Membrane Biochemistry

Lectures by

John F. Allen

School of Biological and Chemical Sciences, Queen Mary, University of London

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Lectures in Membrane Biochemistry by John F. Allen

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Lectures in Membrane Biochemistry

- The endomembrane system - endocytosis and exocytosis (Acrobat, .pdf file)
- The endomembrane system - vesicular transport and protein trafficking (Acrobat, .pdf file)
- Transport across membranes 1 - Proteins (Acrobat, .pdf file)
- Transport across membranes 2 - Small molecules and ions (Acrobat, .pdf file)

Course web pages

Membrane Biochemistry web pages

General reference

Cell and Molecular Biology: Concepts and Experiments
Gerald Karp. Fifth Edition 2008. John Wiley & Sons Inc.

Membrane Biochemistry

The respiratory chain

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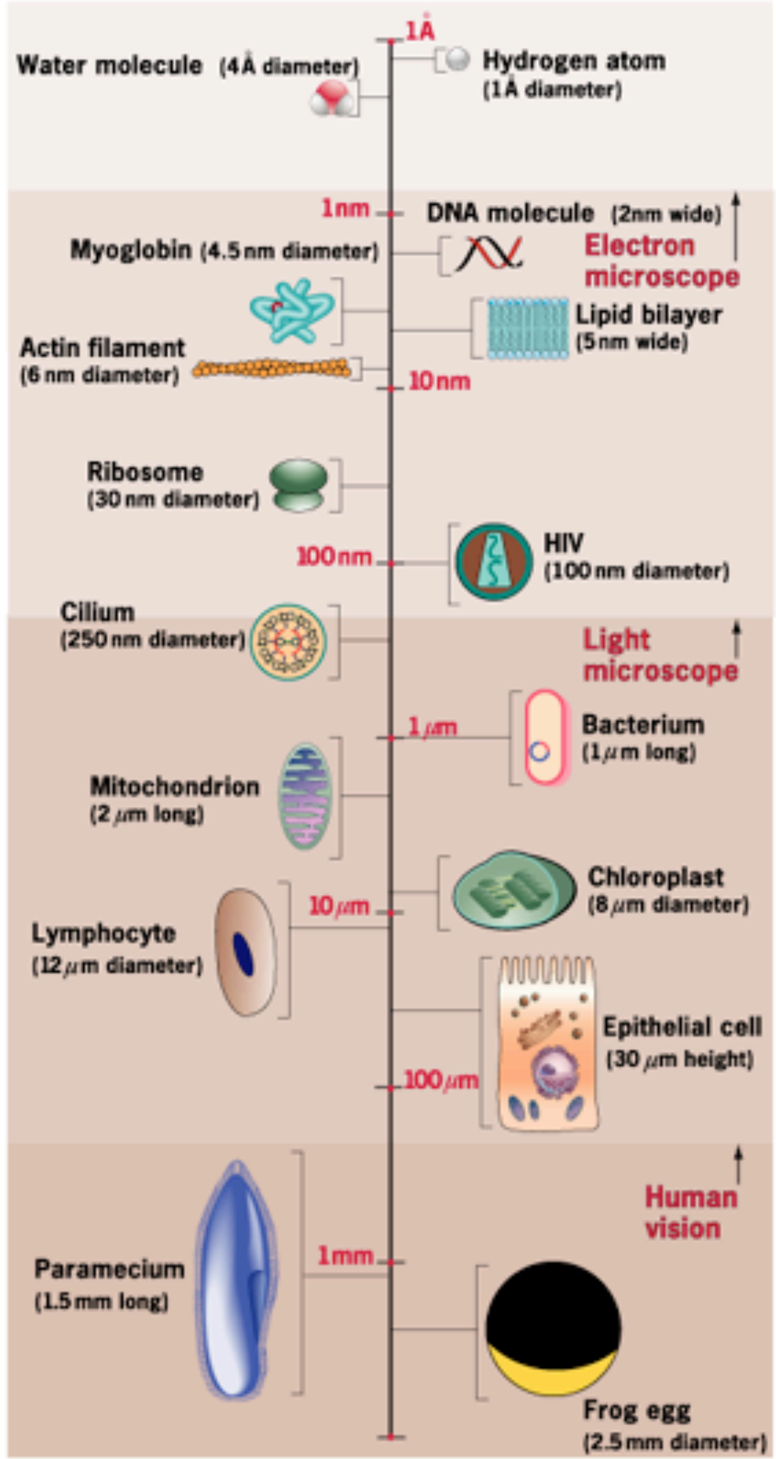
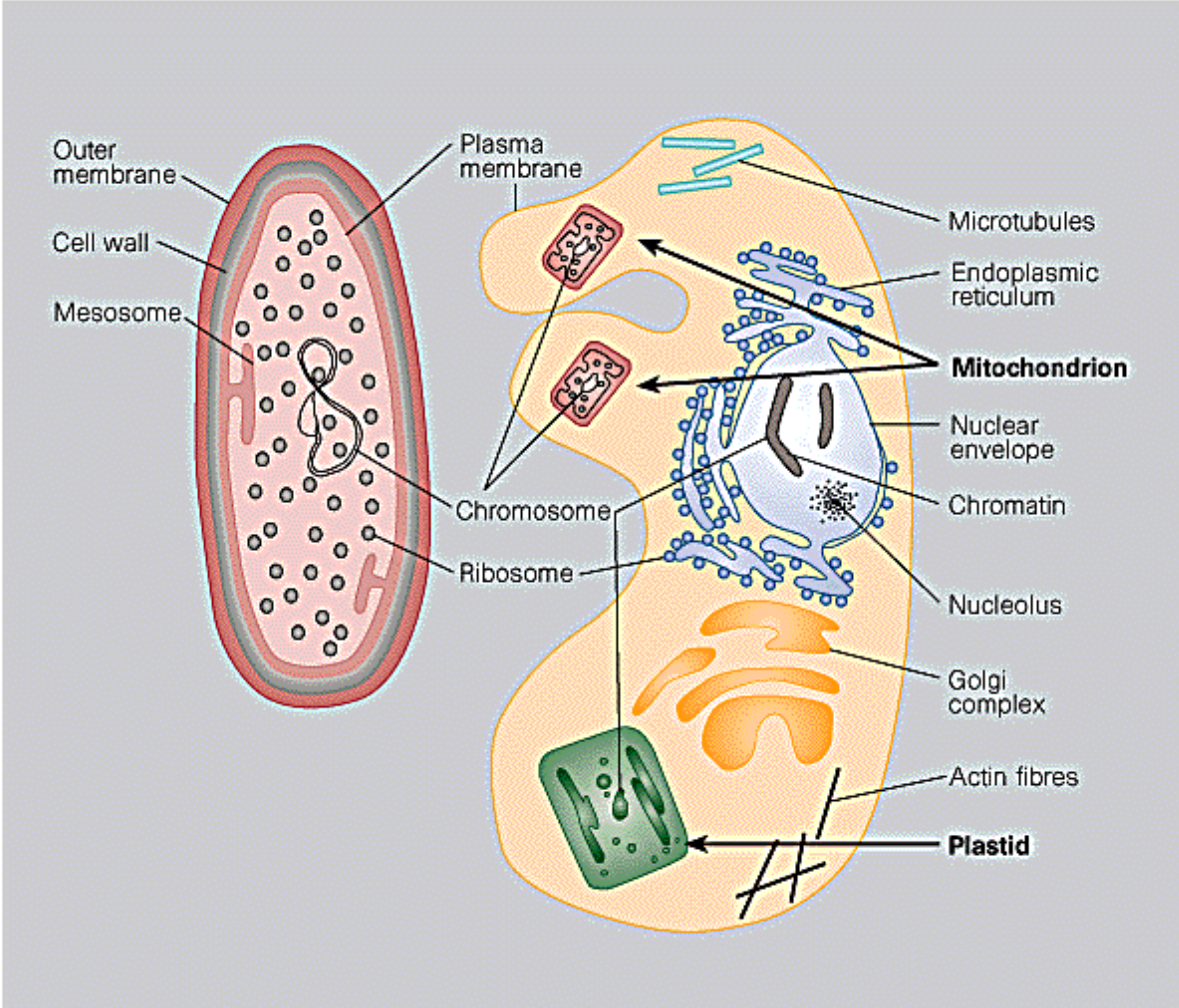
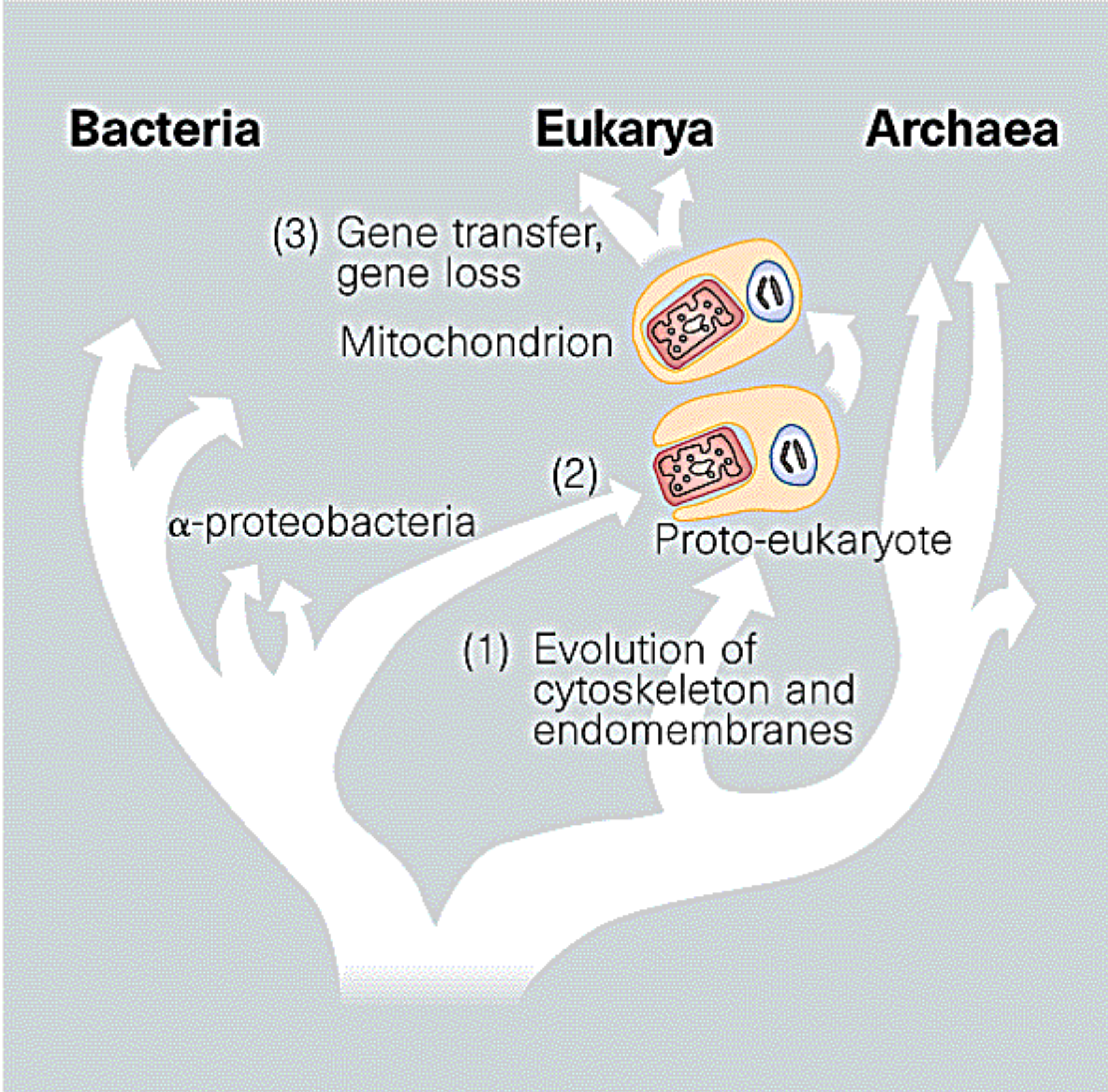


Figure 1.21 Relative sizes of cells and cell components.



Typical prokaryotic (left) and eukaryotic (right) cells.

W. Ford Doolittle *Nature* **392,** 15-16, 1998



The endosymbiont hypothesis for the origin of mitochondria.

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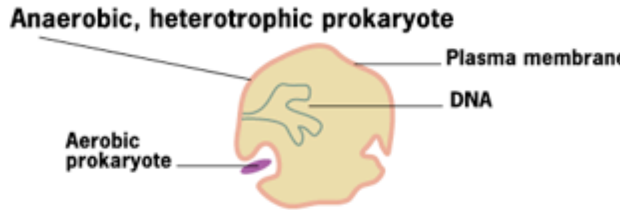
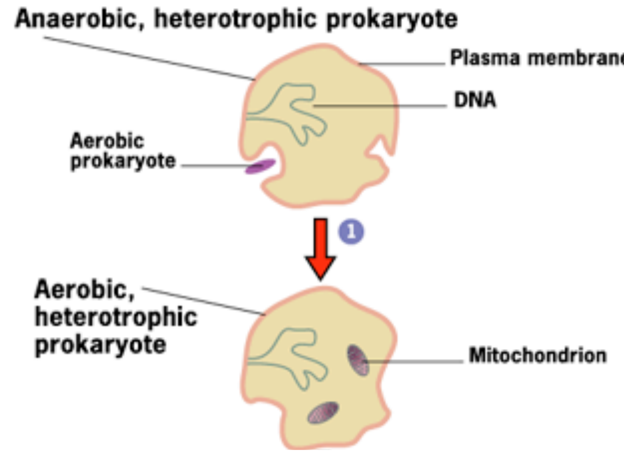
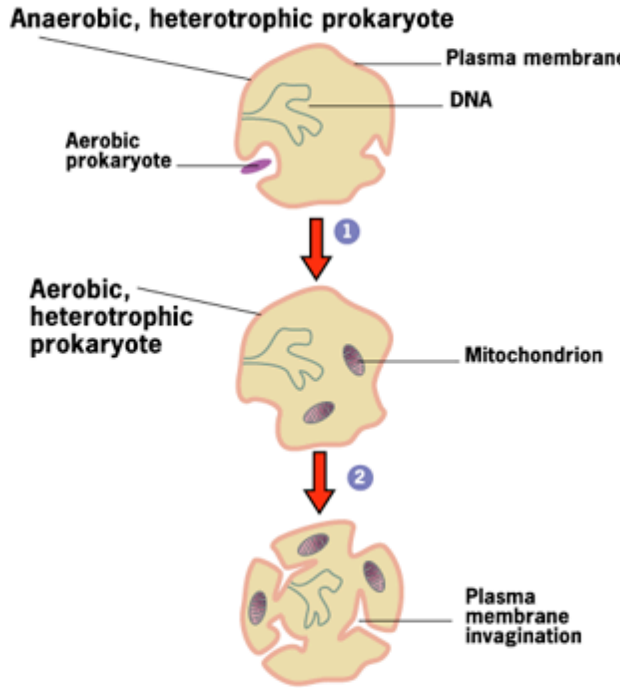
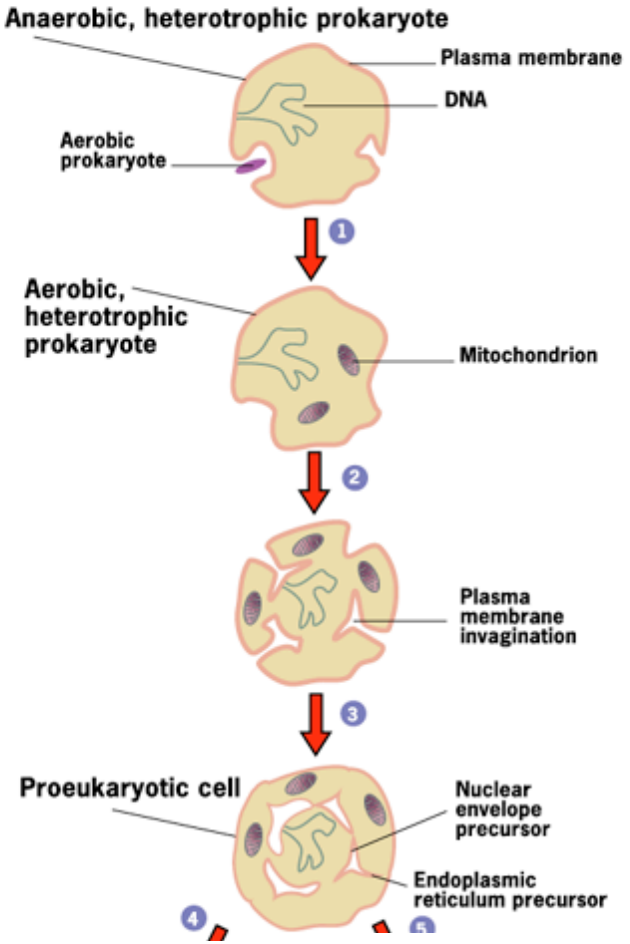
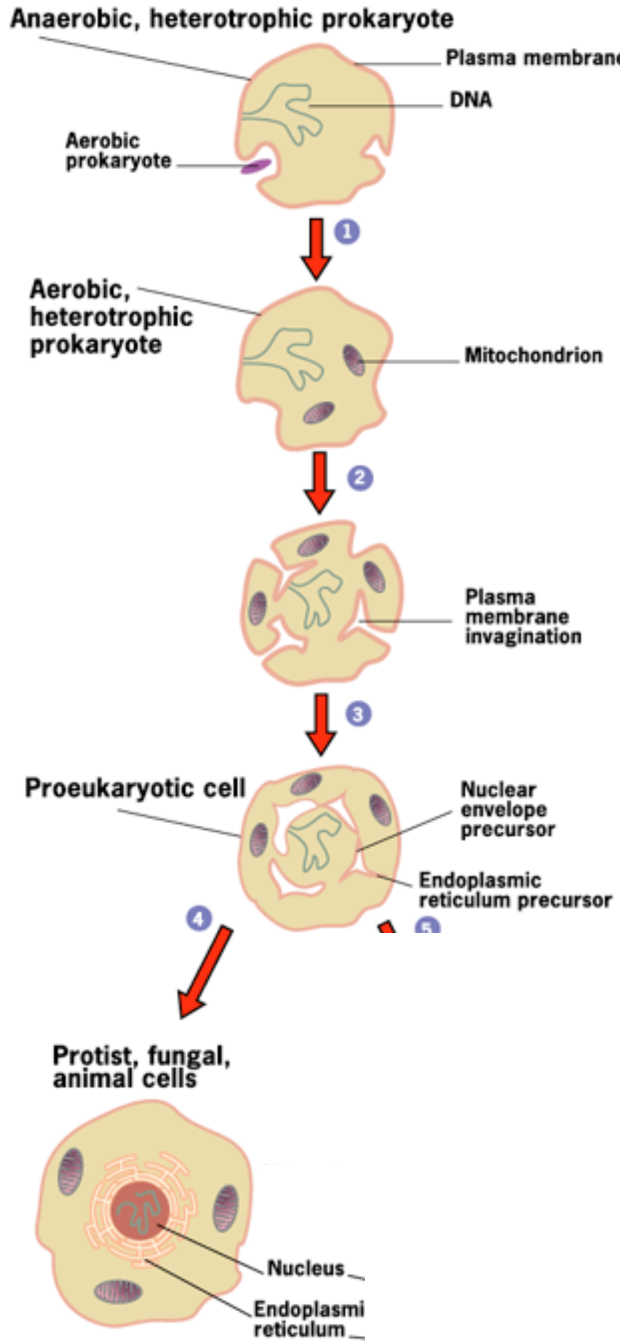


Anaerobic, heterotrophic prokaryote
Plasma membrane
DNA
Aerobic
prokaryote


Anaerobic, heterotrophic prokaryote
Plasma membrane
DNA
Aerobic prokaryote
1
Aerobic, heterotrophic prokaryote
Mitochondrion


Anaerobic, heterotrophic prokaryote
Plasma membrane
DNA
Aerobic
prokaryote
1
Aerobic,
heterotrophic
prokaryote
Mitochondrion
2
Plasma
membrane
invagination


Anaerobic, heterotrophic prokaryote
Plasma membrane
DNA
Aerobic prokaryote
Aerobic, heterotrophic prokaryote
Mitochondrion
Plasma membrane invagination
Proeukaryotic cell
Nuclear envelope precursor
Endoplasmic reticulum precursor
1
2
3
4
5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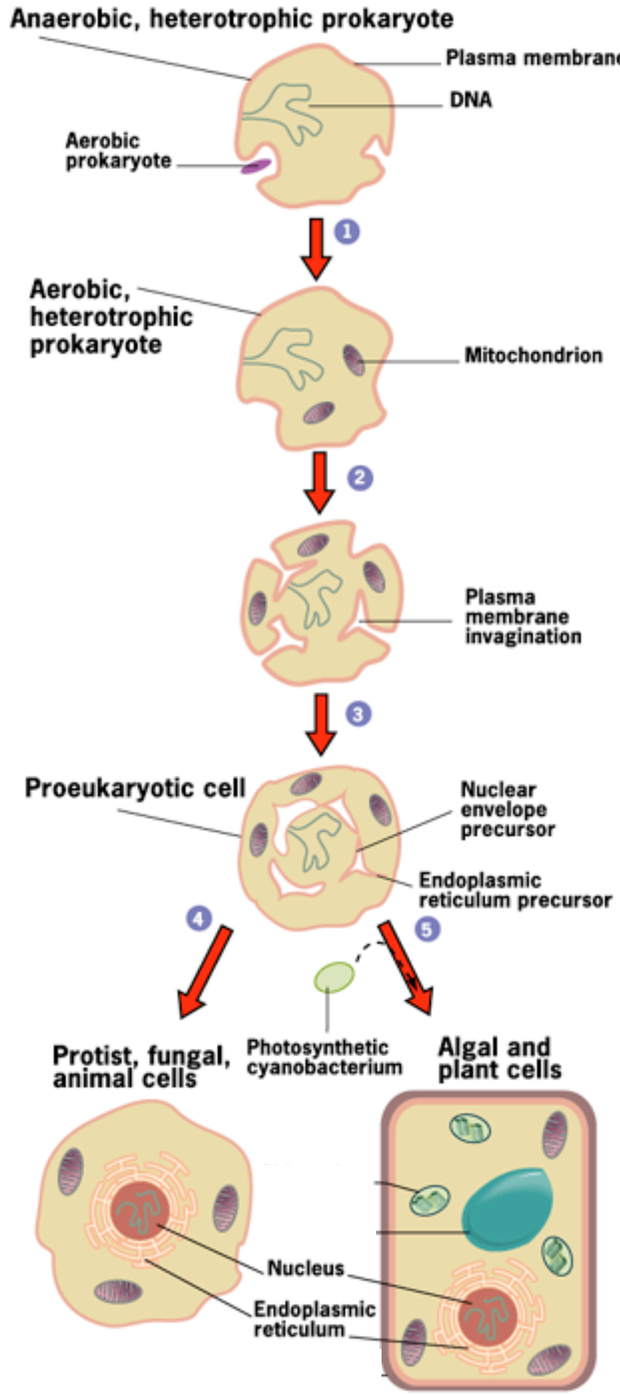
Proeukaryotic cell
Nuclear envelope precursor
Endoplasmic reticulum precursor
Protist, fungal, animal cells
Nucleus
Endoplasmi
reticulum


Anaerobic, heterotrophic prokaryote
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Mitochondrion
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Plasma membrane invagination
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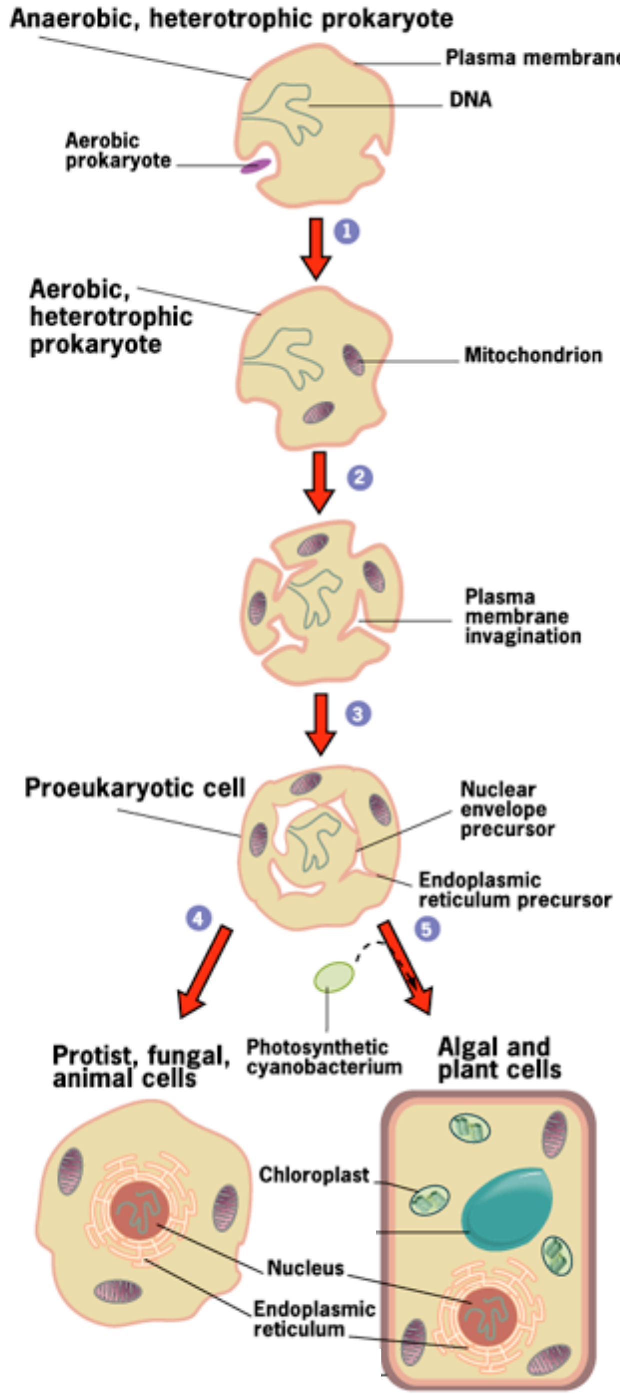
Proeukaryotic cell
Nuclear envelope precursor
Endoplasmic reticulum precursor
4
5
Protist, fungal, animal cells
Photosynthetic cyanobacterium
Algal and plant cells
Nucleus
Endoplasmic reticulum



Anaerobic, heterotrophic prokaryote
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Aerobic, heterotrophic prokaryote
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Proeukaryotic cell
Nuclear envelope precursor
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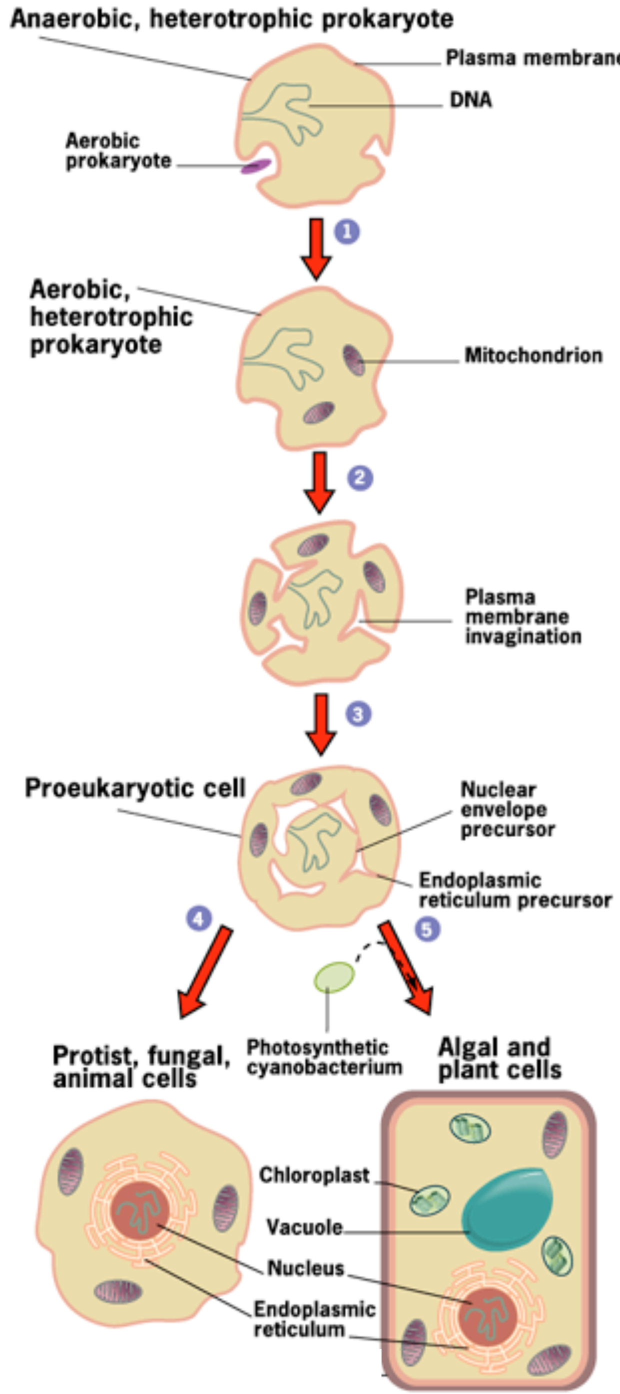
Photosynthetic cyanobacterium
Protist, fungal, animal cells
Algal and plant cells
Chloroplast
Nucleus
Endoplasmic reticulum


Anaerobic, heterotrophic prokaryote
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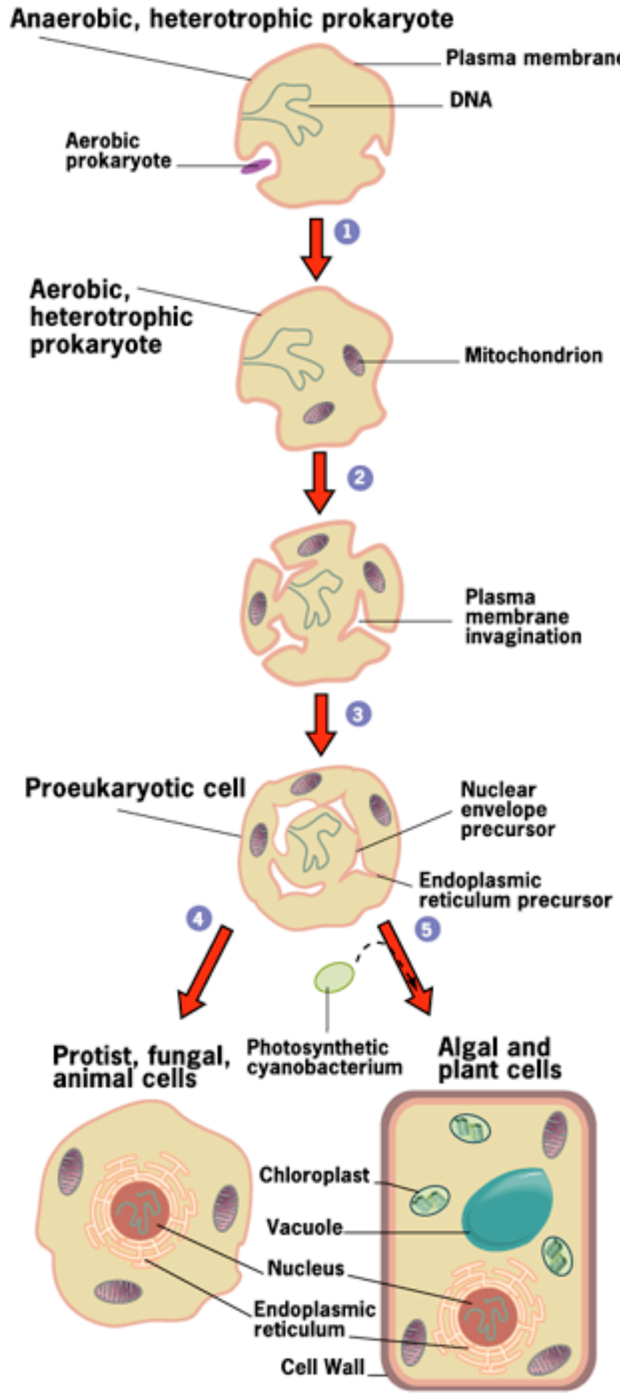

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Plasma membrane
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Protist, fungal, animal cells
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Chloroplast
Vacuole
Nucleus
Endoplasmic reticulum
Cell Wall

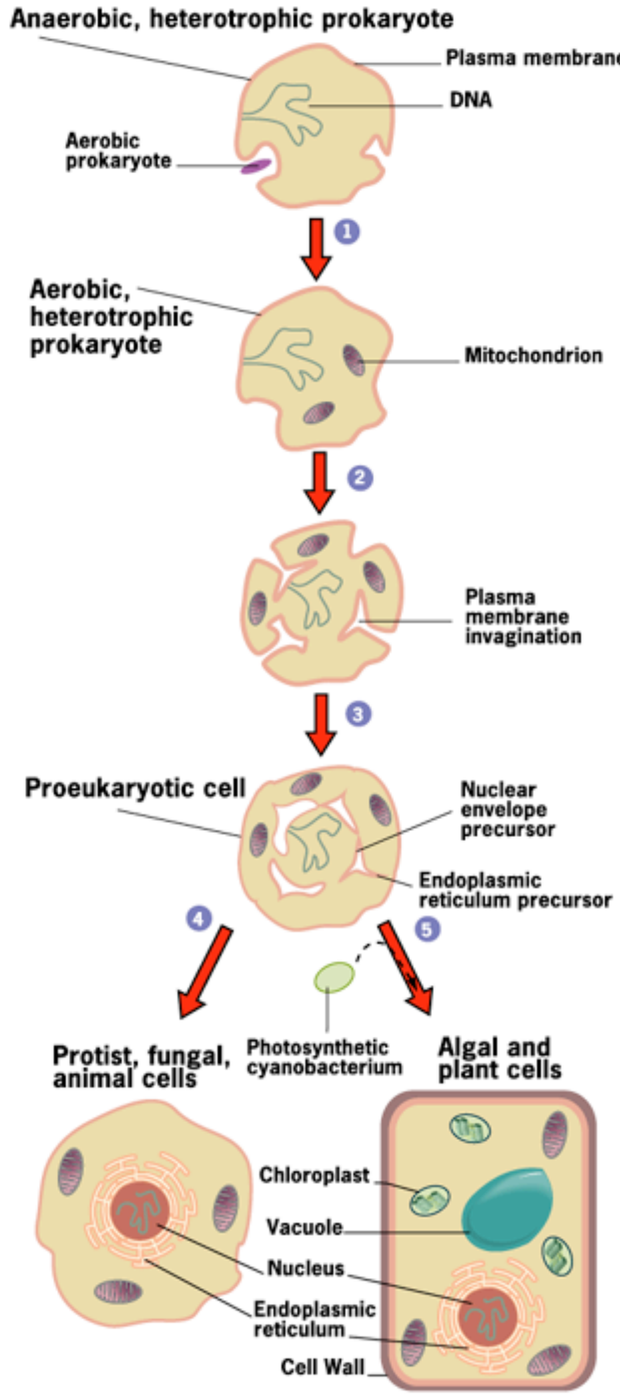

Figure EP.1 A model depicting possible steps in the evolution of eukaryotic cells, including the origin of mitochondria and chloroplasts by endosymbiosis.

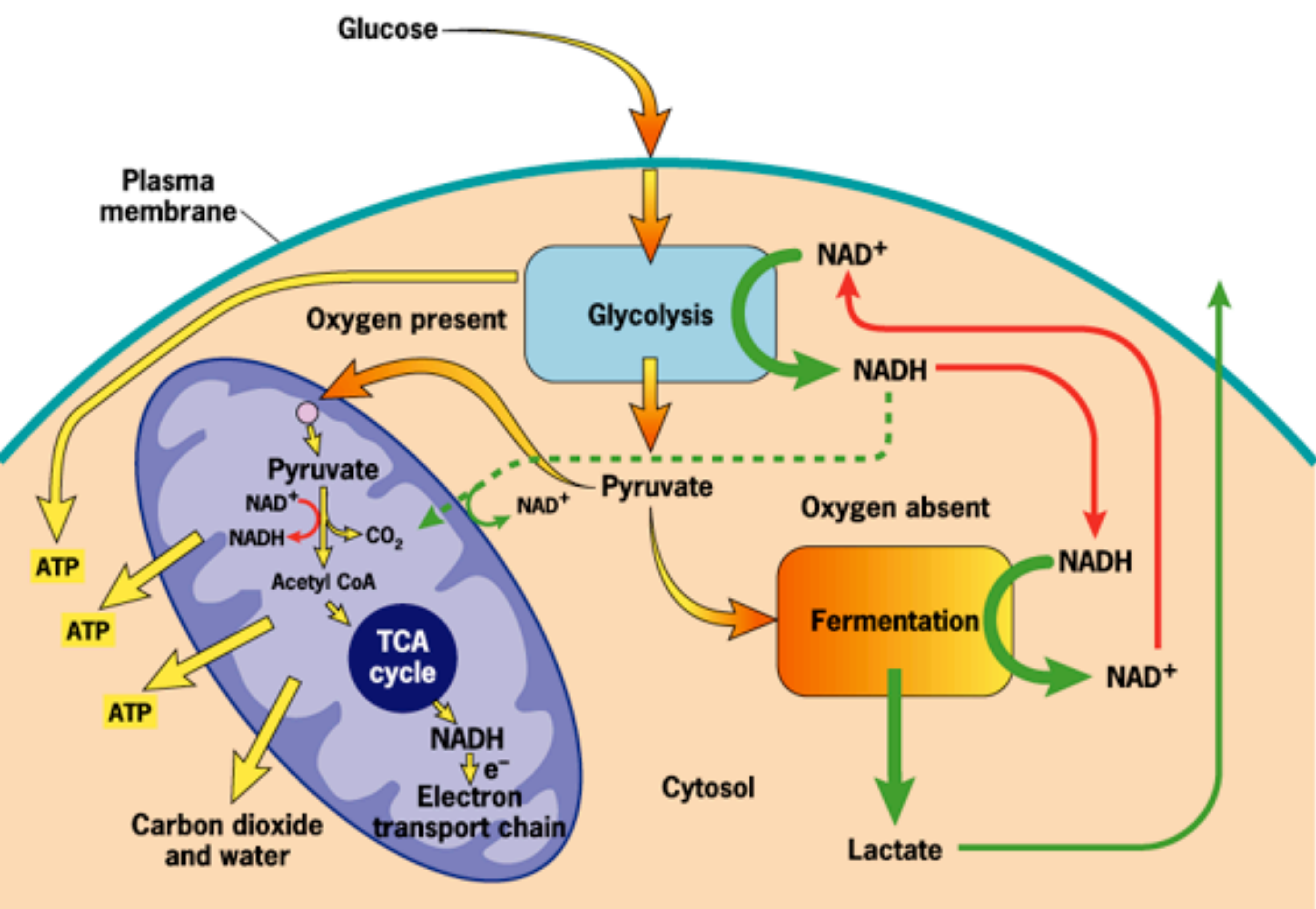

Figure 5.5 An overview of carbohydrate metabolism in eukaryotic cells.

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http://www.wiley.com/college/karp/CL_EWSTU01546_S/animations/chapter05_animation_02_files/chapter05_Animation_02.swf

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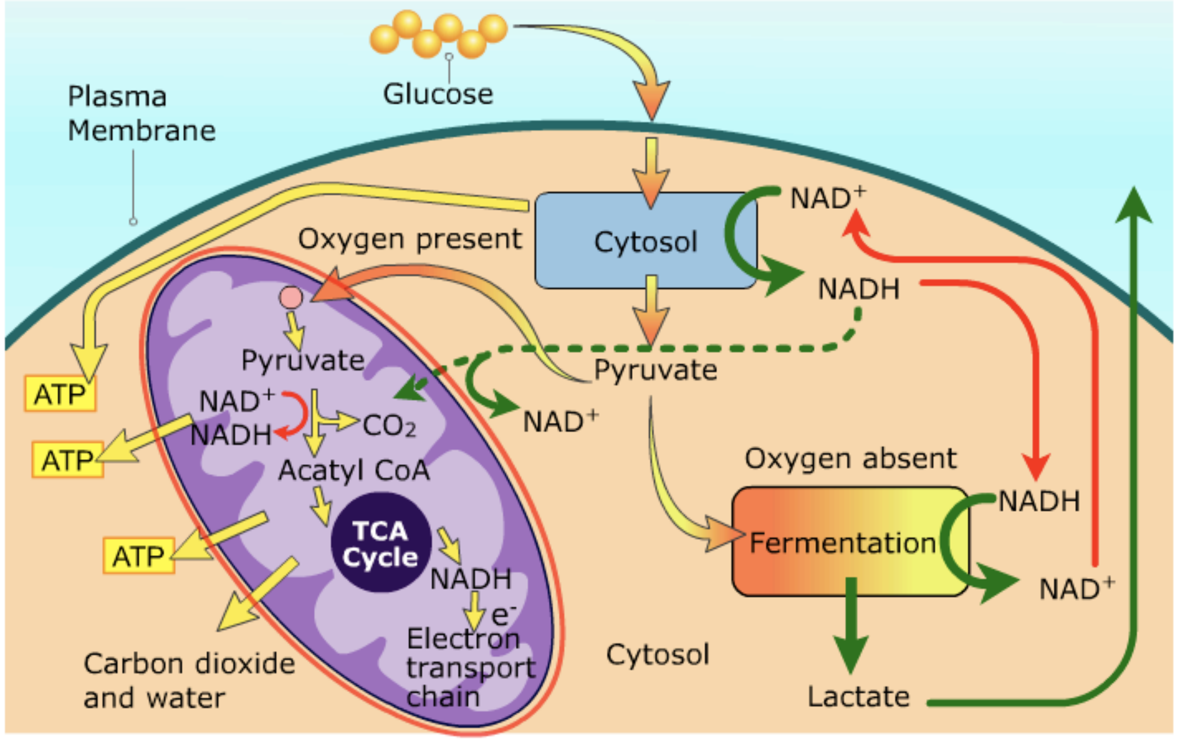
Aerobic Respiration

Glycolysis converts glucose (C6) into two molecules of pyruvate (C3). If oxygen is present, pyruvate enters mitochondria and its free energy is utilized to make ATP via the TCA cycle and oxidative phosphorylation.



Click the mitochondrion to examine the TCA cycle and oxidative phosphorylation.

Step 01 of 03

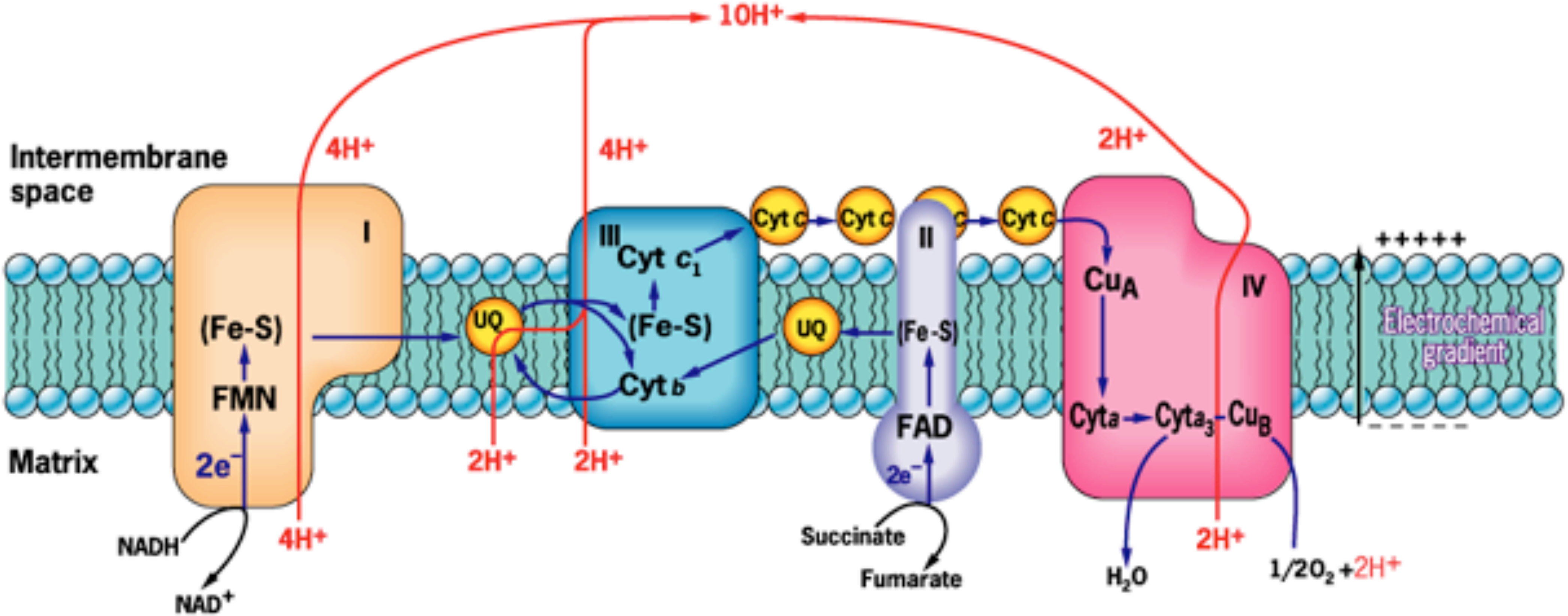
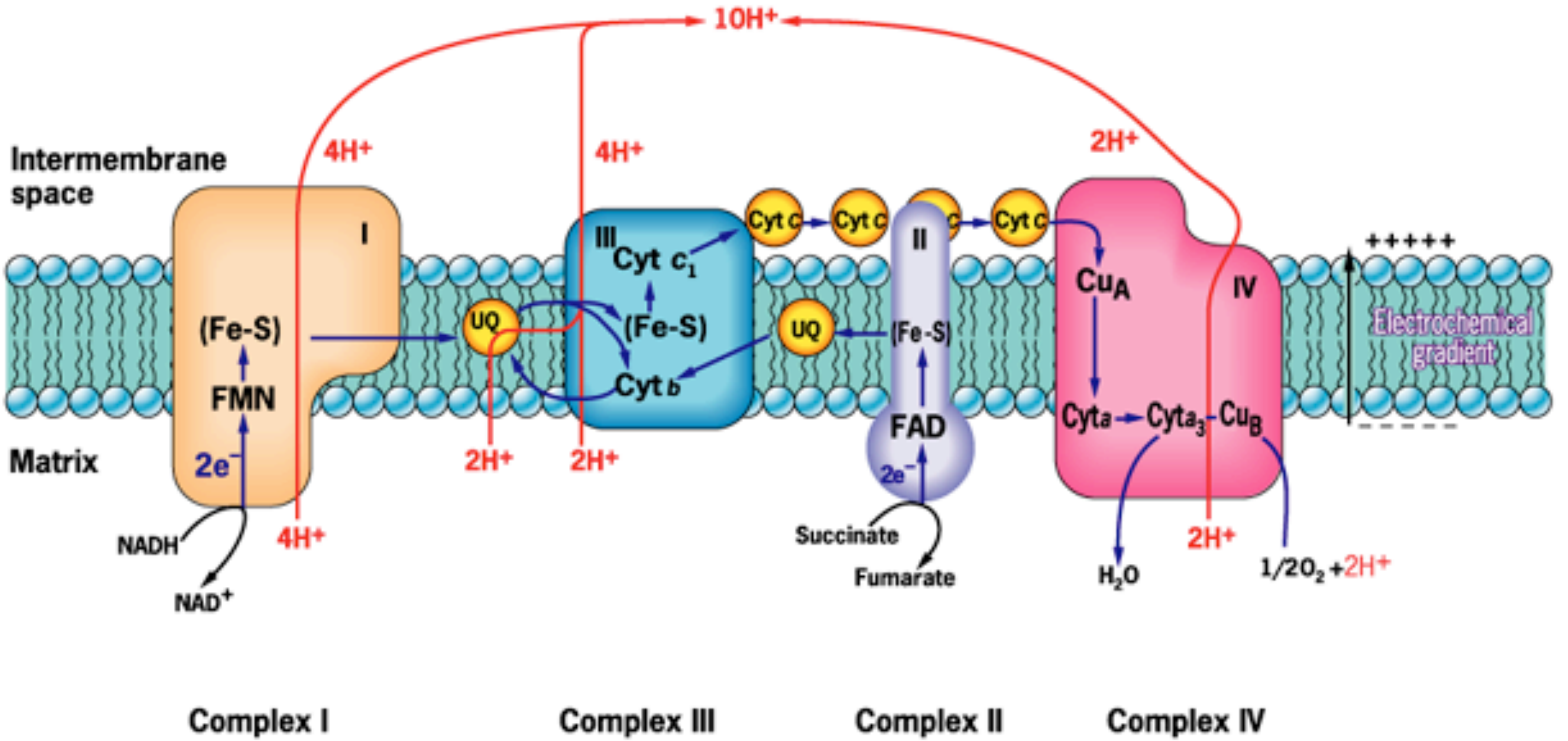


Figure 5.16 Schematic diagram of the components of the electron-transport chain within the inner mitochondrial membrane.



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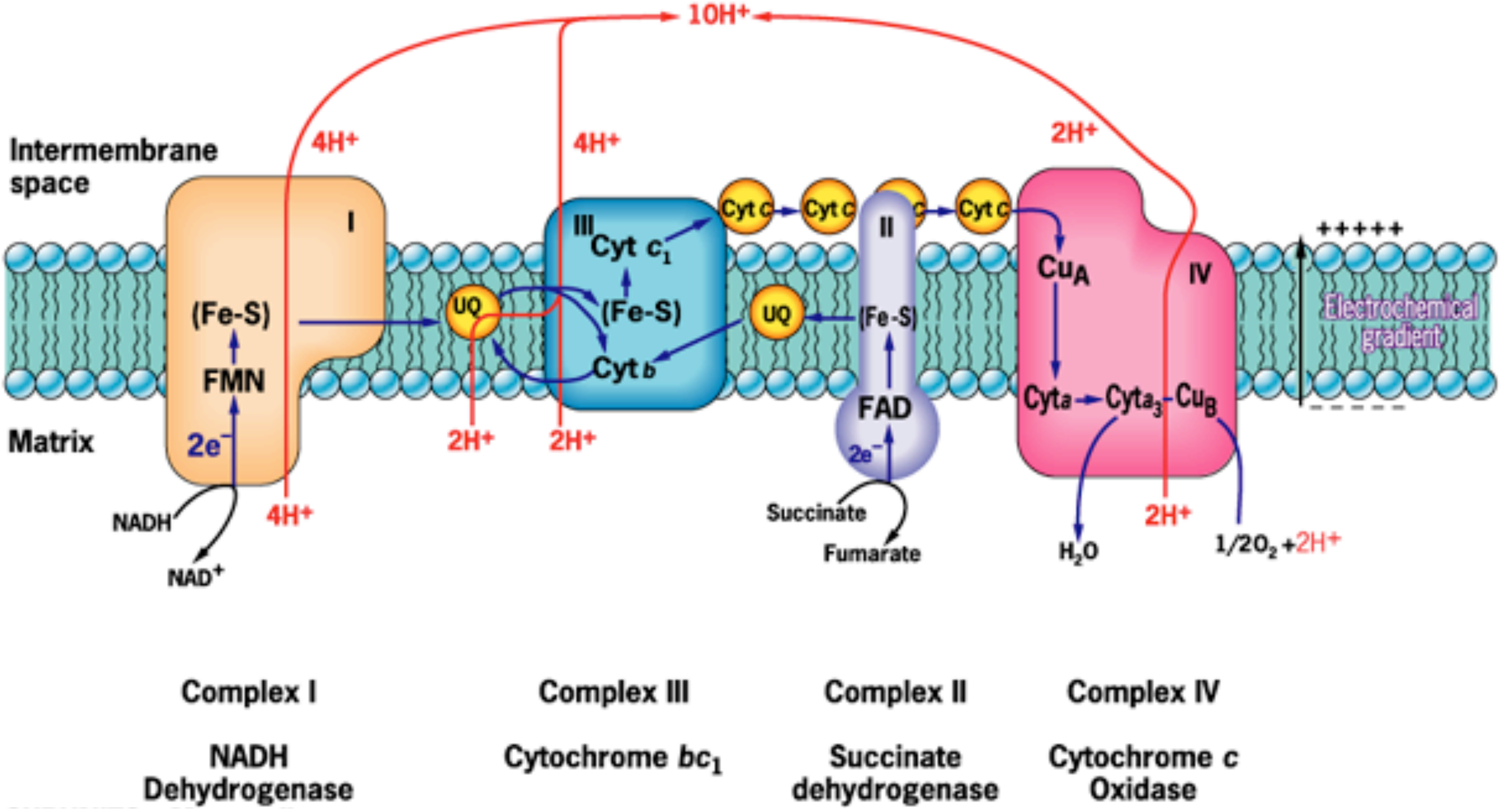

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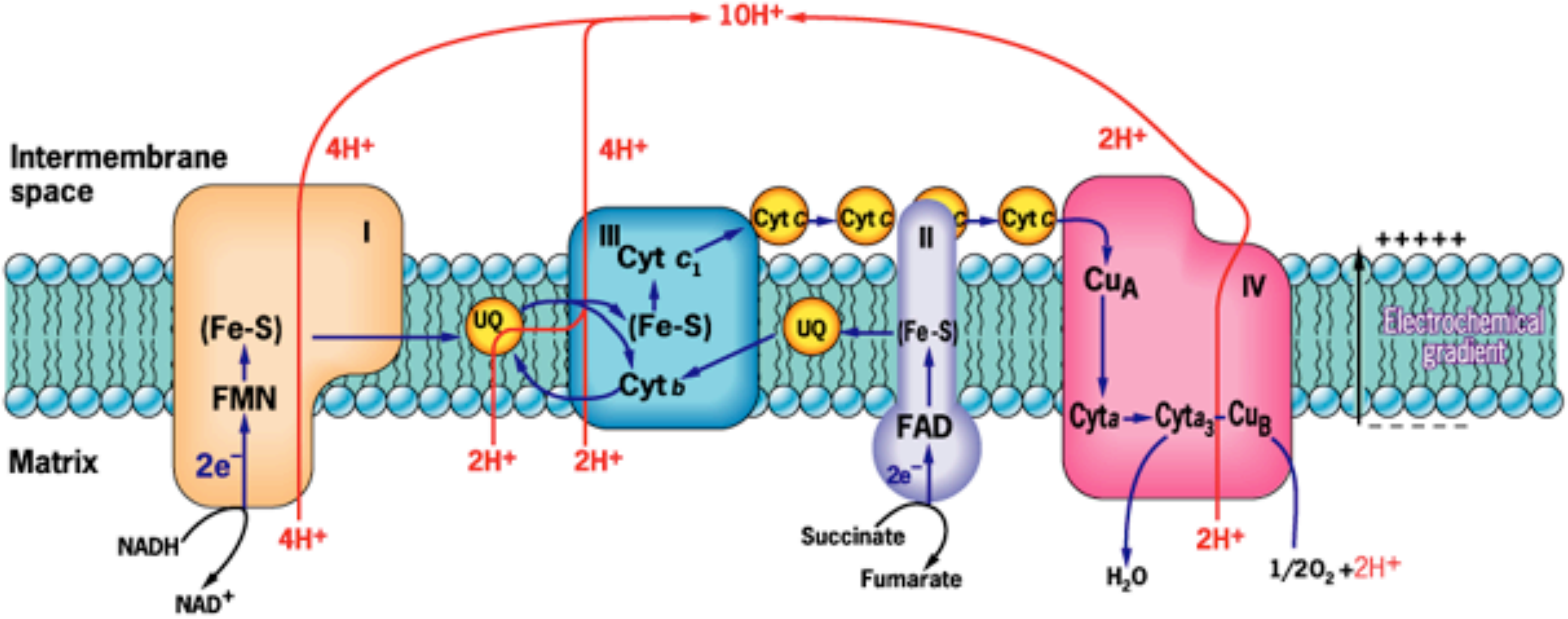
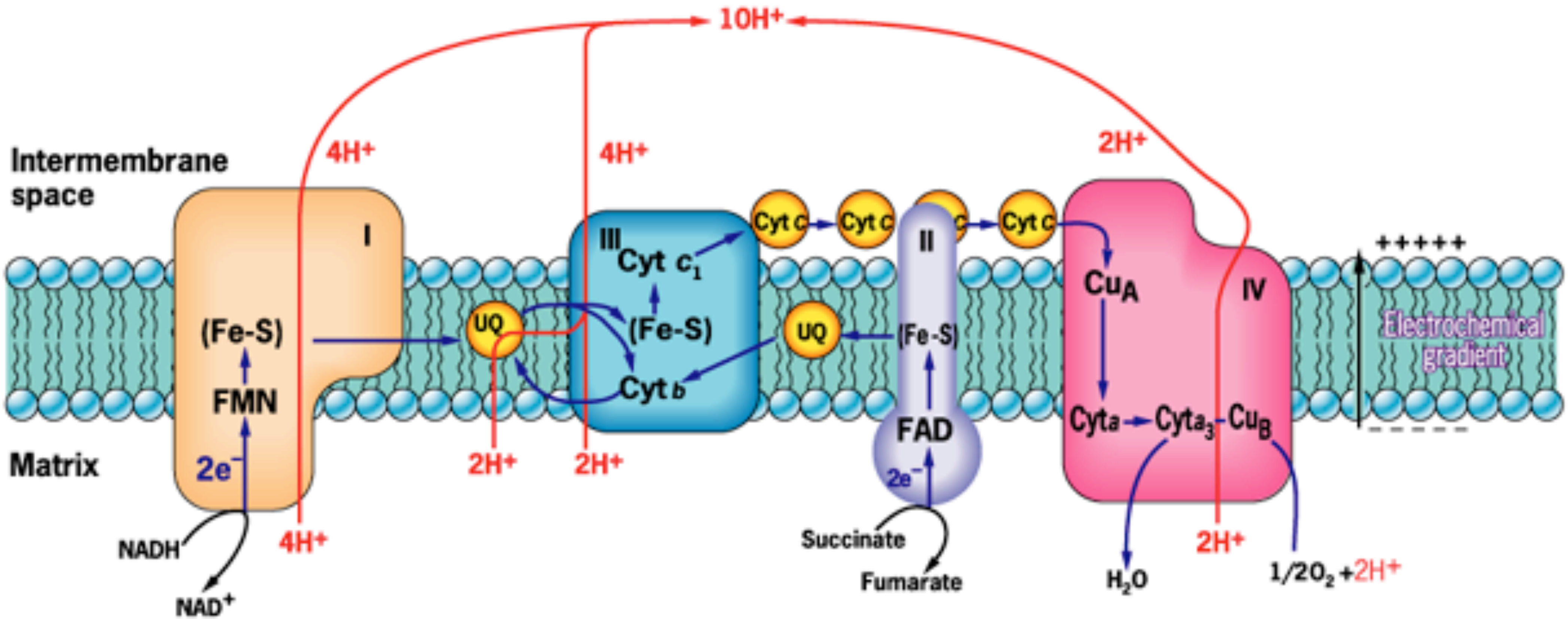


Complex I	Complex III	Complex II	Complex IV
NADH Dehydrogenase	Cytochrome bc_1	Succinate dehydrogenase	Cytochrome *c* Oxidase

SUBUNITS

mtDNA
nDNA
TOTAL

Figure 5.16 Schematic diagram of the components of the electron-transport chain within the inner mitochondrial membrane.



SUBUNITS	Complex I NADH Dehydrogenase Mammalian	Complex III Cytochrome bc_1	Complex II Succinate dehydrogenase	Complex IV Cytochrome c Oxidase
mtDNA	7			
nDNA	35			
TOTAL	42			

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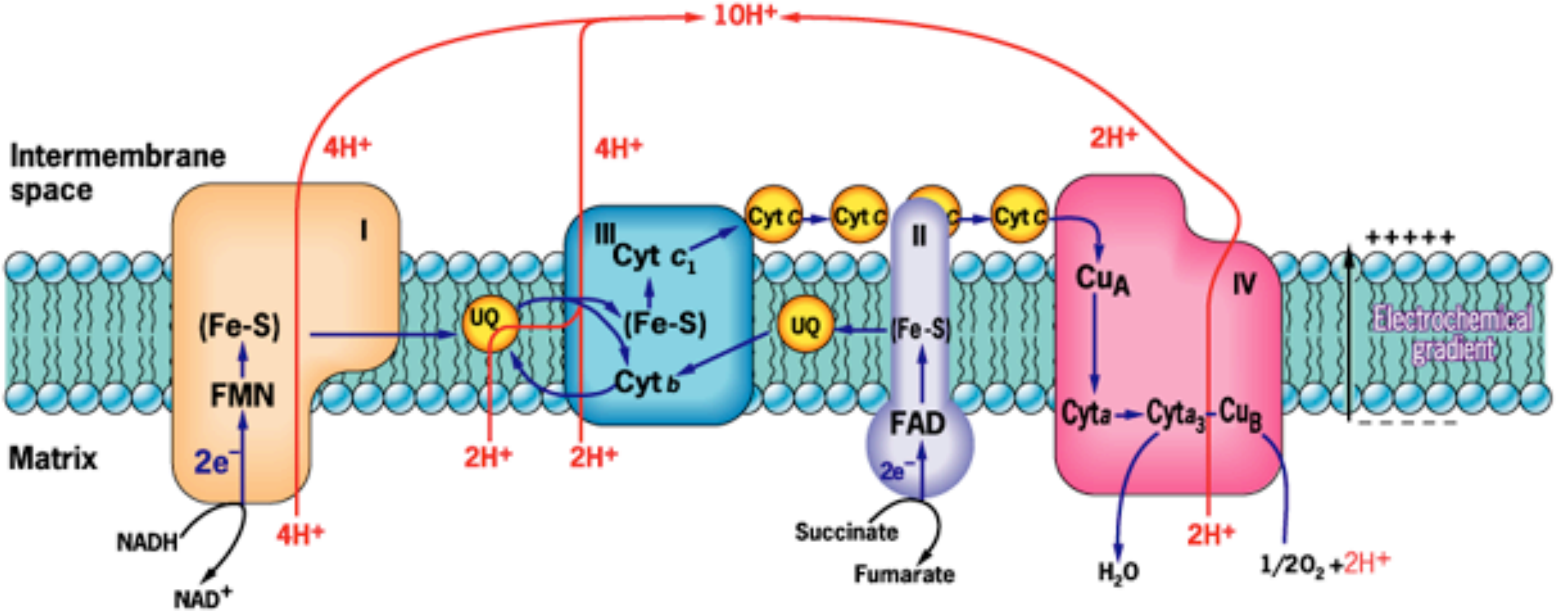
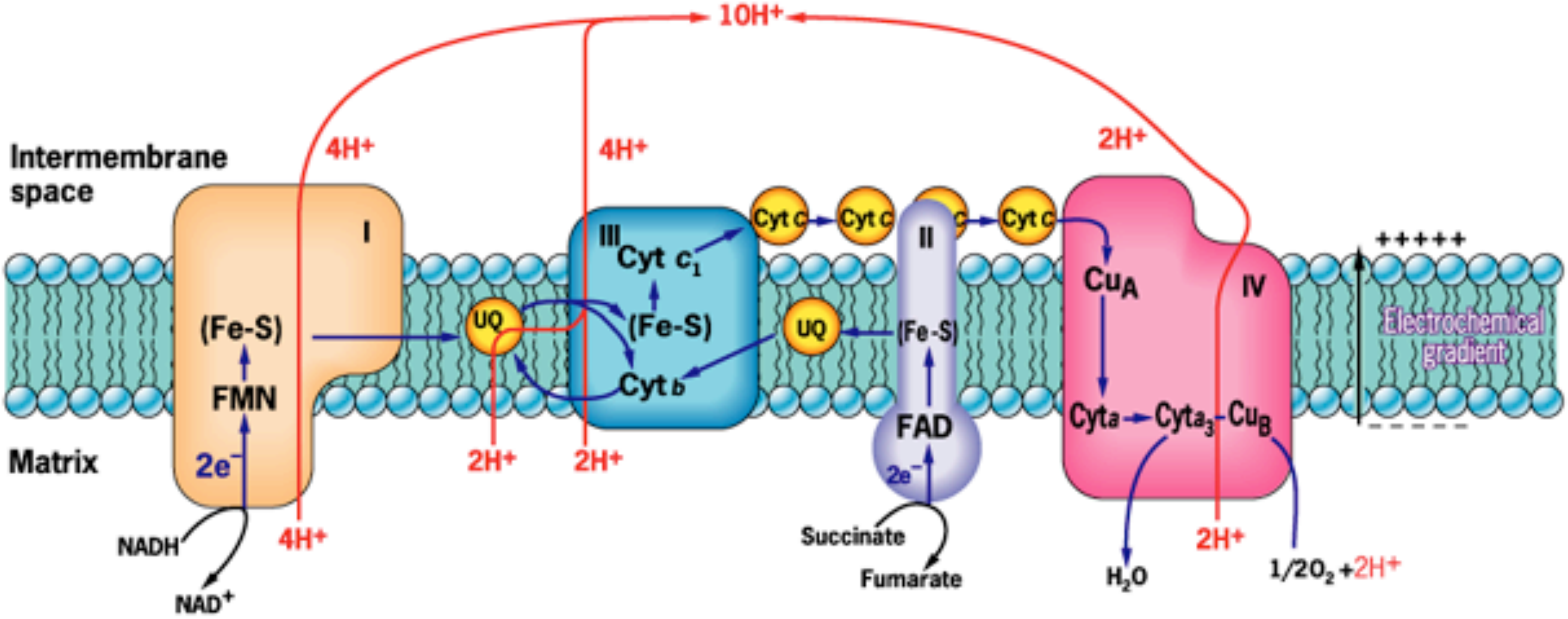


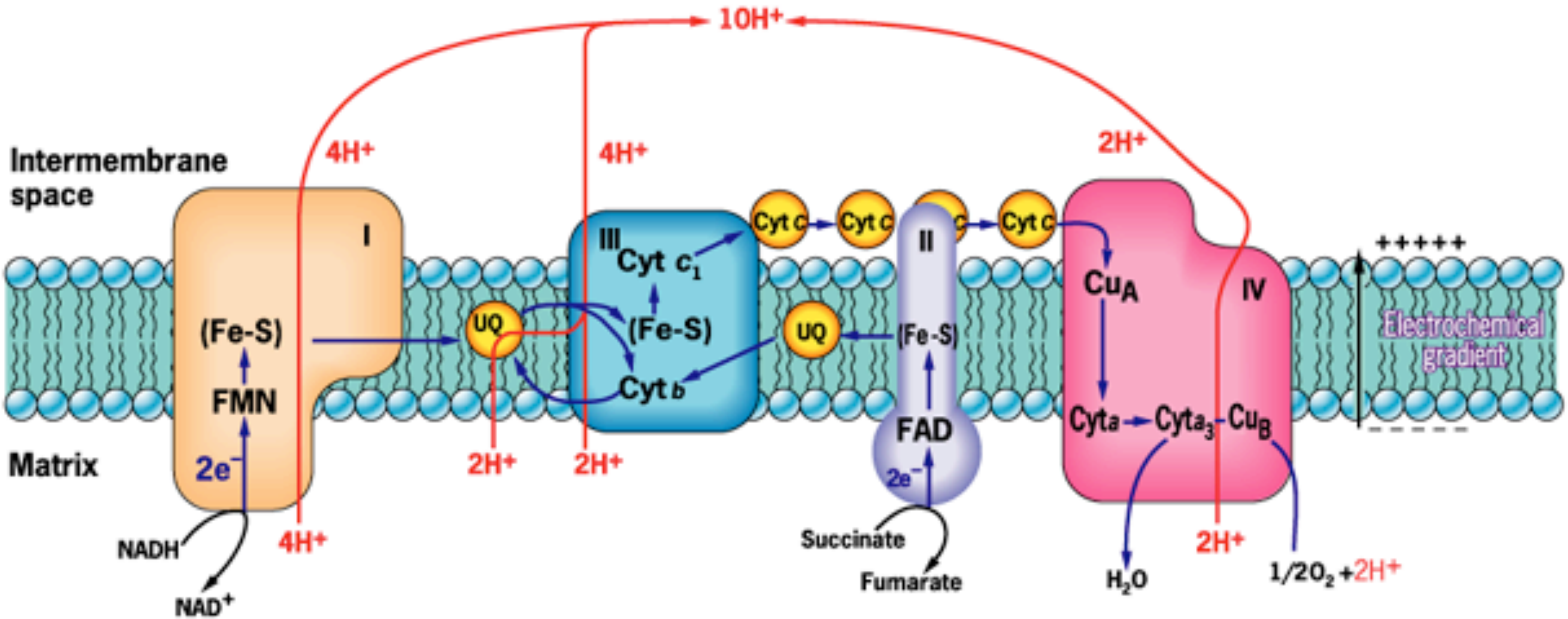
SUBUNITS	Complex I NADH Dehydrogenase Mammalian	Complex III Cytochrome bc_1	Complex II Succinate dehydrogenase	Complex IV Cytochrome *c* Oxidase
mtDNA	7	1		
nDNA	35	10		
TOTAL	42	11		

Figure 5.16 Schematic diagram of the components of the electron-transport chain within the inner mitochondrial membrane.



SUBUNITS	Complex I NADH Dehydrogenase Mammalian	Complex III Cytochrome bc_1	Complex II Succinate dehydrogenase	Complex IV Cytochrome *c* Oxidase
mtDNA	7	1	0	
nDNA	35	10	4	
TOTAL	42	11	4	

Figure 5.16 Schematic diagram of the components of the electron-transport chain within the inner mitochondrial membrane.



SUBUNITS	Complex I NADH Dehydrogenase Mammalian	Complex III Cytochrome bc_1	Complex II Succinate dehydrogenase	Complex IV Cytochrome *c* Oxidase
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nDNA	35	10	4	10
TOTAL	42	11	4	13

Figure 5.16 Schematic diagram of the components of the electron-transport chain within the inner mitochondrial membrane.

Problem

Why Do Mitochondria and Chloroplasts Have Their Own Genetic Systems?

Problem

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Mitochondrial DNA is a relic of ancient history. It is a legacy from a single aerobic bacterium that took up residence in the cytoplasm of a primitive cell that ultimately became an ancestor of all eukaryotic cells. Most of the genes of this ancient symbiont were either lost or transferred over the course of evolution to the nucleus of the host cell, leaving only a handful of genes to encode some of the most hydrophobic proteins of the inner mitochondrial membrane.

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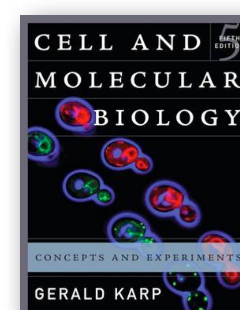

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Why do mitochondria and chloroplasts require their own separate genetic systems when other organelles that share the same cytoplasm, such as peroxisomes and lysosomes, do not? …. The reason for such a costly arrangement is not clear, and the hope that the nucleotide sequences of mitochondrial and chloroplast genomes would provide the answer has proved unfounded. We cannot think of compelling reasons why the proteins made in mitochondria and chloroplasts should be made there rather than in the cytosol.

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At one time, it was suggested that some proteins have to be made in the organelle because they are too hydrophobic to get to their site in the membrane from the cytosol. More recent studies, however, make this explanation implausible. In many cases, even highly hydrophobic subunits are synthesized in the cytosol.

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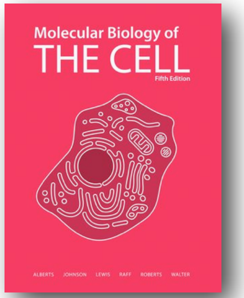
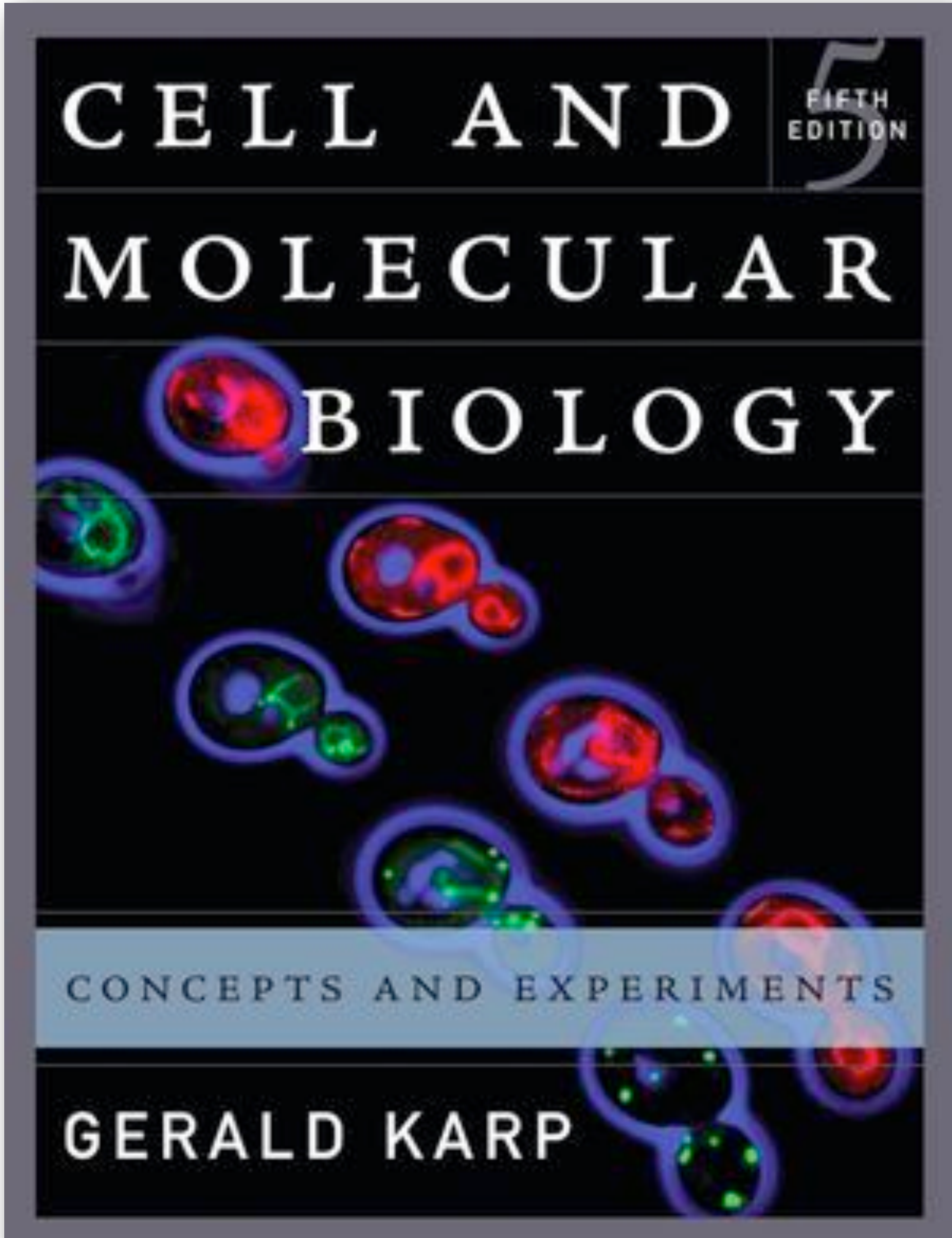


Molecular Biology of the Cell

Alberts B, Johnson A, Lewis J, Raff M, Roberts K, and Walter P Molecular Biology of the Cell. Fifth Edition. New York and London: Garland Science; 2007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BIOLOGY
CONCEPTS AND EXPERIMENTS
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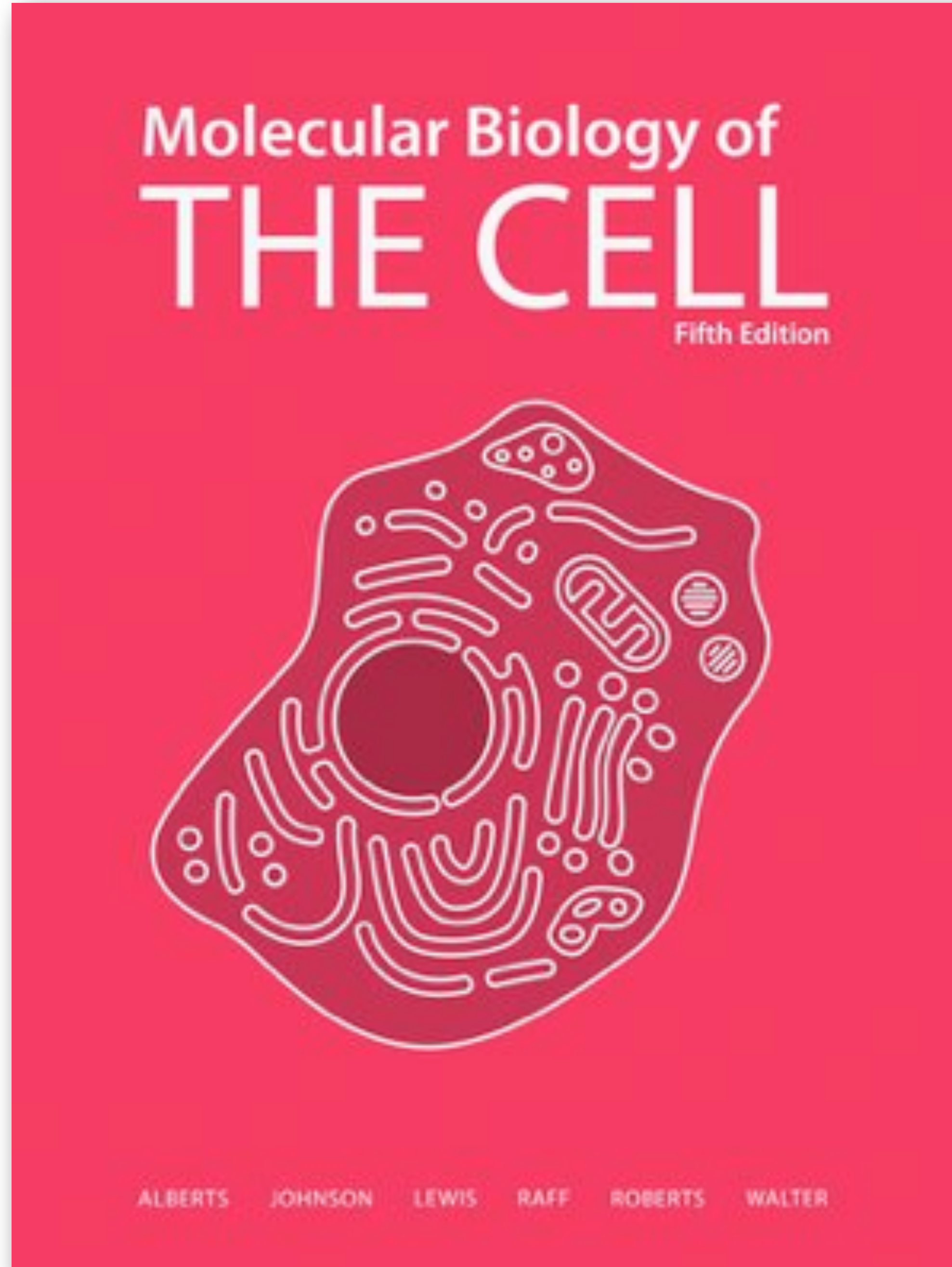
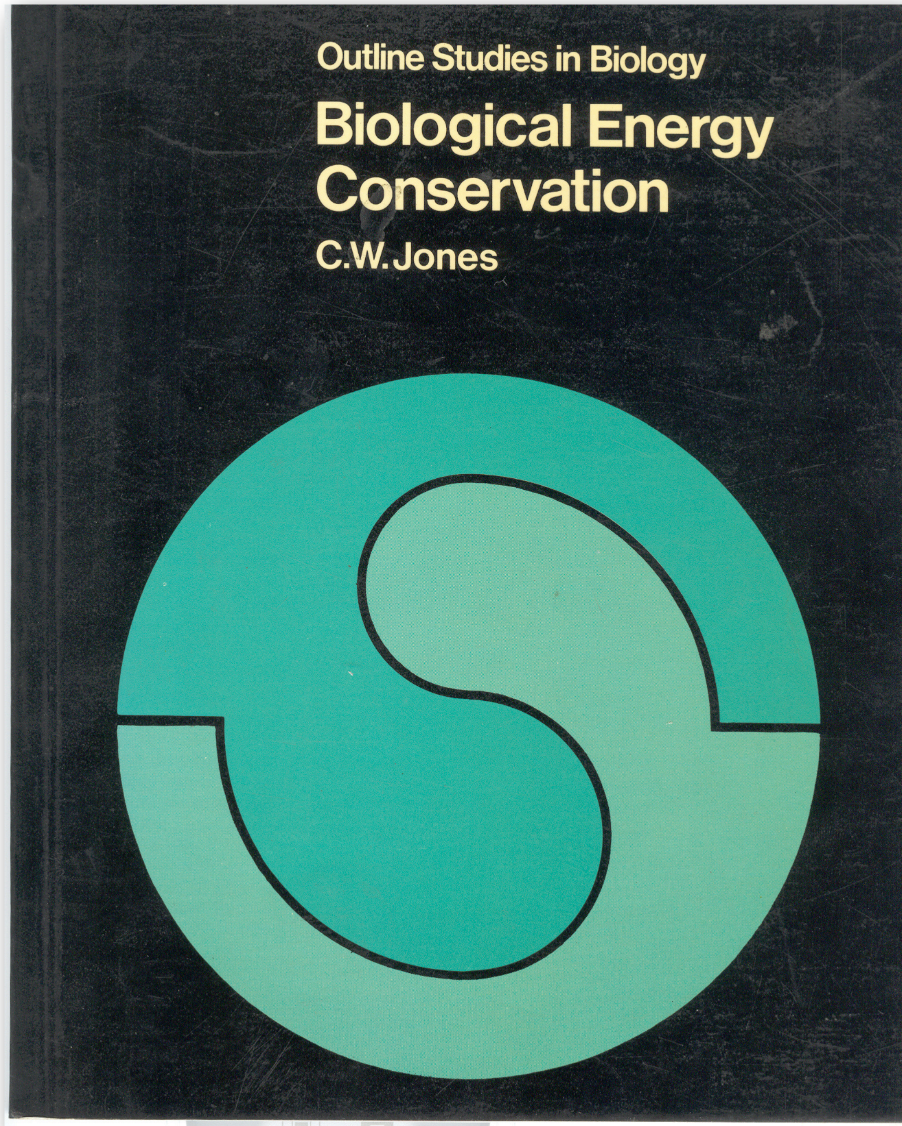

Molecular Biology of
THE CELL
Fifth Edition
ALBERTS JOHNSON LEWIS RAFF ROBERTS WALTER

Characteristics of oxidative phosphorylation

Reference

C W Jones "Biological Energy Conservation " [2nd edition]



Characteristics of oxidative phosphorylation

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a) the rate of electron transport – the number of electrons transferred along the chain in unit time – by measuring the rate at which oxygen is consumed (1 0 atom = $2e^-$)

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a) the rate of electron transport – the number of electrons transferred along the chain in unit time – by measuring the rate at which oxygen is consumed (1 0 atom = $2e^-$)

b) the amount of ATP synthesised (or amount of ADP or Pi converted into ATP)

Characteristics of oxidative phosphorylation

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From these measurements, observed characteristics fall into 5 main categories

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1] Energy coupling sites

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You will observe 1-4 in Practical 4.

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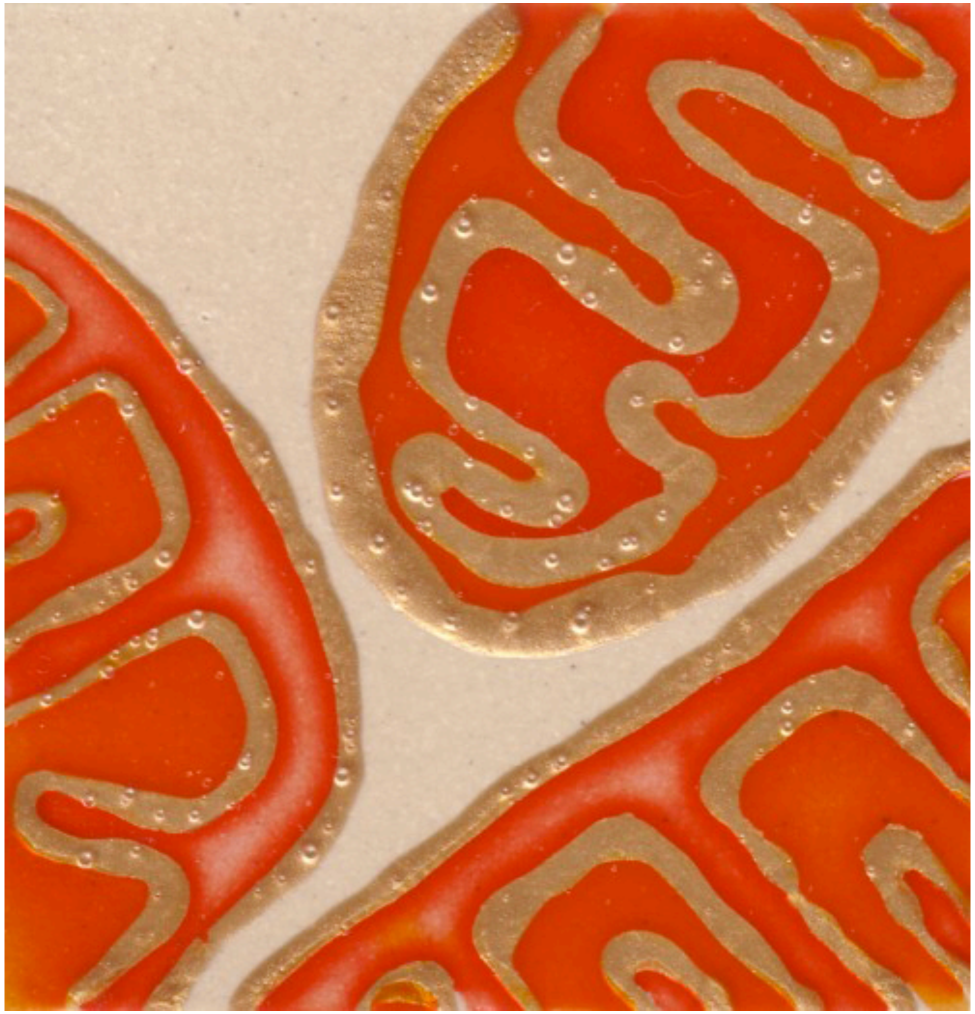
1) the nature of the substrate undergoing oxidation
2) the integrity of coupling membrane
3) the redox carrier composition of respiratory chain



Membrane Biochemistry

Next lecture....

Oxidative phosphorylation and respiratory control

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