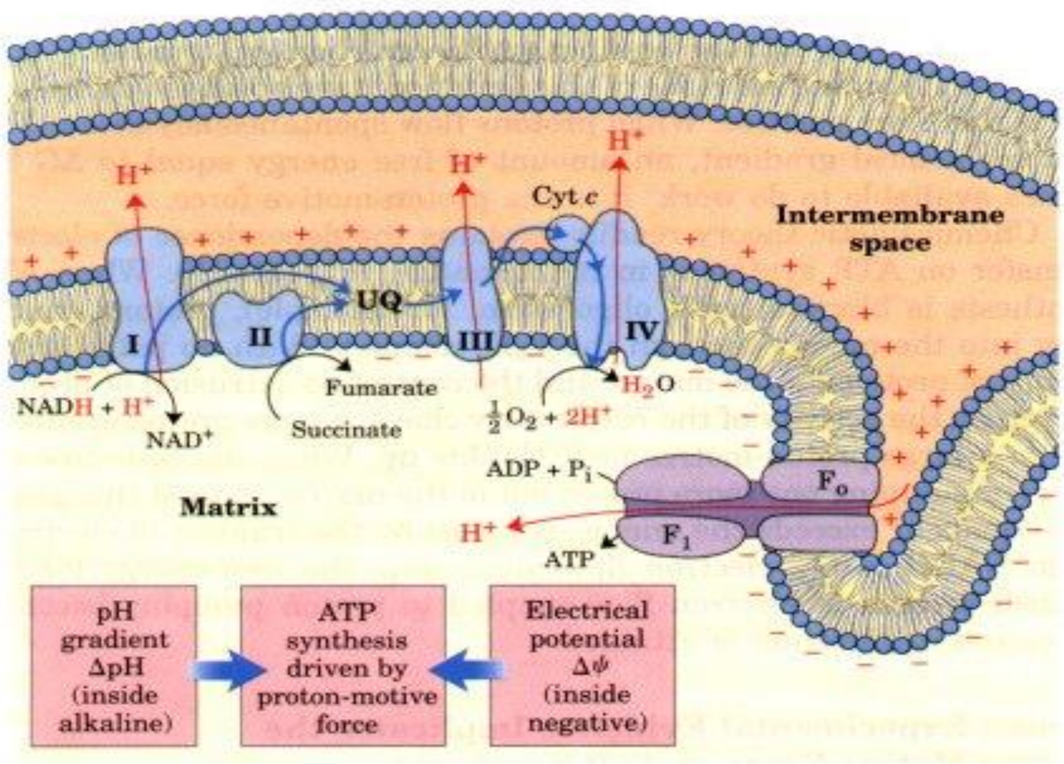
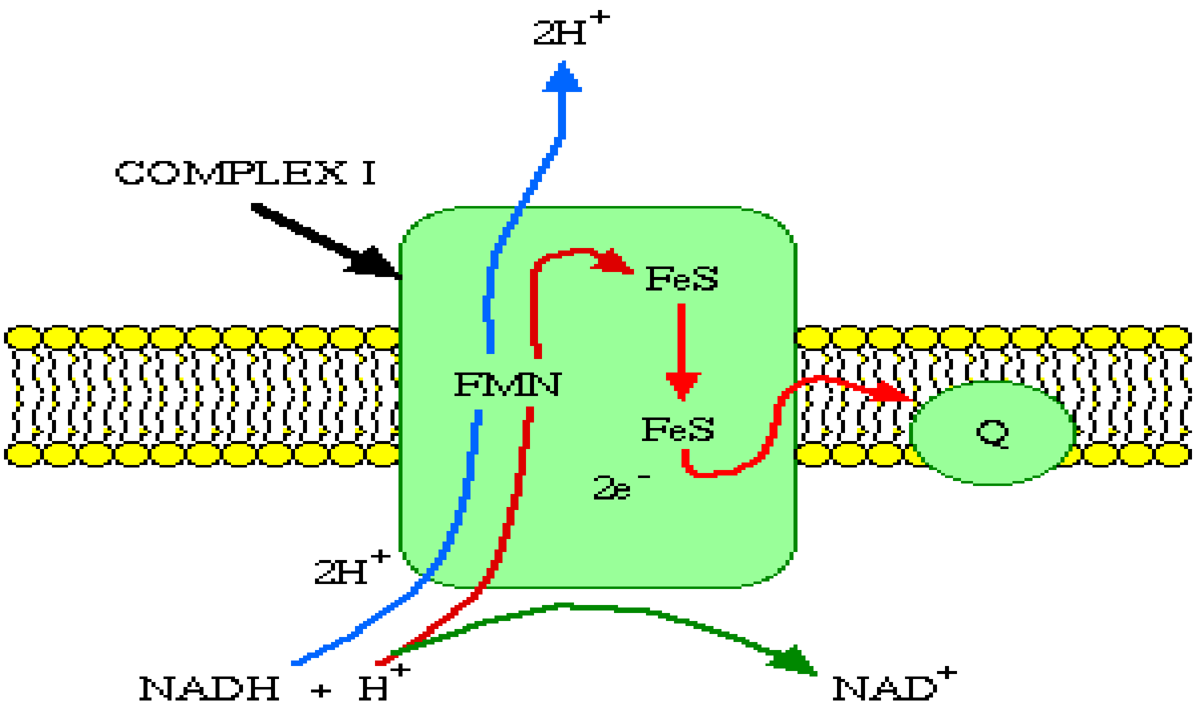
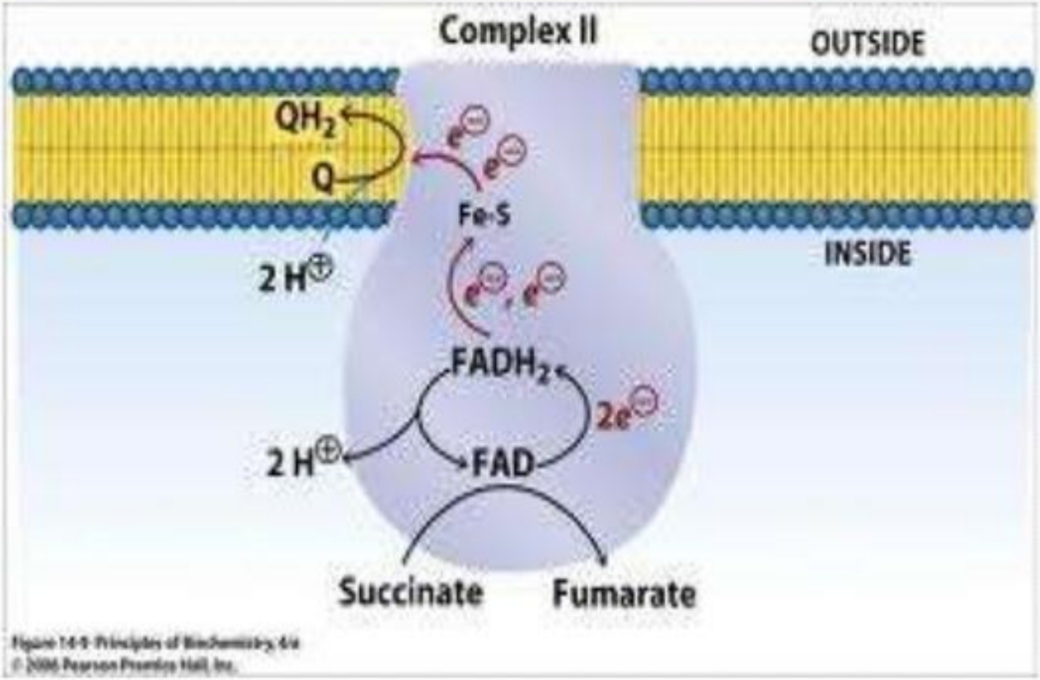
Oxidative Phosphorylation



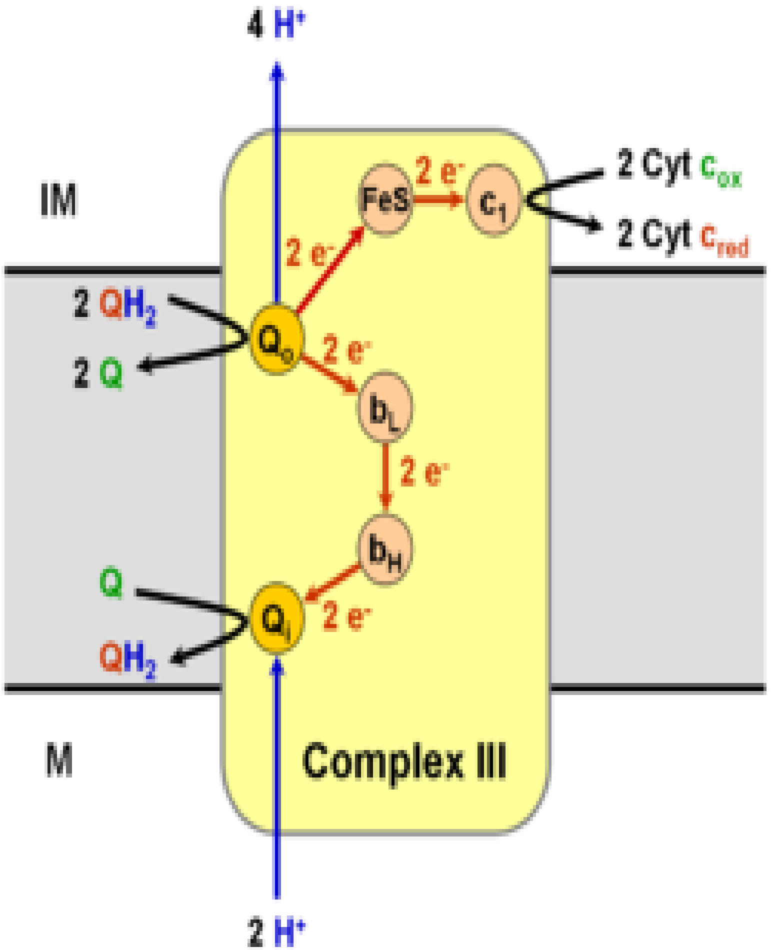


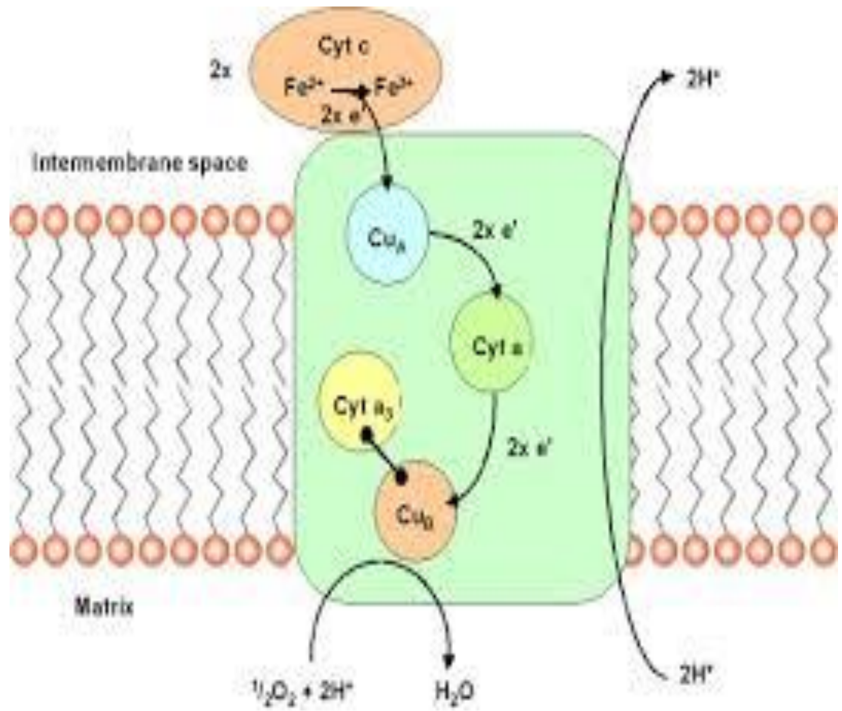
2H+
COMPLEX I
FeS
FMN
FeS
Q
2e-
2H+
NADH + H+
NAD+

PATHWAY OF ELECTRON TRANSFER THROUGH COMPLEX II



✓No transfer of protons from the matrix to intermembrane space.

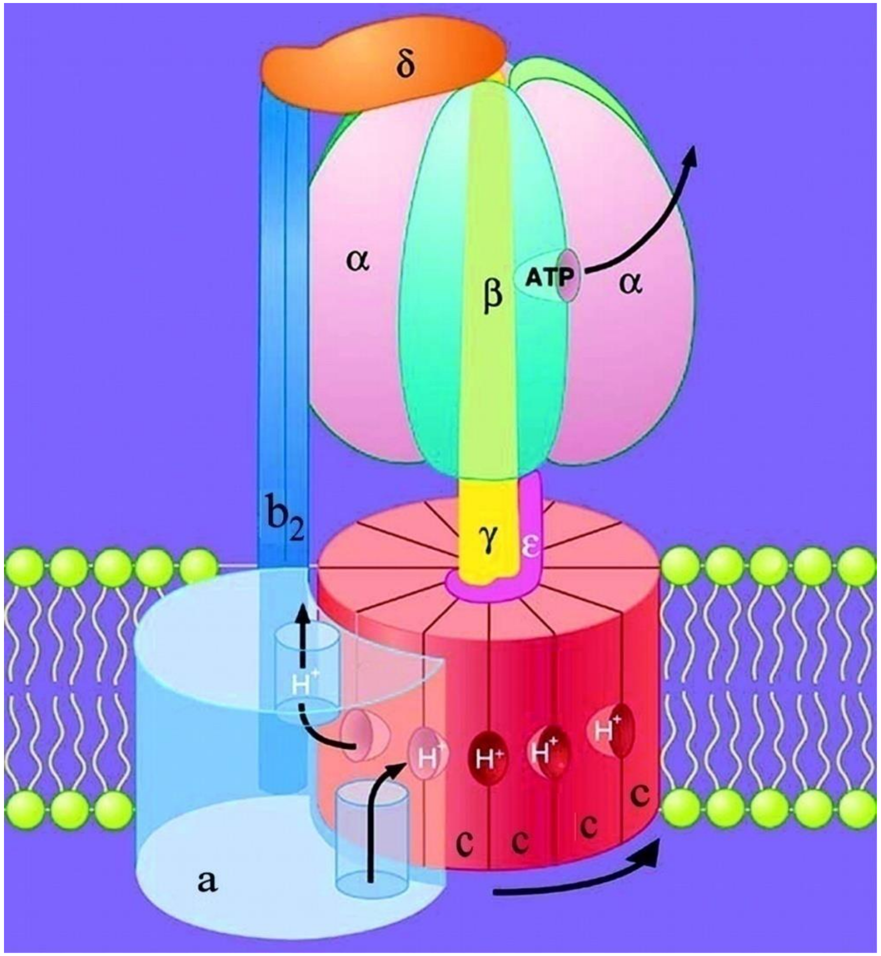

4 H+
IM
2 e-
FeS
2 e-
c1
2 Cyt cox
2 Cyt cred
2 QH2
2 Q
Qo
2 e-
bL
2 e-
bH
Q
Qi
2 e-
QH2
M
Complex III
2 H+


Cyt c
2x
Fe^{2+} Fe^{3+}
2x e'
Intermembrane space
Cu_A
2x e'
Cyt a
Cyt a_3
2x e'
Cu_B
Matrix
$^1/_2O_2$ + $2H^+$
H_2O
$2H^+$
$2H^+$

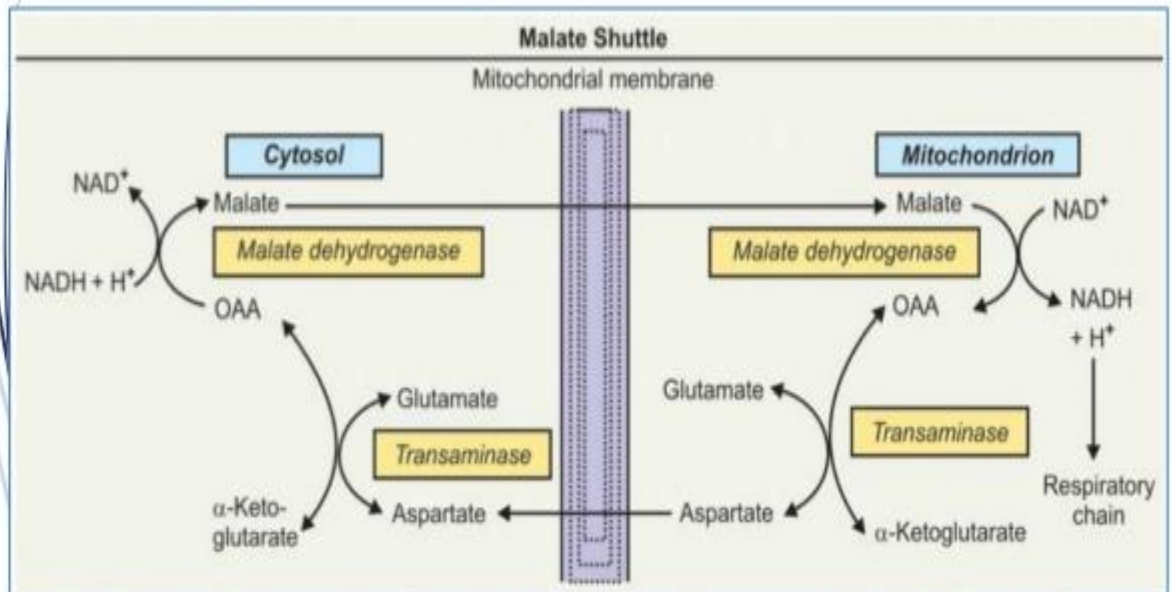
- NADH dehydrogenase
- Succinate dehydrogenase
- Ubiquinone cytochrome C oxidoreductase
- Cytochrome oxidase

Electron Carriers

- NAD/NADH
- Iron-sulfur protein, Rieske protein
- Ubiquinone
- Cytochrome b
- Cytochrome c_1
- Cytochrome c
- Cytochrome a
- Cytochrome a_3
- O_2/H_2O


δ
α
β
ATP
α
b2
γ
ε
H+
H+
H+
H+
H+
c
c
c
c
a

Malate-Aspartate shuttle



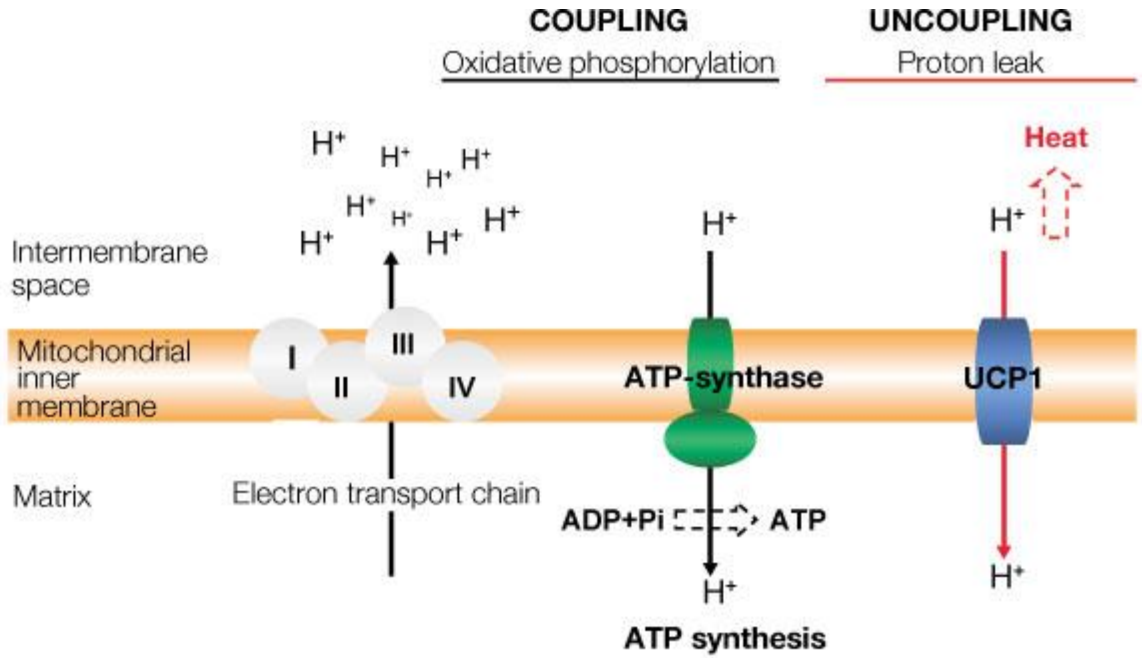


Figure 1. UCP1 location and function in the mitochondrial respiratory chain (MRC). Numbers I-IV corresponds to the MRC complexes. ATP-synthase is the fifth complex of the MRC. During respiration, protons are pumped through the MRC complexes, and a proton gradient is generated. The energy of the proton gradient drives the synthesis of ATP by the ATP-synthase complex. UCP1 catalyzes a regulated re-entry of protons into the matrix, uncoupling the MRC and, consequently, reducing ATP synthesis and generating heat.

Inhibitors and Uncouplers

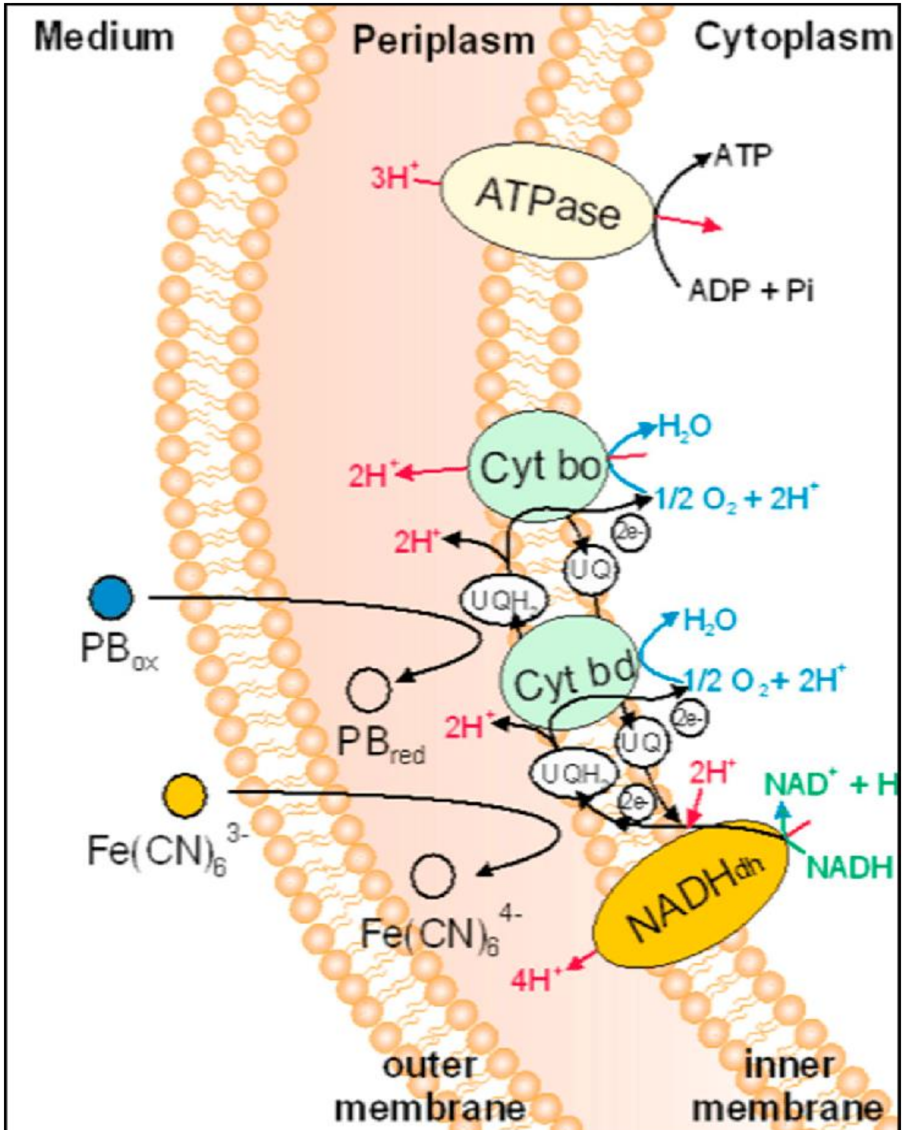
Table 1. Inhibitors of Respiration and Oxidative Phosphory

Site-Specific	Target Complex
Carbon monoxide	IV
Cyanide	IV
Sodium Azide	IV
Rotenone	I
Antimycin A	III
Amytal	I
Phosphorylation	
Oligomycin	F_o
Uncouplers	
2,4-Dinitrophenol (DNP)	Proton gradient
Trifluorocarbonylcyanide Phenylhydrazone (FCCP)	Proton gradient

Any compound that stops electron transport will stop respiration…this means you stop breathing

Electron transport can be stopped by inhibiting ATP synthesis

An uncoupler breaks the connection between ATP synthesis and electron transport


Medium
Periplasm
Cytoplasm
3H⁺
ATPase
ATP
ADP + Pi
H₂O
2H⁺
Cyt bo
1/2 O₂ + 2H⁺
2e-
2H⁺
UQ
UQH₂
PBox
H₂O
Cyt bd
1/2 O₂+ 2H⁺
PBred
2H⁺
2e-
UQ
UQH₂
2H⁺
2e-
NAD⁺ + H
Fe(CN)6 3-
NADH
NADHdh
Fe(CN)6 4-
4H⁺
outer
membrane
inner
membrane

Transport of Electron

- A,B,C and D are electron Carriers
- A= 0.32 V
- B = 0.75 V
- C= 0.66 V
- D = 1.05 V
- State the direction of electron flow

- Direction Of electron flow is from lower reduction potential to higher reduction potential

- Proton Motive Force: The electrochemical energy inherent in the difference in proton concentration and separation of charge represents a temporary conservation of much of the energy of electron transfer . The energy stored in such a gradient is termed as proton motive force. This force has two components:
- Chemical Potential energy
- Electrical potential Energy

Aerobic respiration in *E.coli*

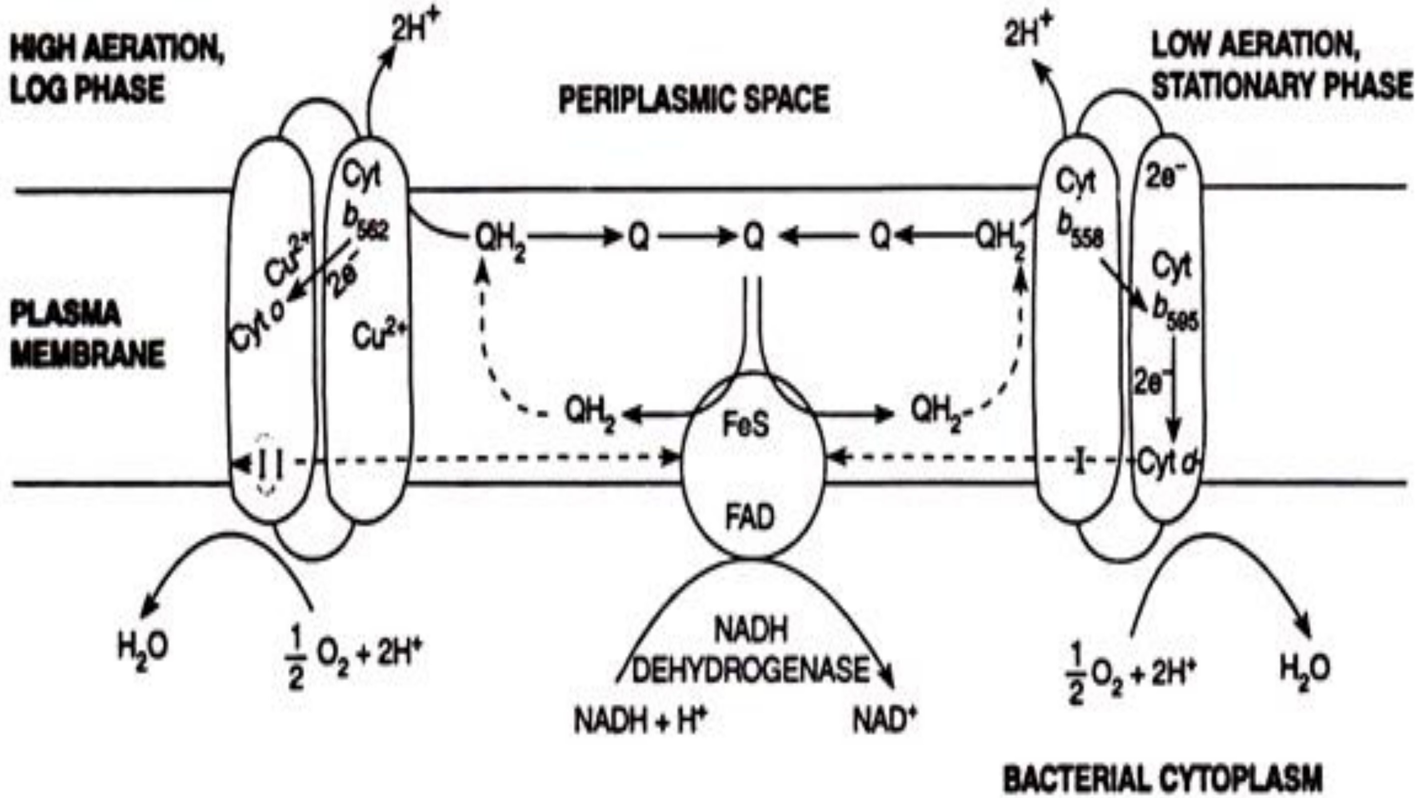
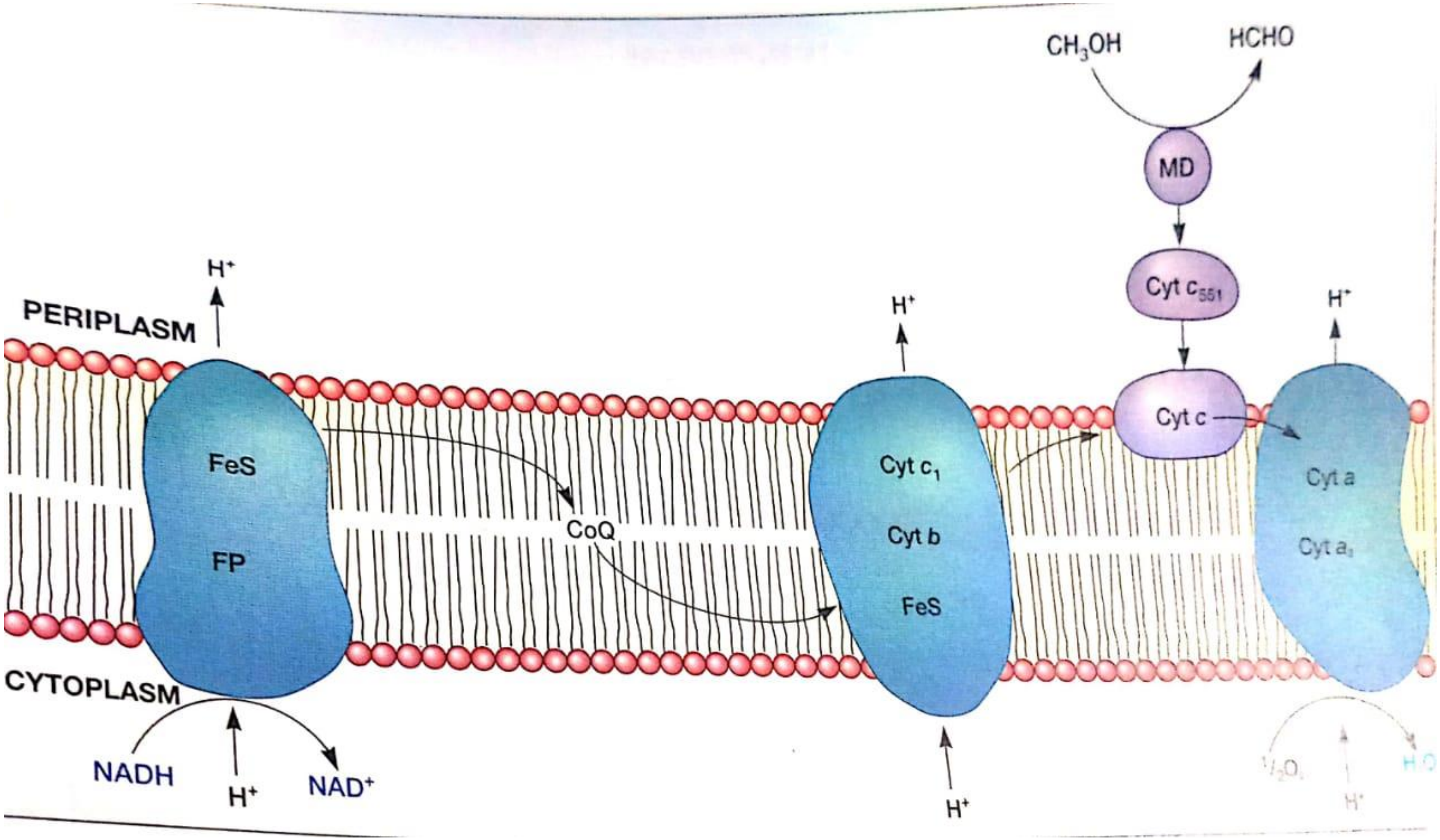


FIG. 24.7. Electron transport chain of *E. coli* that operates in aerobic conditions. NADH is the electron donor. Ubiquinone (Q) is the connecting link between NADH dehydrogenase with two terminal oxidase systems of the two branches, cytochrome *d* branch (shown as I) and cytochrome *o* branch (shown as II).

Aerobic respiration in *Paracoccus denitrificans (Methanol and methyamine can contribute electrons at the cytochrome C level*

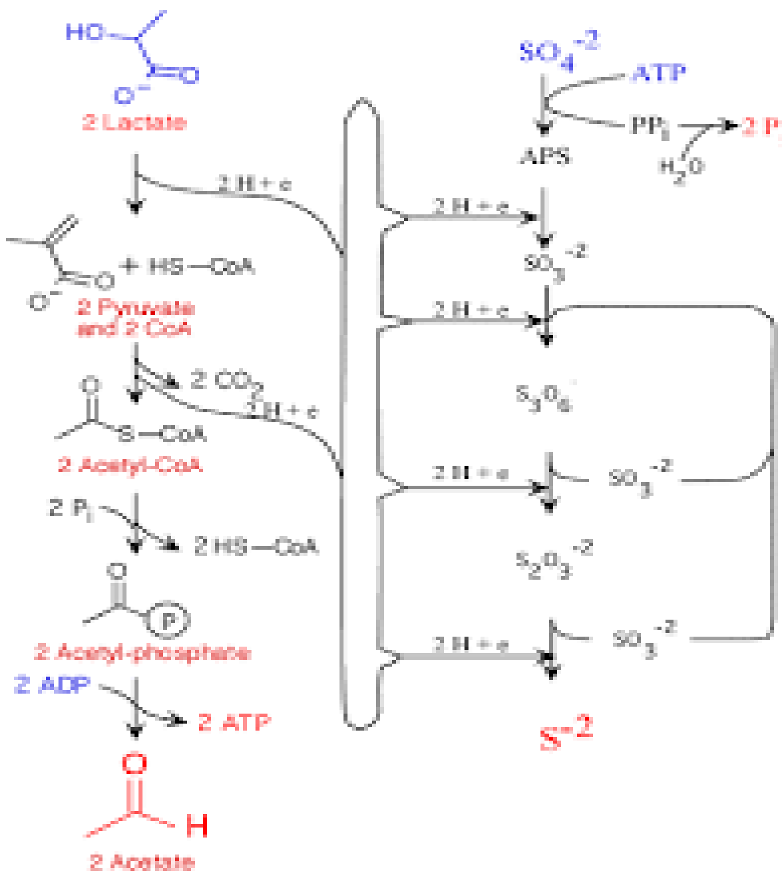


P/O ratio

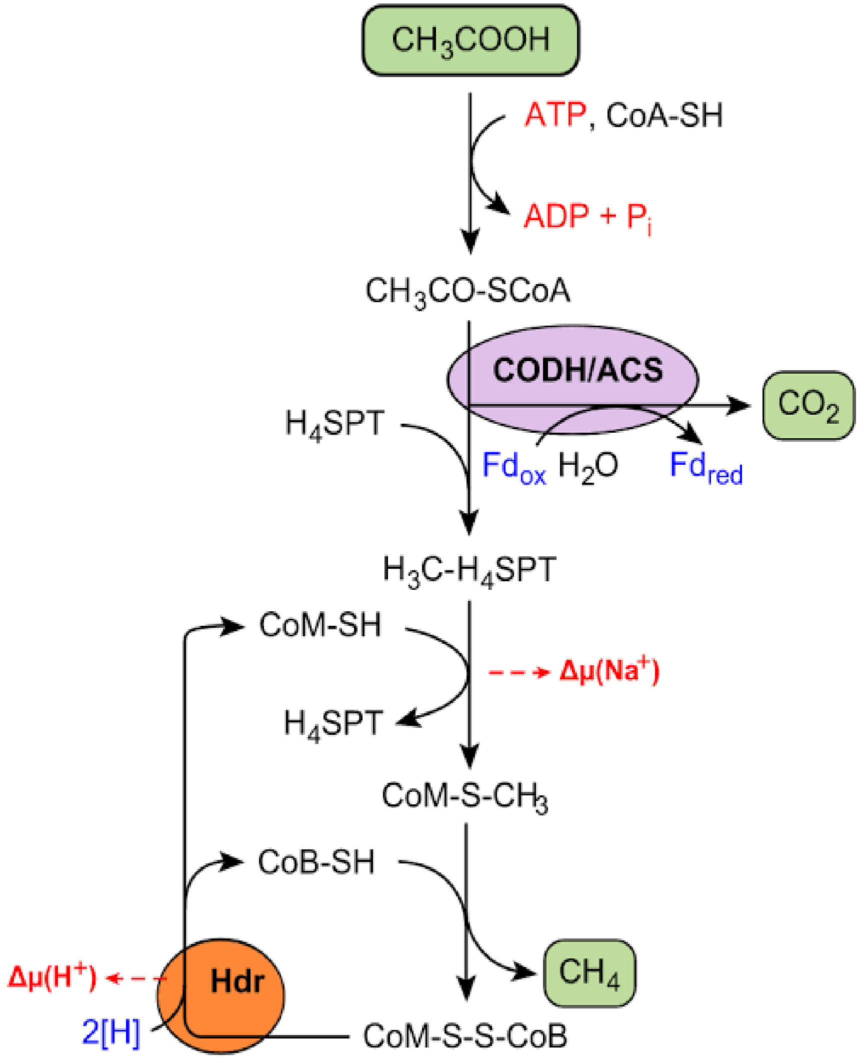
- **P/O ratio (phosphorus:oxygen ratio)** The number of atoms of phosphorus (i.e. as phosphate) incorporated as ATP per molecule of oxygen (O_2) consumed during oxidative phosphorylation in aerobically respiring cells

Chemiosmotic Theory

- Trans membrane difference in proton concentration are the reservoir for the energy extracted from biological oxidation reaction. This theory is introduced by Peter mitchell



HO
O⁻
2 Lactate
2 H + e
+ HS—CoA
2 Pyruvate and 2 CoA
2 CO2
2 H + e
S—CoA
2 Acetyl-CoA
2 Pi
2 HS—CoA
P
2 Acetyl-phosphate
2 ADP
2 ATP
H
2 Acetate
SO4-2
ATP
PPi
2 Pi
H2O
APS
2 H + e
SO3-2
2 H + e
S3O6
2 H + e
SO3-2
S2O3-2
2 H + e
SO3-2
S-2



CH3COOH
ATP, CoA-SH
ADP + Pi
CH3CO-SCoA
CODH/ACS
CO2
H4SPT
Fdox H2O
Fdred
H3C-H4SPT
CoM-SH
Δμ(Na+)
H4SPT
CoM-S-CH3
CoB-SH
CH4
Δμ(H+)
Hdr
2[H]
CoM-S-S-CoB

Anaerobic respiration

334 Electron transport under anaerobic conditions

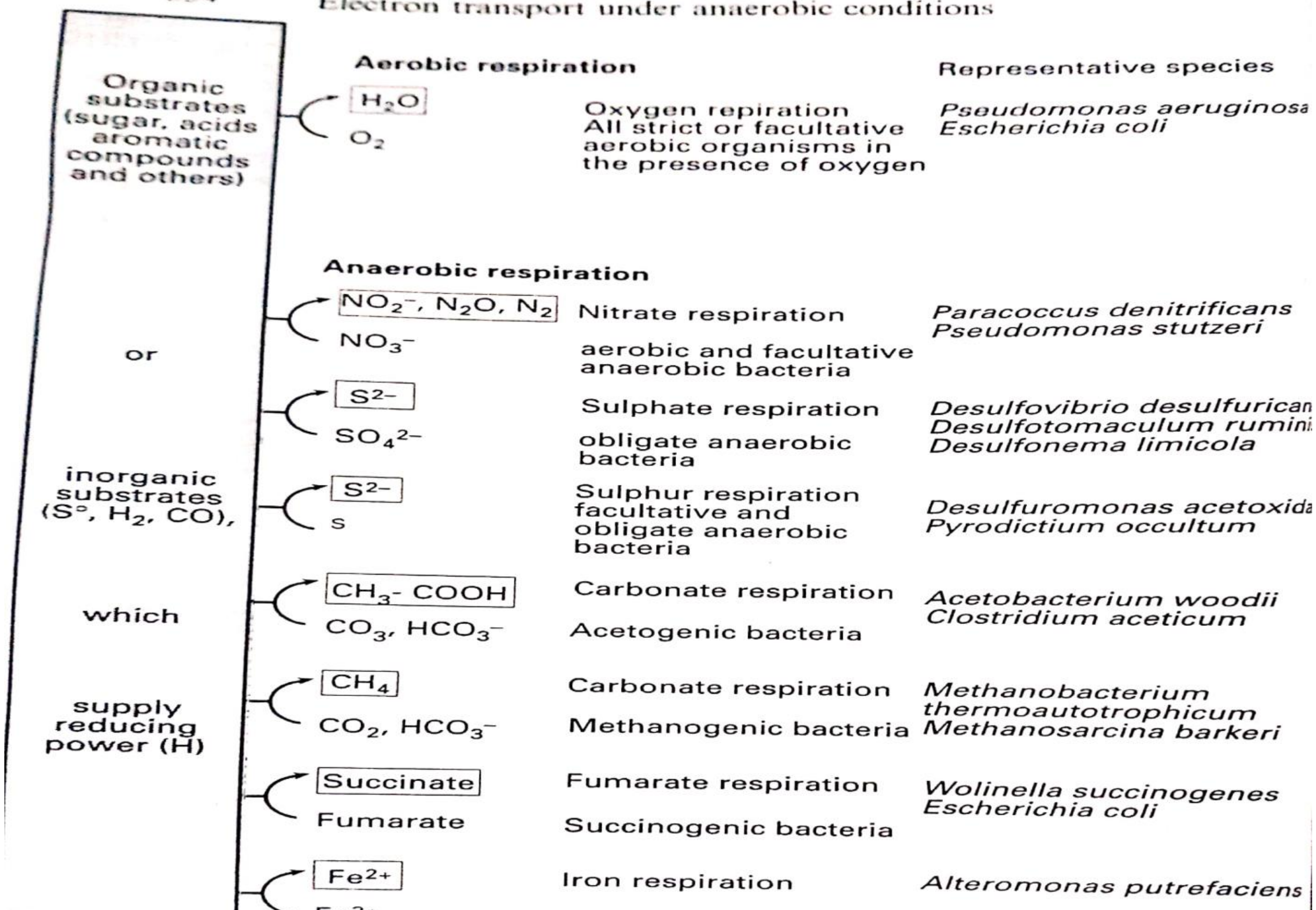


Fig. 9.1. *Processes that yield energy by electron transport phosphorylation under aerobic and anaerobic conditions.*

(Also called aerobic and anaerobic respiration.)

Dissimilatory Nitrate reduction

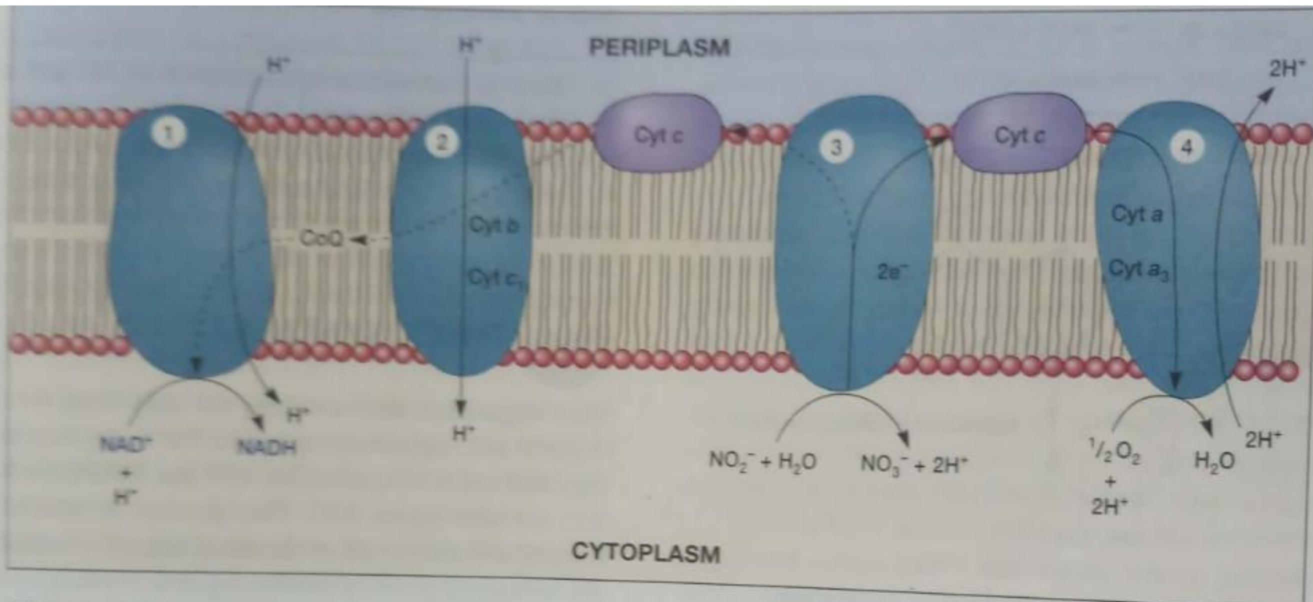
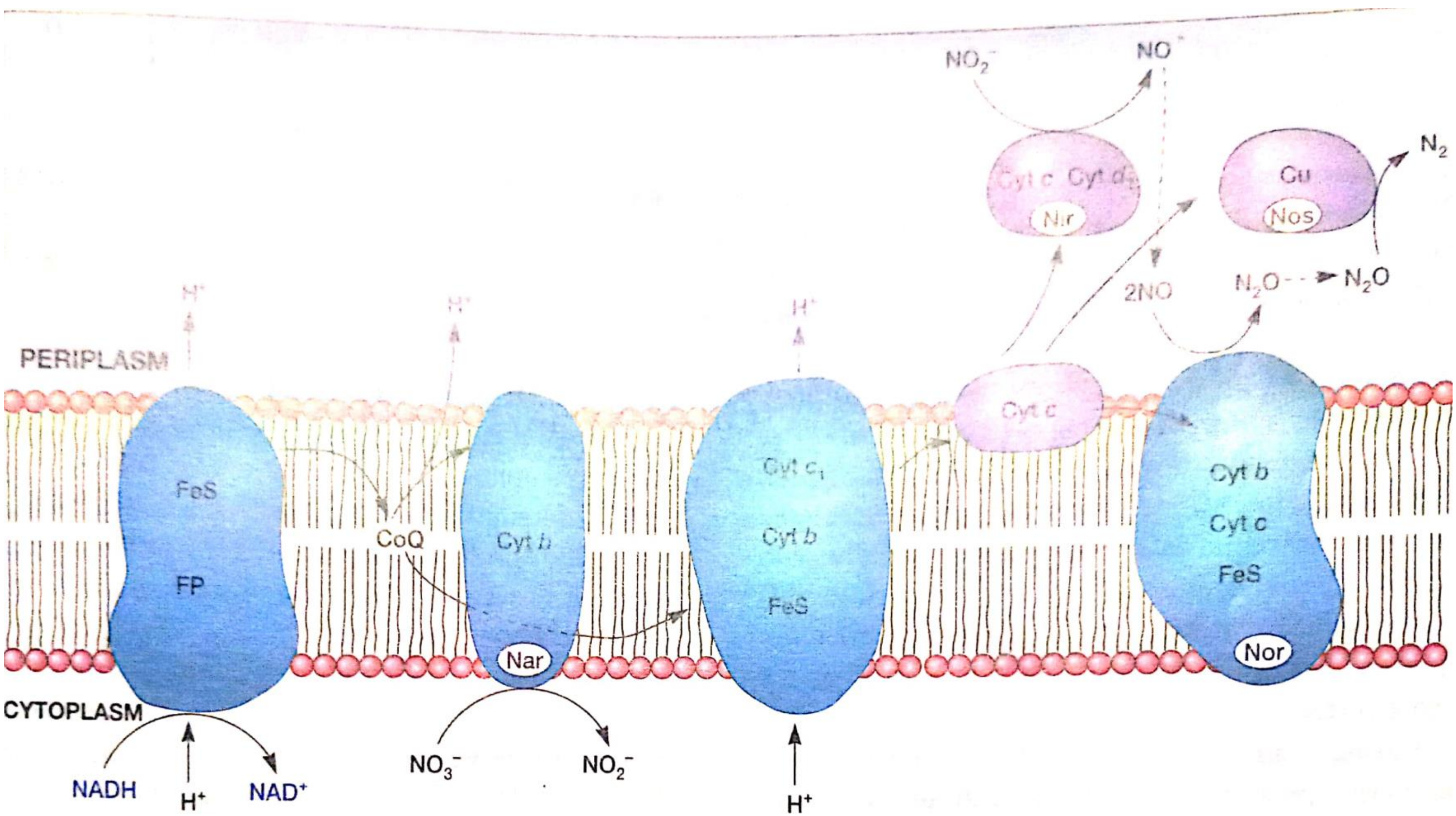


Figure 9.24 Electron Flow in *Nitrobacter* Electron Transport Chain. *Nitrobacter* oxidizes nitrite and carries out normal electron transport to generate proton motive force for ATP synthesis. This is the right-hand branch of the diagram. Some of the proton motive force also is used to force electrons to flow up the reduction potential gradient from nitrite to NAD^+ (left-hand branch). Cytochrome *c* and four complexes are involved: NADH-ubiquinone oxidoreductase (1), ubiquinol-cytochrome *c* oxidoreductase (2), nitrite oxidase (3), and cytochrome aa_3 oxidase (4).



NO2⁻
NO
N2
Cyt c Cyt d1
Nir
Cu
Nos
2NO
N2O
N2O
H⁺
H⁺
H⁺
PERIPLASM
Cyt c
FeS
FP
CoQ
Cyt b
Nar
Cyt c1
Cyt b
FeS
Cyt b
Cyt c
FeS
Nor
CYTOPLASM
NADH
H⁺
NAD⁺
NO3⁻
NO2⁻
H⁺

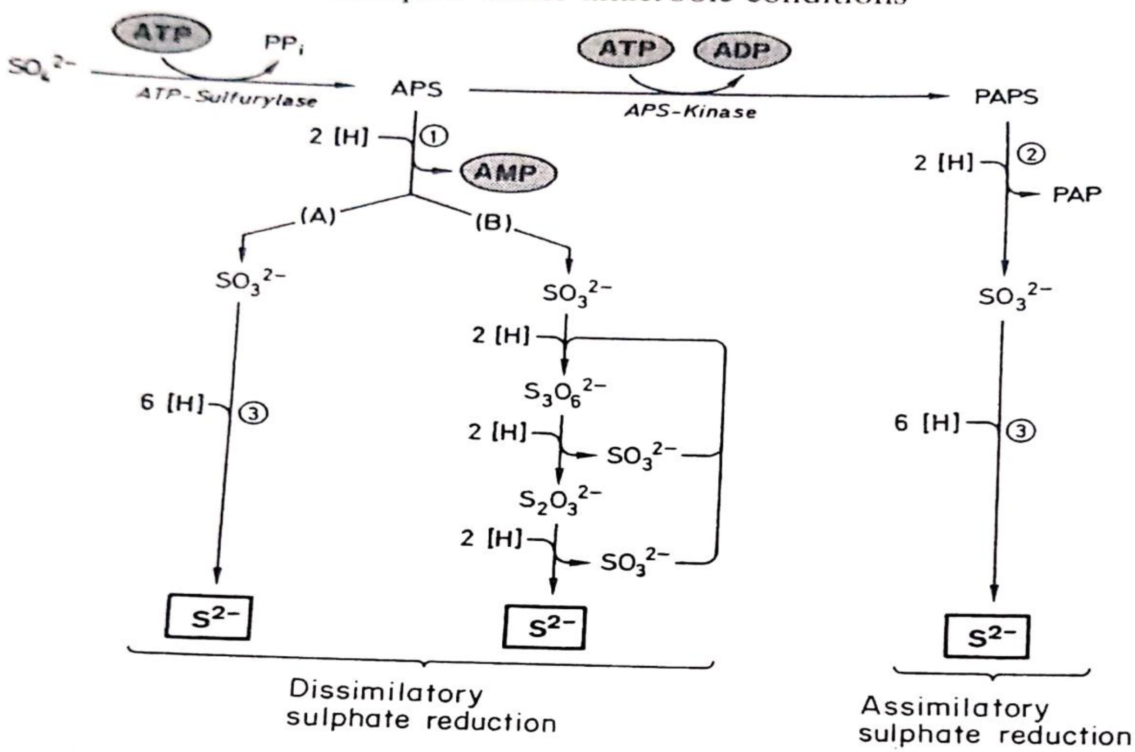


Fig. 9.3. *Diagrams of dissimilatory sulphate reduction (sulphate respiration) and assimilatory sulphate reduction.*

APS, adenosine-5'-phosphosulphate; PAPS, phosphoadenosine-5'-phosphosulphate; PAP, phospho-adenosine-5'-phosphate.

Enzymes: (!) APS reductase; (2) PAPS reductase; (3) sulphite reductase (bisulphite reductase).