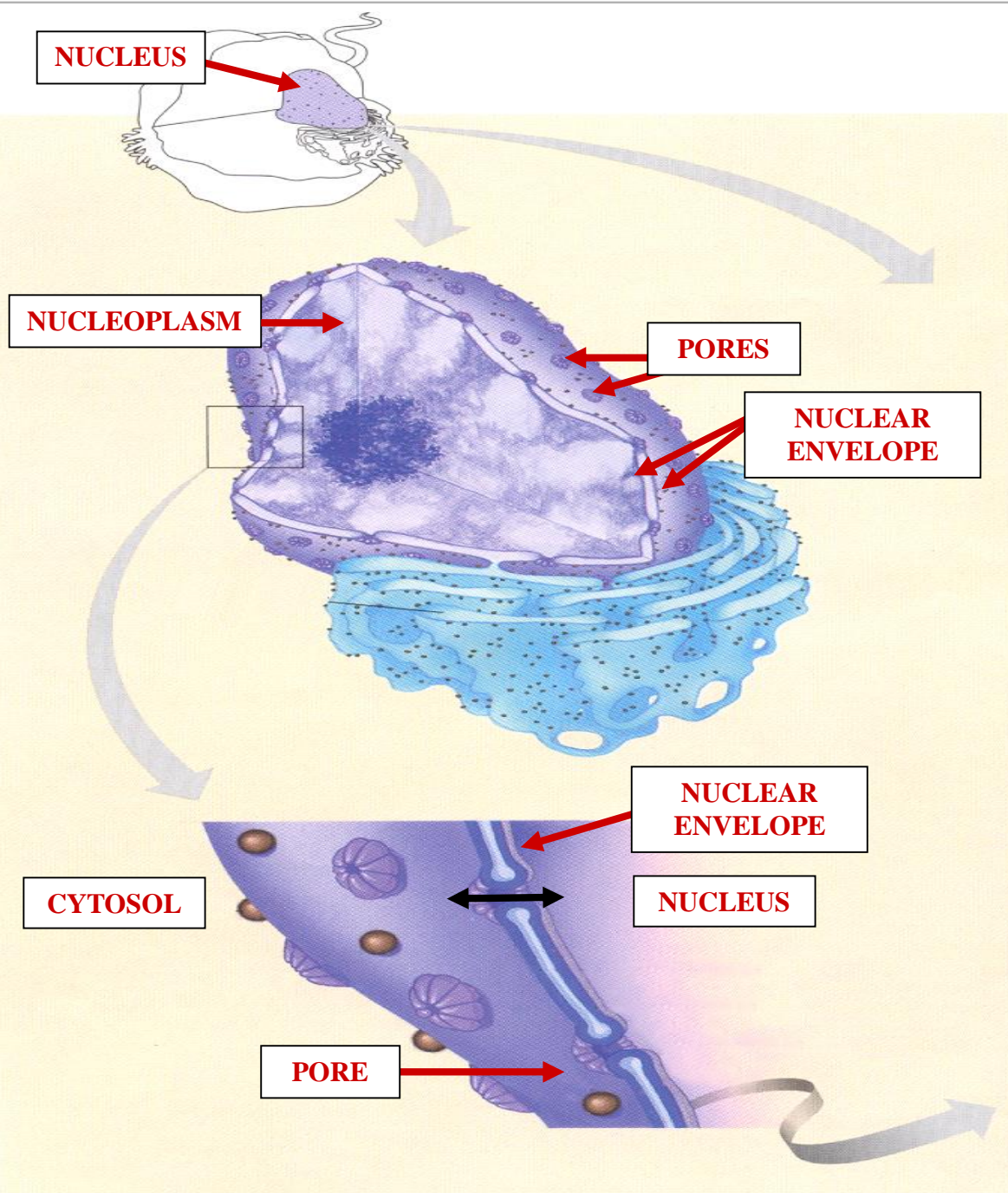
NUCLEOPLASM



NUCLEUS
NUCLEOPLASM

NUCLEUS
FLUID MATRIX

NUCLEUS
NUCLEOPLASM



EUKARYOTE CHROMOSOMES



EUKARYOTE CHROMOSOMES

LINEAR DNA

EUKARYOTE CHROMOSOMES

EUKARYOTE CHROMOSOMES

LINEAR DNA

**HISTONE PROTEINS
PRESENT**

**EUKARYOTE
CHROMOSOMES**



NUCLEUS

**EUKARYOTE
CHROMOSOMES**

L

NUCLEOPLASM

PORES

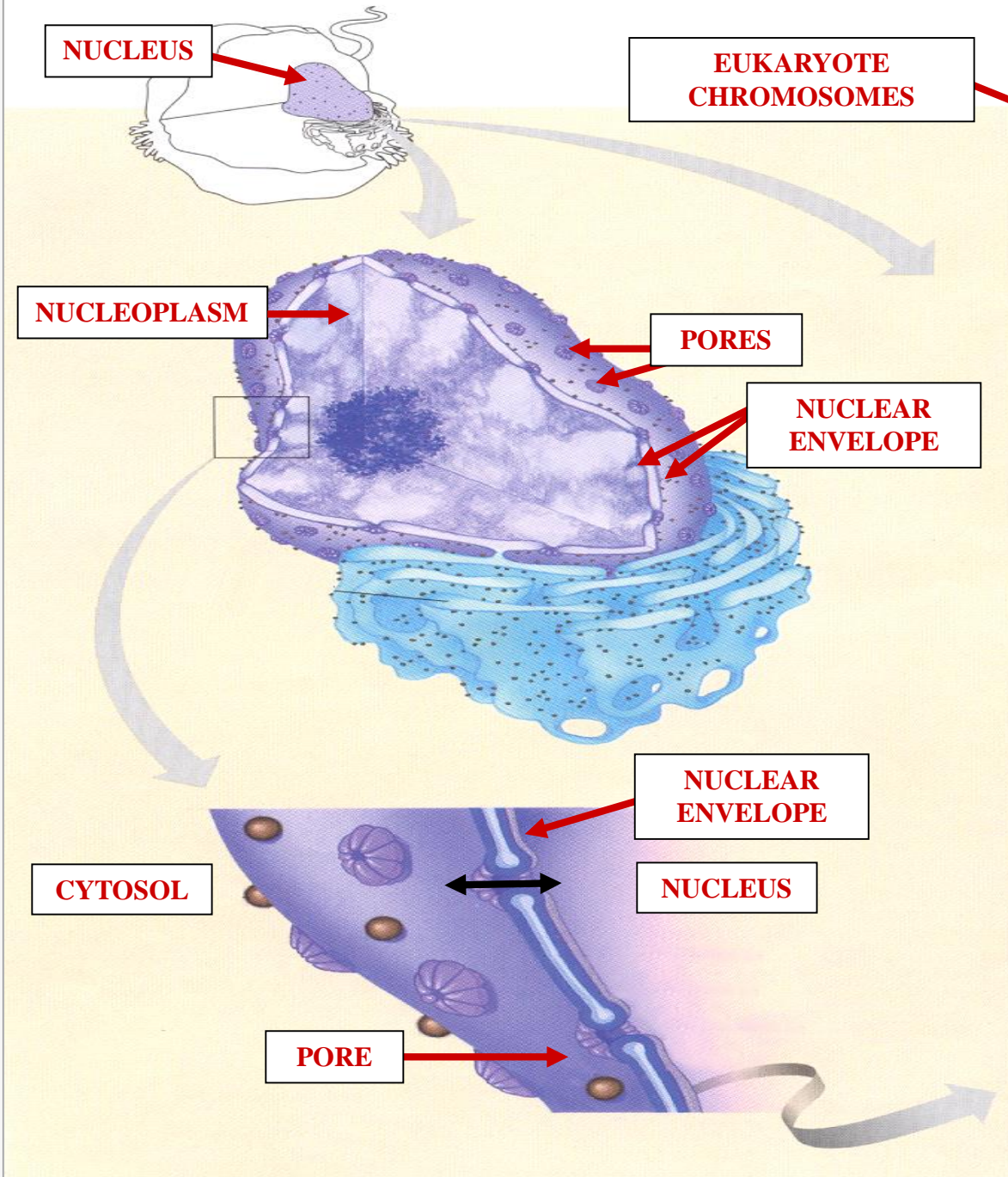
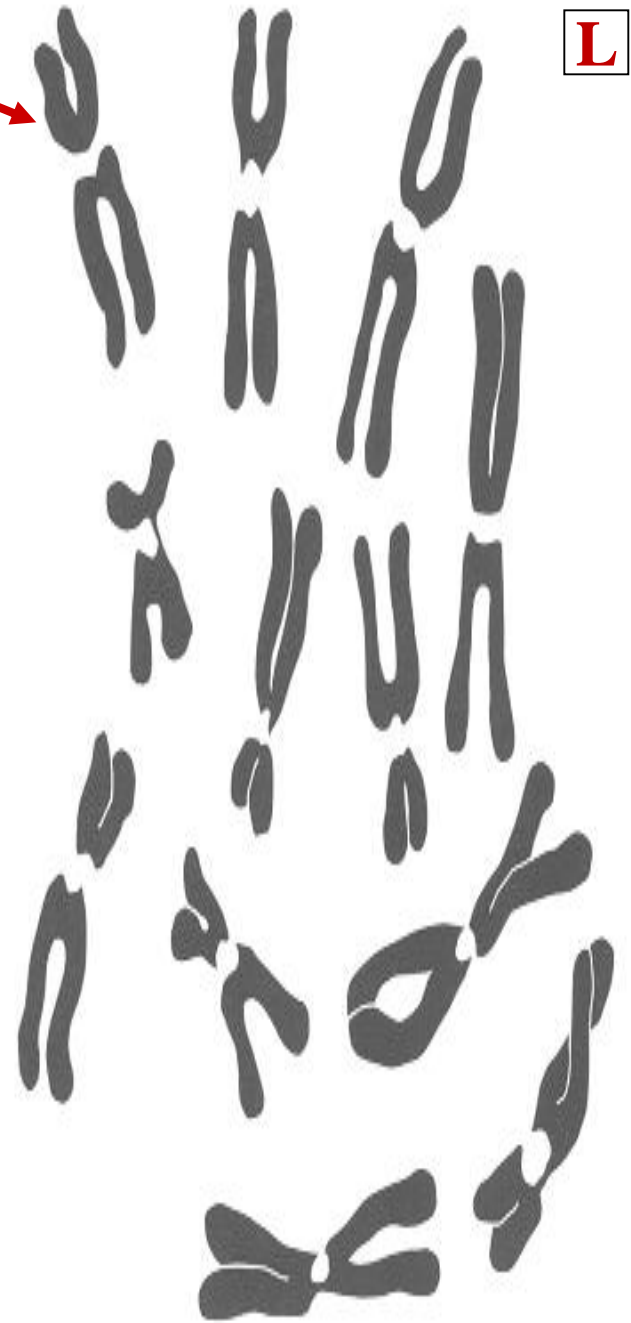
**NUCLEAR
ENVELOPE**

CYTOSOL

**NUCLEAR
ENVELOPE**

NUCLEUS

PORE



NUCLEUS

**CHROMOSOMES
LINEAR**

NUCLEOPLASM

PORES

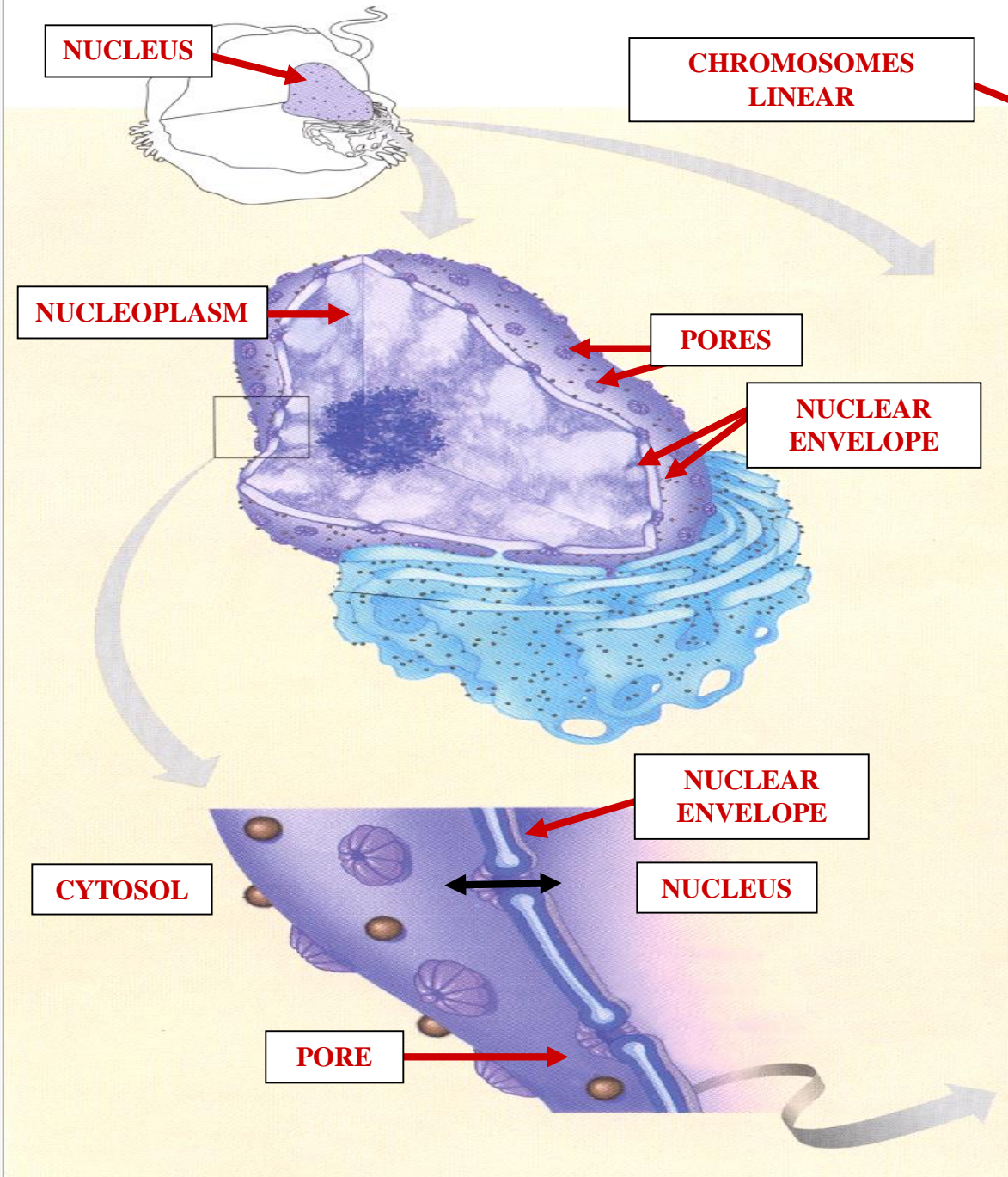
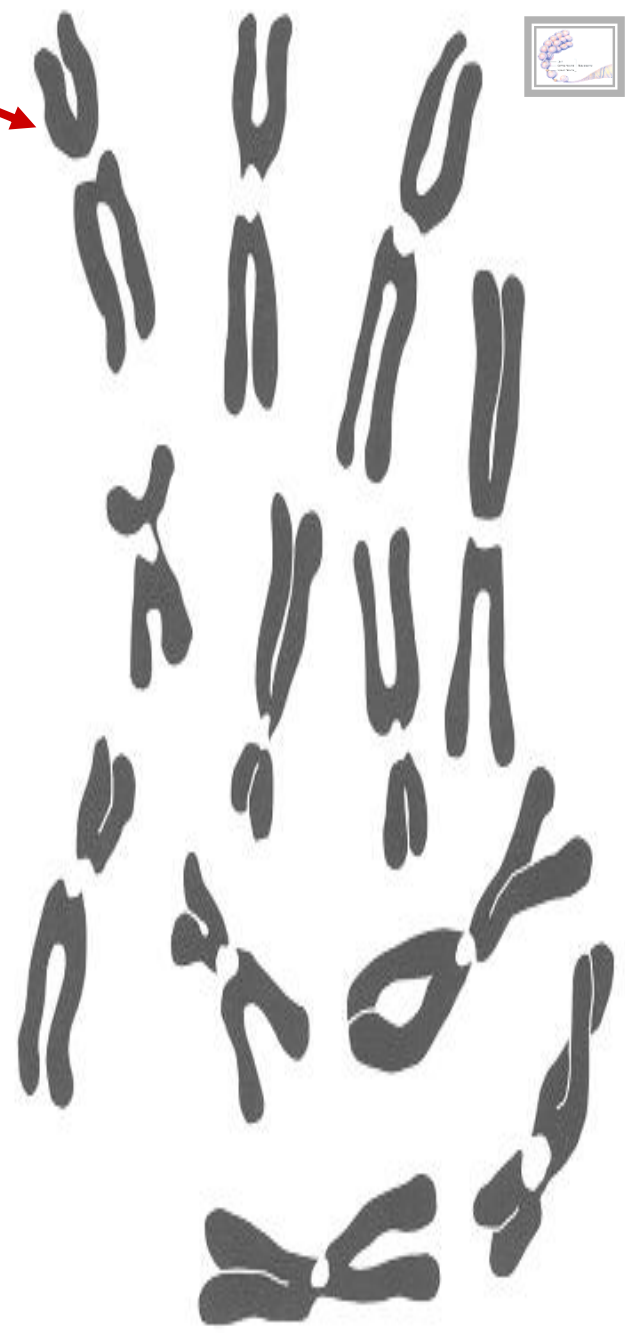
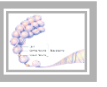
**NUCLEAR
ENVELOPE**

CYTOSOL

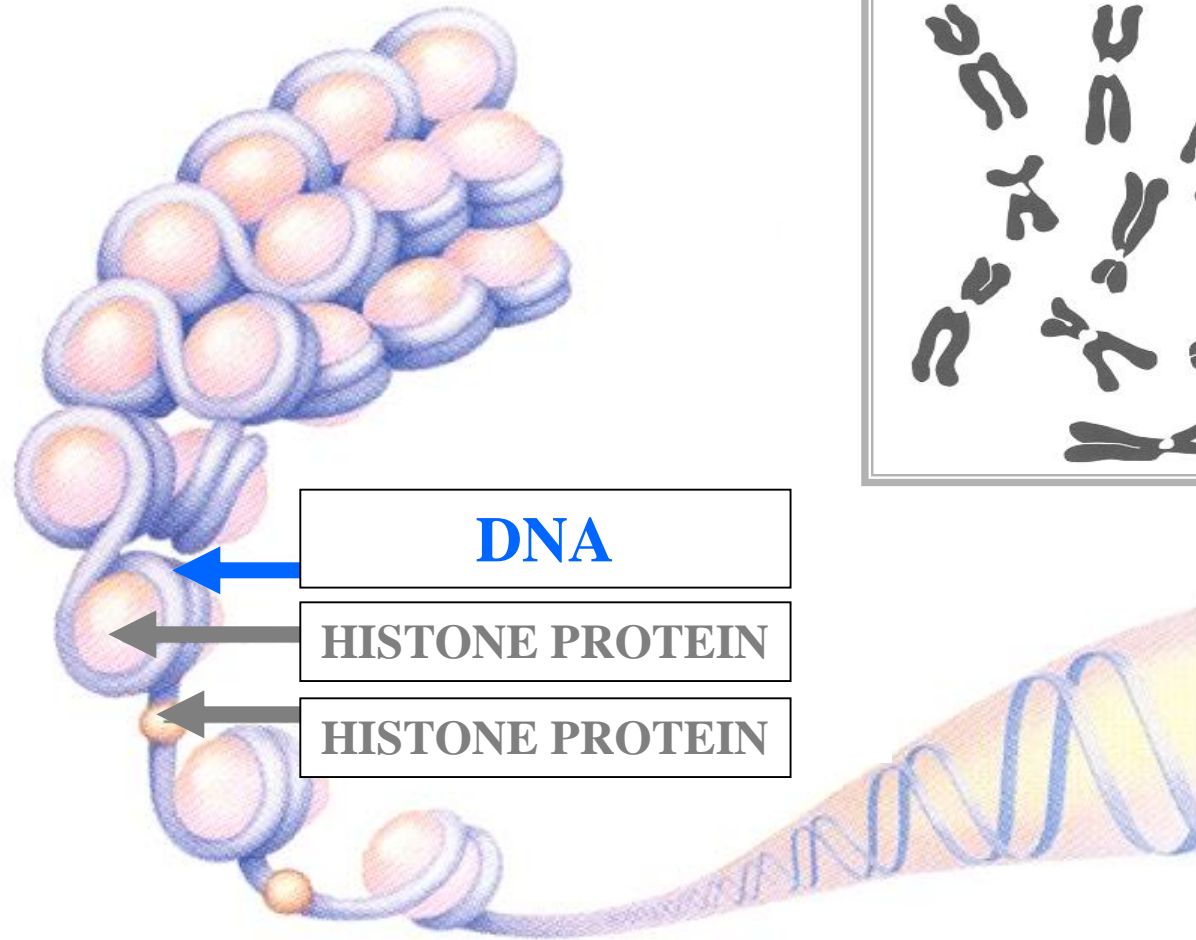
**NUCLEAR
ENVELOPE**

NUCLEUS

PORE



EUKARYOTE CHROMOSOME



EUKARYOTE CHROMOSOME: HISTONE PROTEINS PRESENT

NUCLEOLUS



NUCLEOLUS

SITE: RIBOSOME SYNTHESIS

NUCLEOLUS

NUCLEUS

**CHROMOSOMES
LINEAR DNA**

NUCLEOPLASM

PORES

NUCLEOLUS

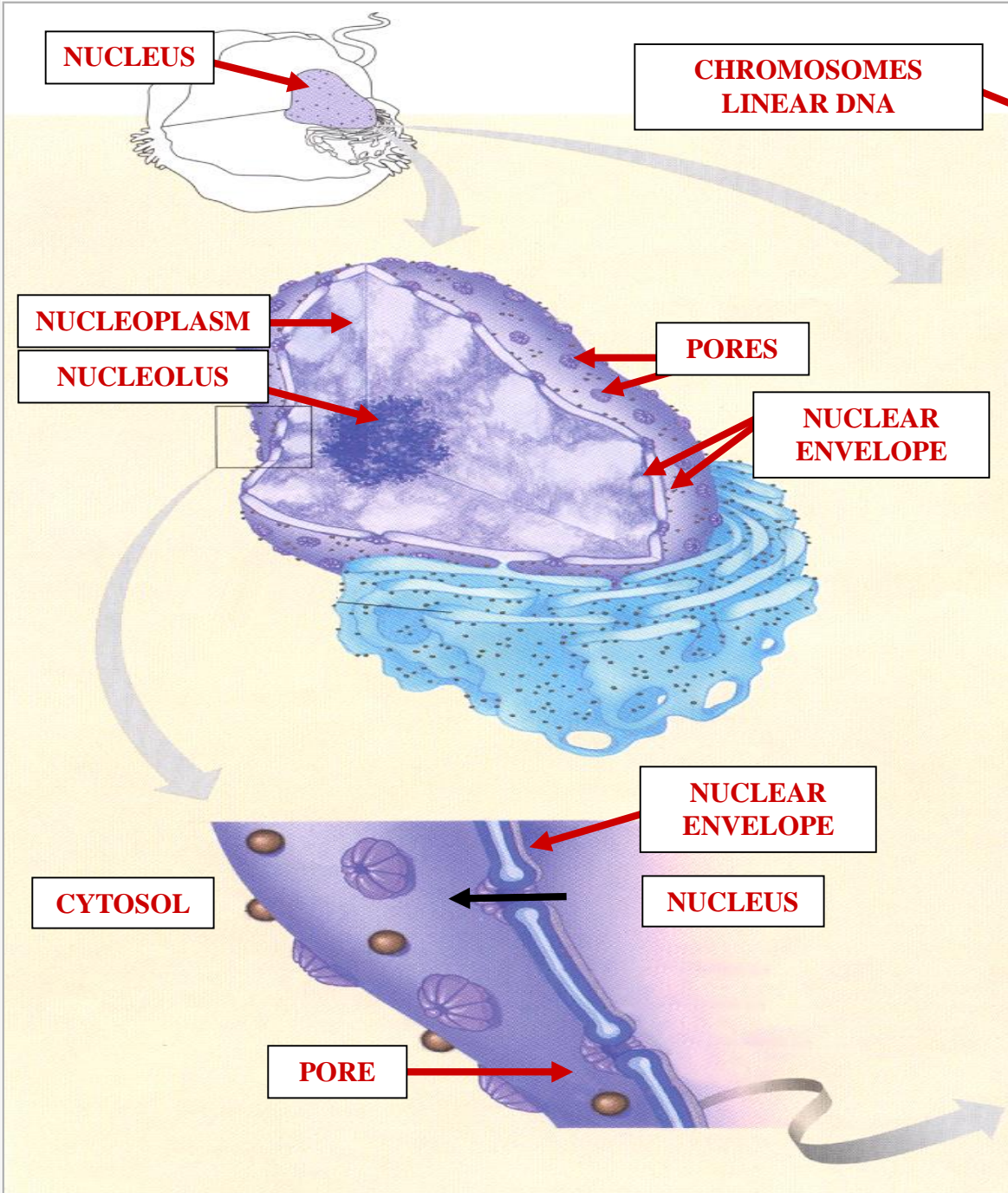
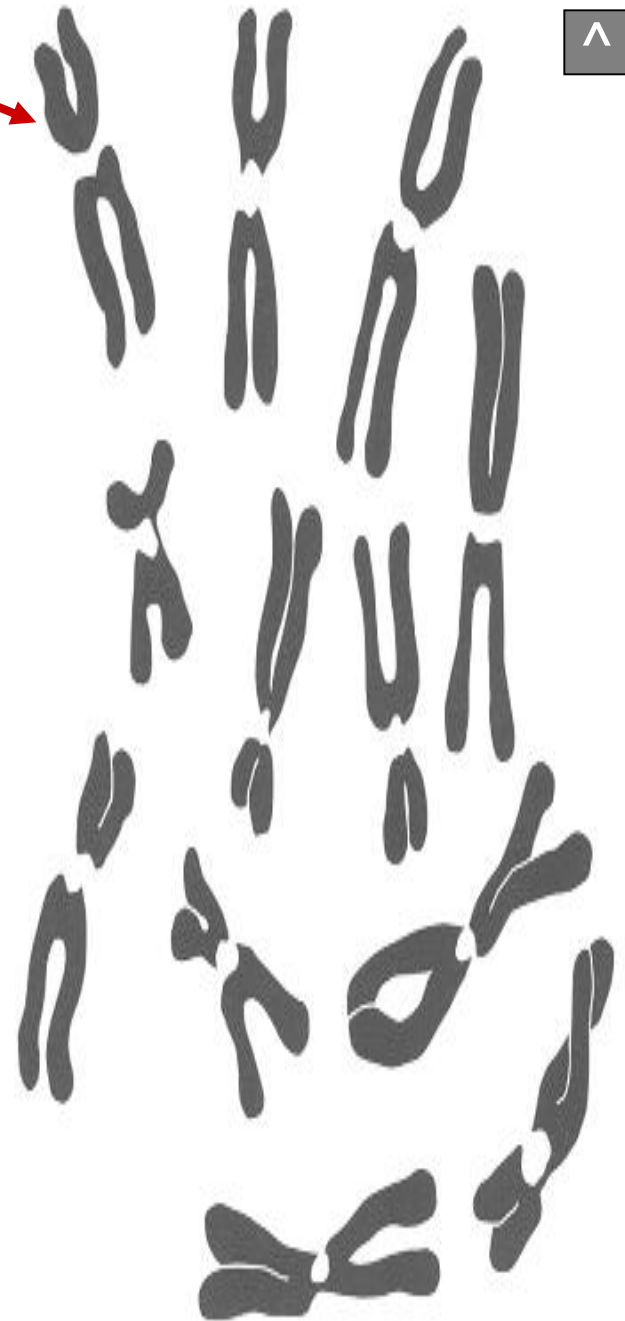
**NUCLEAR
ENVELOPE**

CYTOSOL

**NUCLEAR
ENVELOPE**

NUCLEUS

PORE





NUCLEUS EVOLUTION



**EUKARYOTE
CYTOLOGY**

A

NUCLEUS

**NUCLEUS
EVOLUTION**



**EUKARYOTE
CYTOLOGY**

NUCLEUS

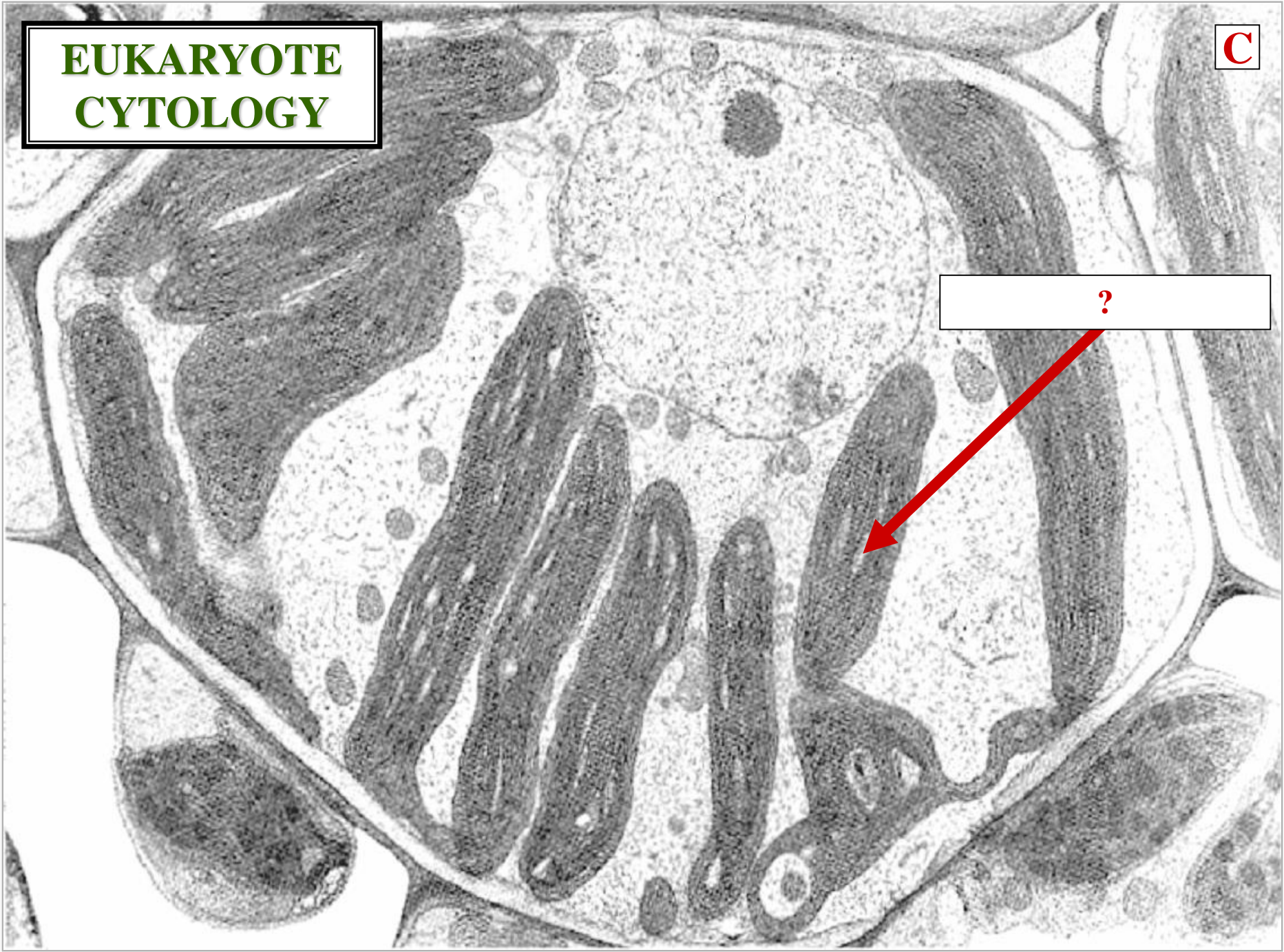
**AUTOGENOUS
THEORY**



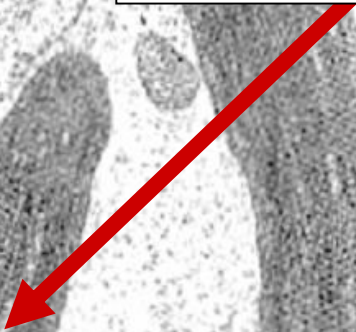
DOUBLE MEMBRANE BOUND ORGANELLES SUMMARY

EUKARYOTE CYTOLOGY

C



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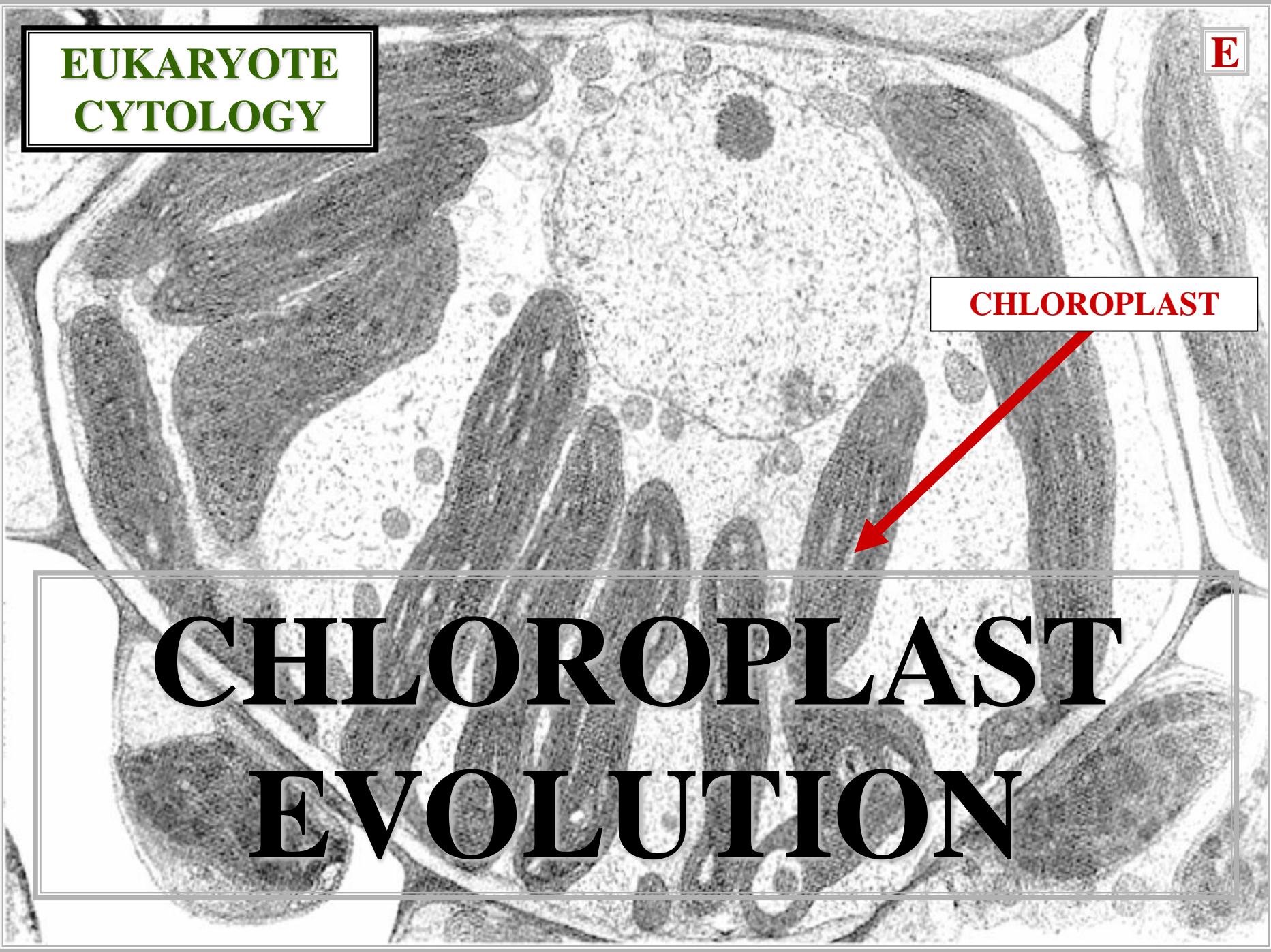


**EUKARYOTE
CYTOLOGY**

E

CHLOROPLAST

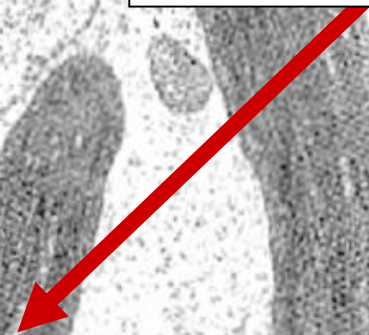
**CHLOROPLAST
EVOLUTION**



**EUKARYOTE
CYTOLOGY**

?

CHLOROPLAST

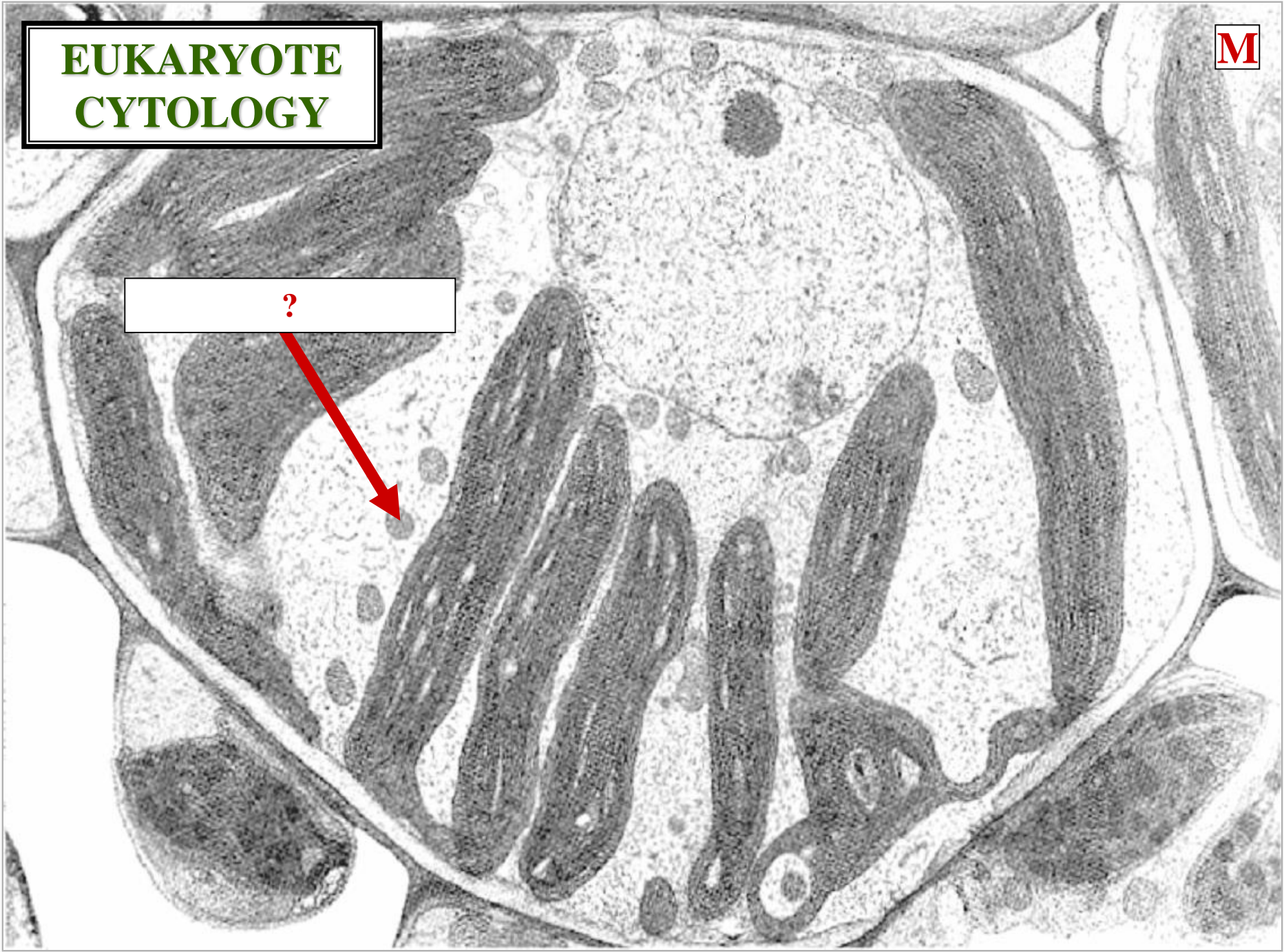


**ENDOSYMBIOTIC
THEORY**

EUKARYOTE CYTOLOGY

M

?



An electron micrograph of a eukaryotic cell. The image shows a large nucleus with a prominent nucleolus and dense chromatin. Surrounding the nucleus are various organelles, including several mitochondria with visible internal folds (cristae). The cytoplasm is filled with a network of endoplasmic reticulum and other smaller organelles. The overall structure is highly organized and complex.

**EUKARYOTE
CYTOLOGY**

E

MITOCHONDRION

A red arrow originates from the 'MITOCHONDRION' label and points to a specific mitochondrion in the lower-left quadrant of the image.

**MITOCHONDRION
EVOLUTION**

An electron micrograph showing a cross-section of a cell. A large, centrally located nucleus is visible, surrounded by a nuclear envelope. Several mitochondria are scattered throughout the cytoplasm, characterized by their bean-like shape and internal folds called cristae. A red arrow points from a label to one of these mitochondria. The overall image is in grayscale, typical of electron microscopy.

**EUKARYOTE
CYTOLOGY**

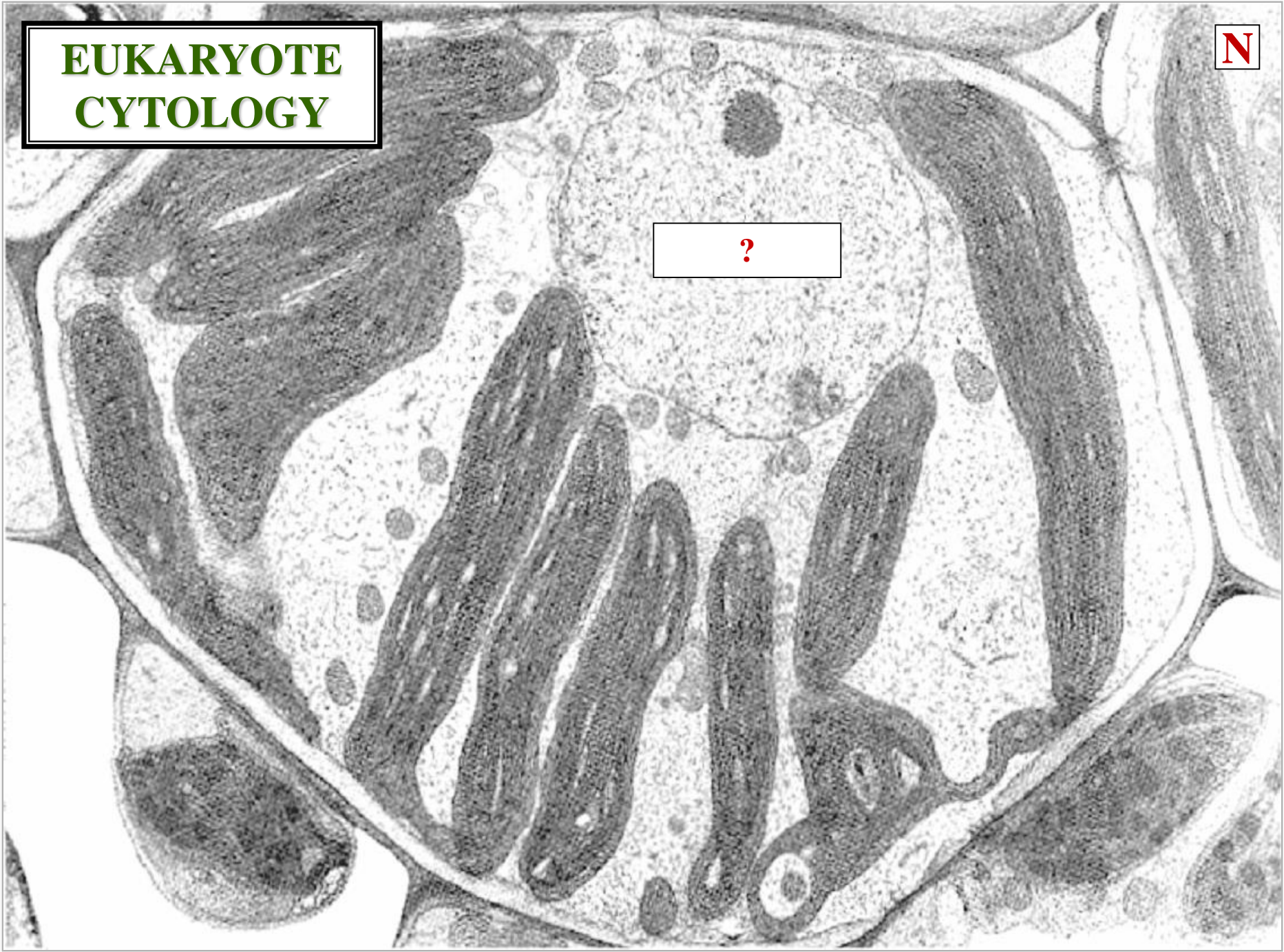
MITOCHONDRION

**ENDOSYMBIOTIC
THEORY**

EUKARYOTE CYTOLOGY

N

?





**EUKARYOTE
CYTOLOGY**

A

NUCLEUS

**NUCLEUS
EVOLUTION**

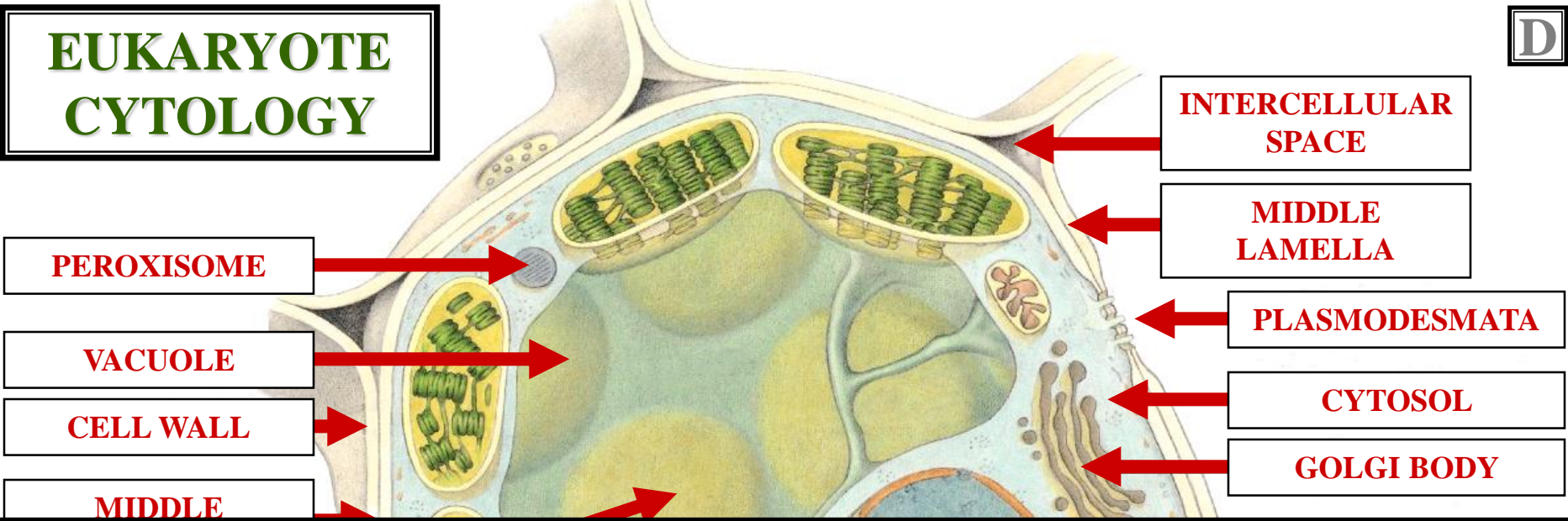


**EUKARYOTE
CYTOLOGY**

NUCLEUS

**AUTOGENOUS
THEORY**

EUKARYOTE CYTOLOGY



PEROXISOME

VACUOLE

CELL WALL

MIDDLE

INTERCELLULAR SPACE

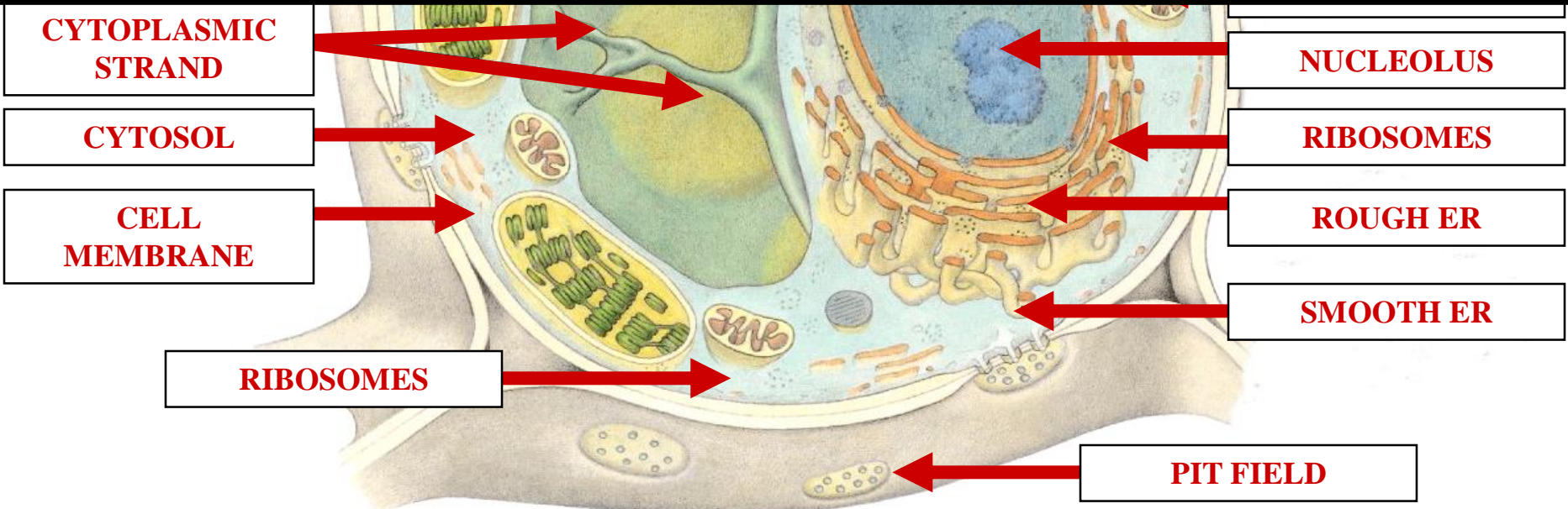
MIDDLE LAMELLA

PLASMODESMATA

CYTOSOL

GOLGI BODY

SUMMARY



CYTOPLASMIC STRAND

CYTOSOL

CELL MEMBRANE

RIBOSOMES

NUCLEOLUS

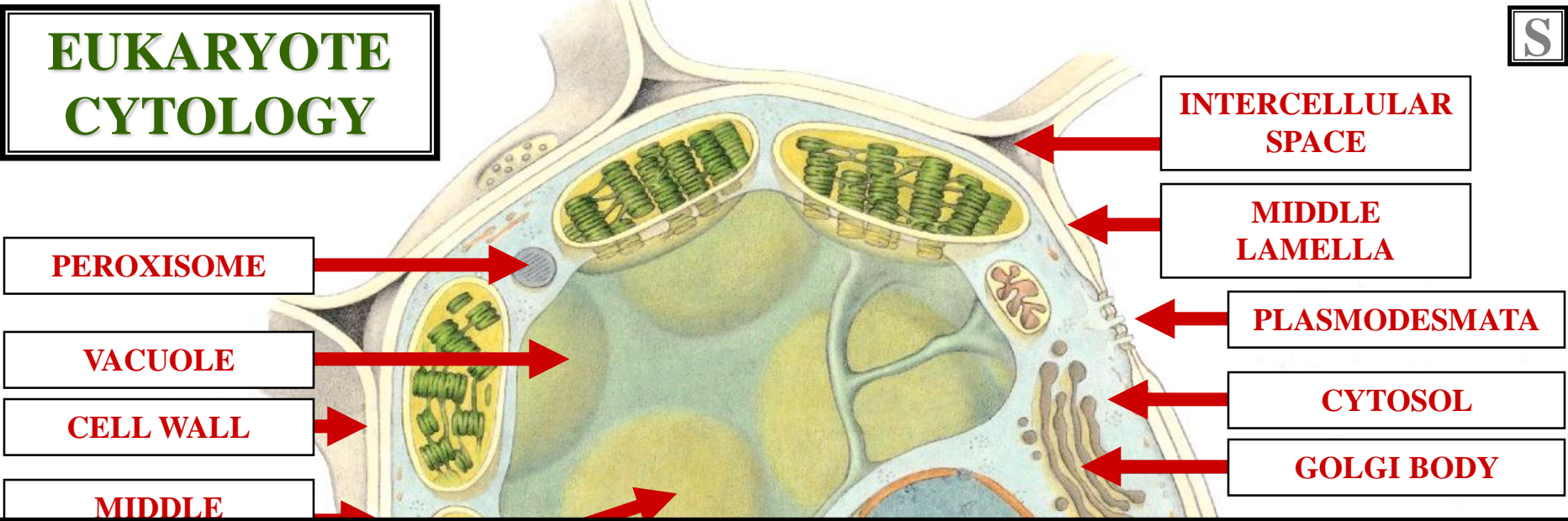
RIBOSOMES

ROUGH ER

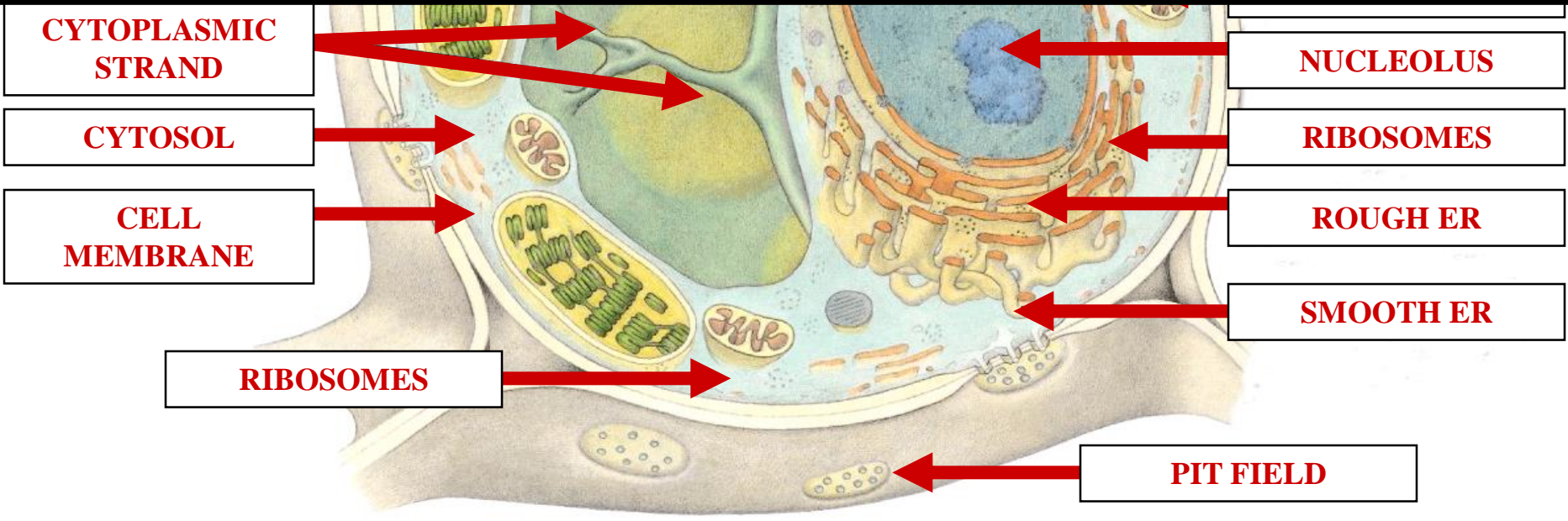
SMOOTH ER

PIT FIELD

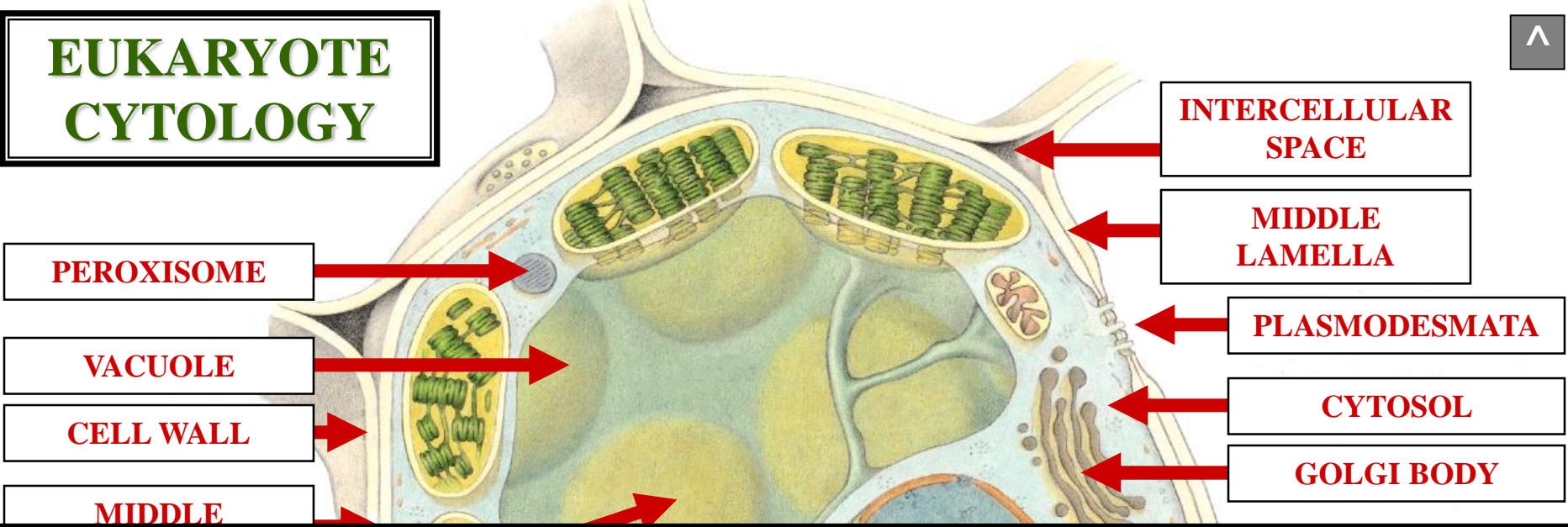
EUKARYOTE CYTOLOGY



DOUBLE-MB ORGANELLES



EUKARYOTE CYTOLOGY



INTERCELLULAR SPACE

MIDDLE LAMELLA

PLASMODESMATA

CYTOSOL

GOLGI BODY

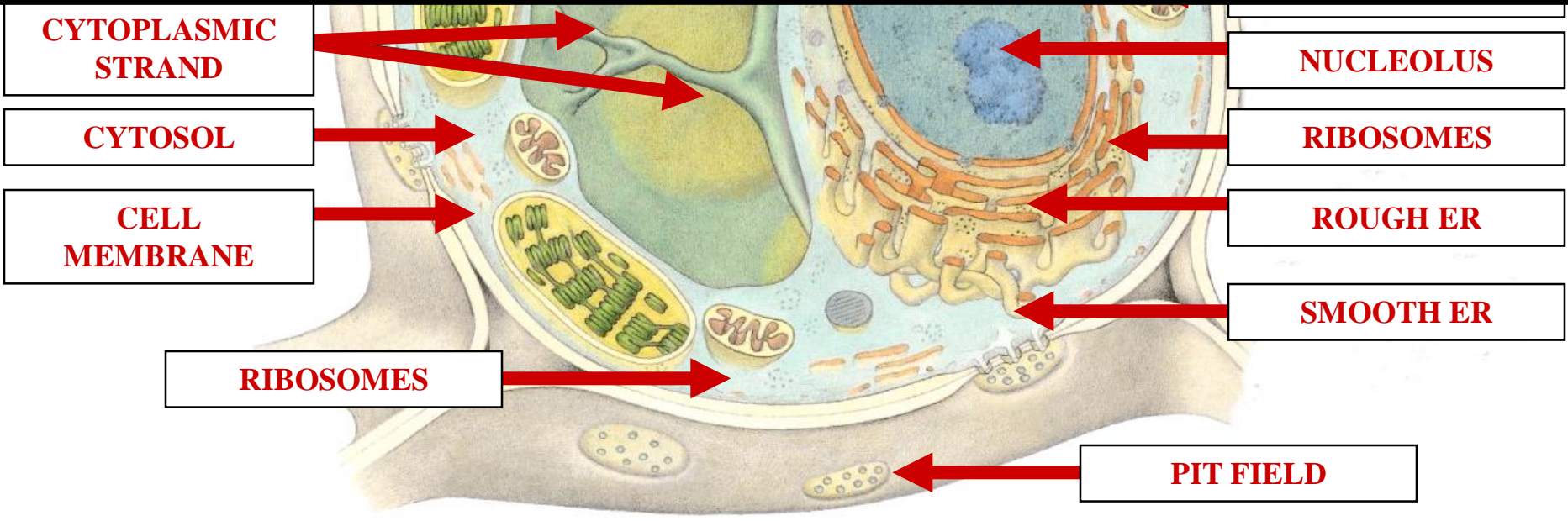
PEROXISOME

VACUOLE

CELL WALL

MIDDLE

SINGLE-MB ORGANELLE



CYTOPLASMIC STRAND

CYTOSOL

CELL MEMBRANE

RIBOSOMES

NUCLEOLUS

RIBOSOMES

ROUGH ER

SMOOTH ER

PIT FIELD



**SINGLE
MEMBRANE
BOUND
ORGANELLE**

VACUOLE

VACUOLE

VACUOLE



PLANT CELLS ONLY

VACUOLE