Université de Sfax

University of Sfax
TUNISIA

Faculté de Médecine de Sfax

UEF 109

Bioénergétique 2/2

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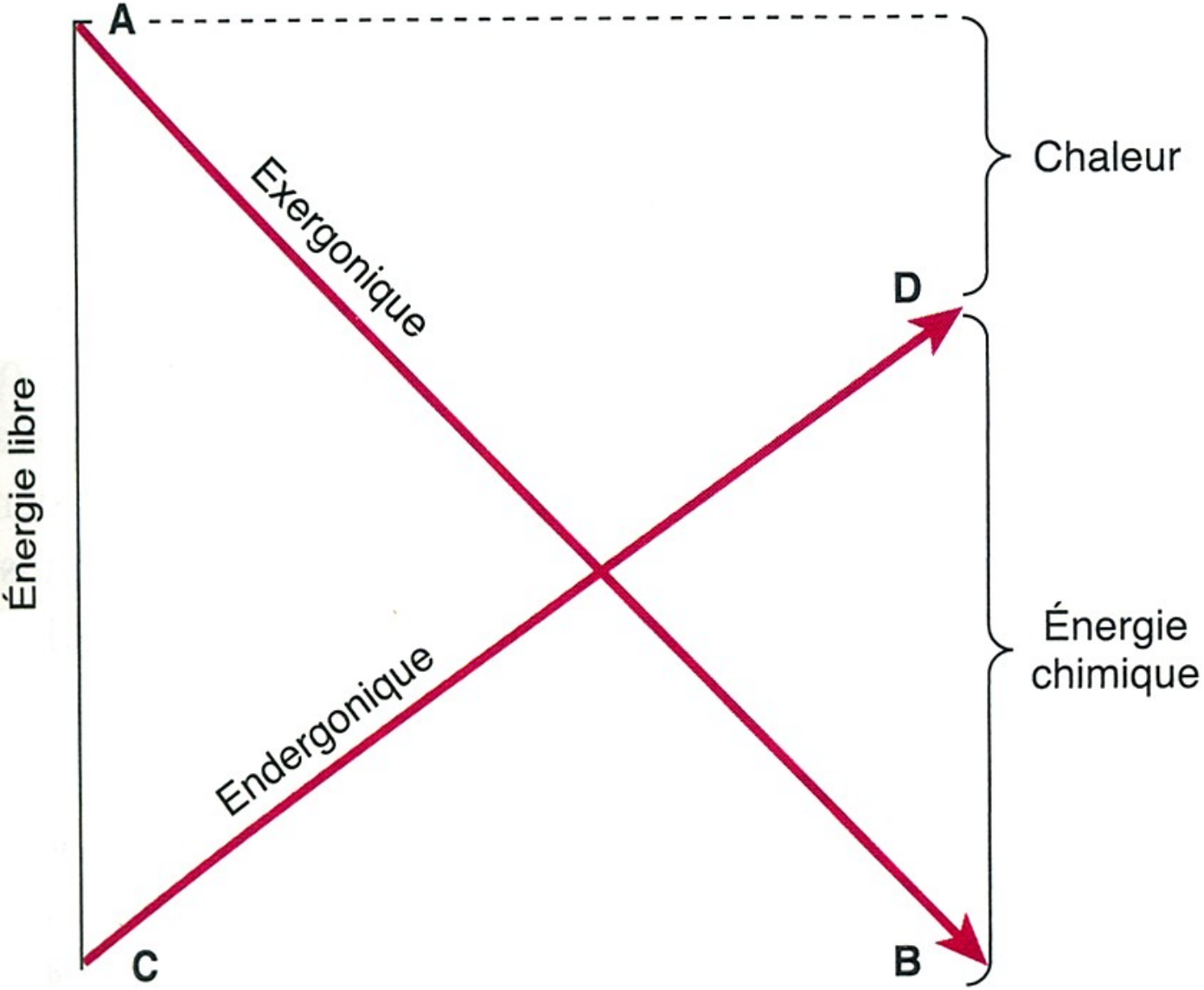
Section de Biochimie
Département des Sciences de base A

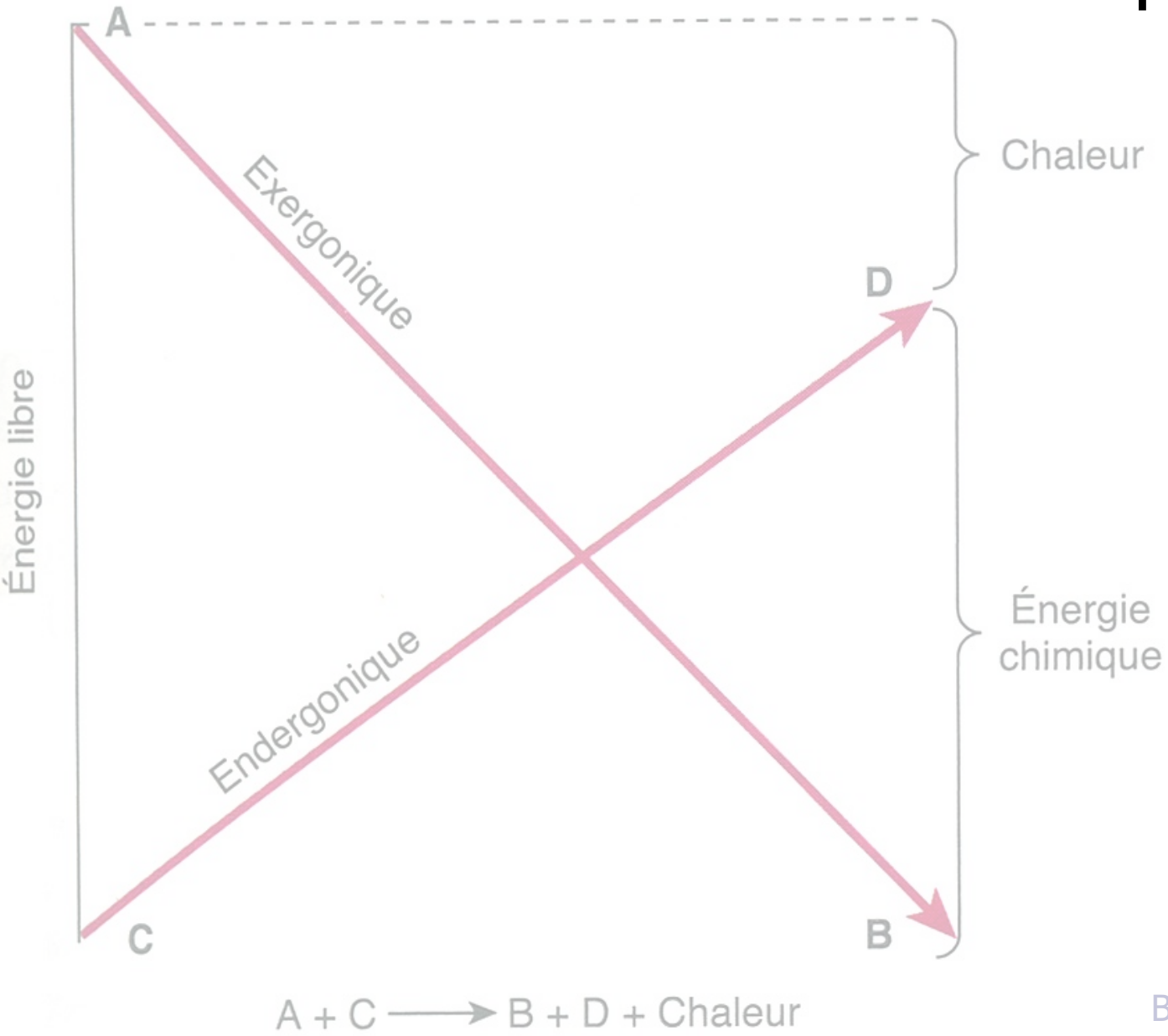
Couplage d'une réaction Exergonique à une réaction Endergonique



$$A + C \longrightarrow B + D + \text{Chaleur}$$

Biochimie de Harper.
4e édition. 2011. de boeck

Couplage direct



$A + C \longrightarrow B + D + \text{Chaleur}$

Biochimie de Harper.
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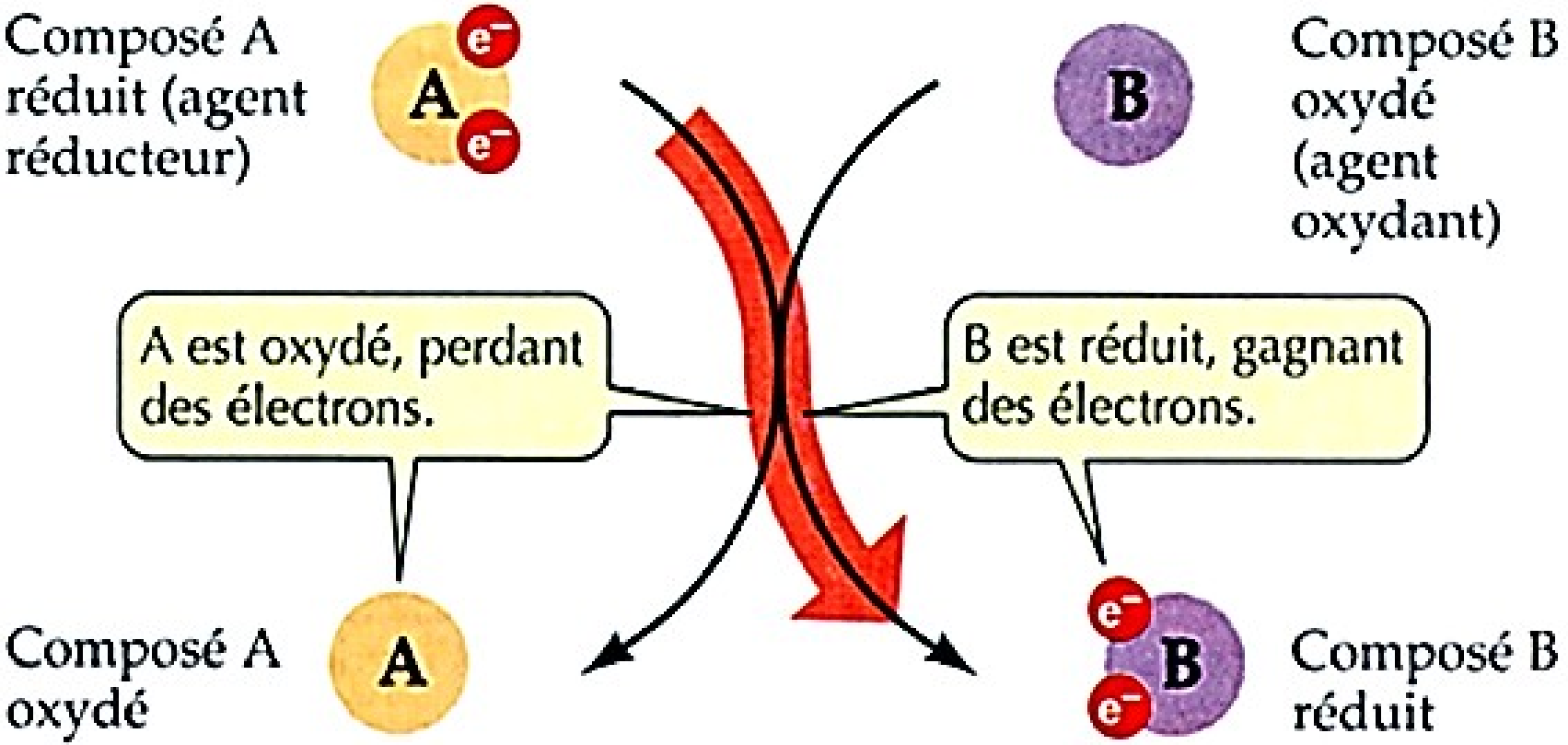
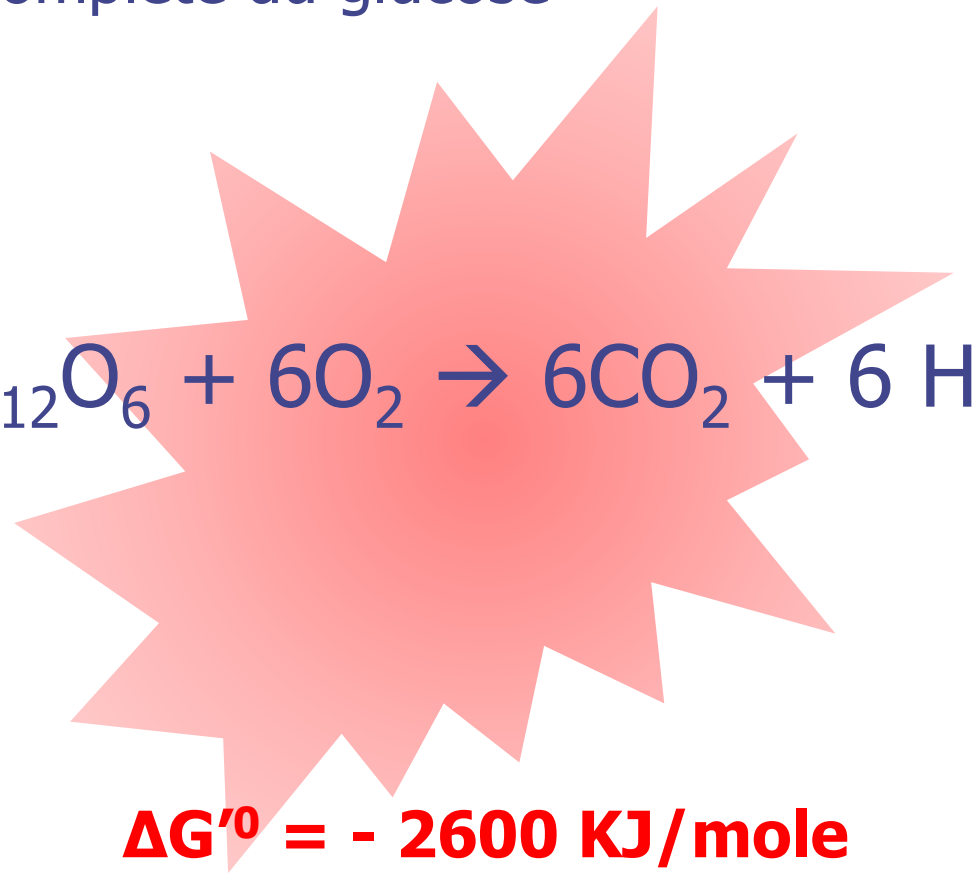
Réaction d'oxydo-réduction



A/A^{2e-} et B/B^{2e-} sont deux COUPLES RÉDOX

Exemple de carbone réduit alimentaire : Glucose

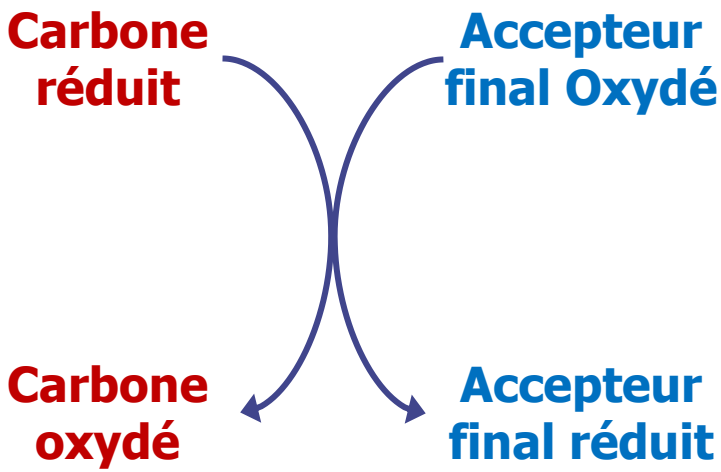
Oxydation complète du glucose

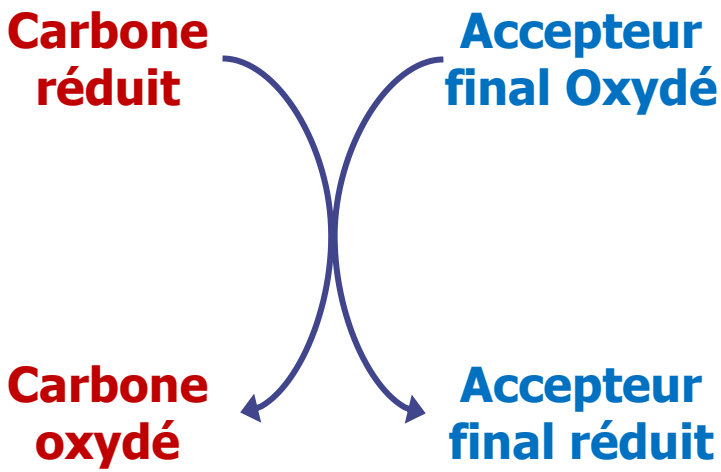


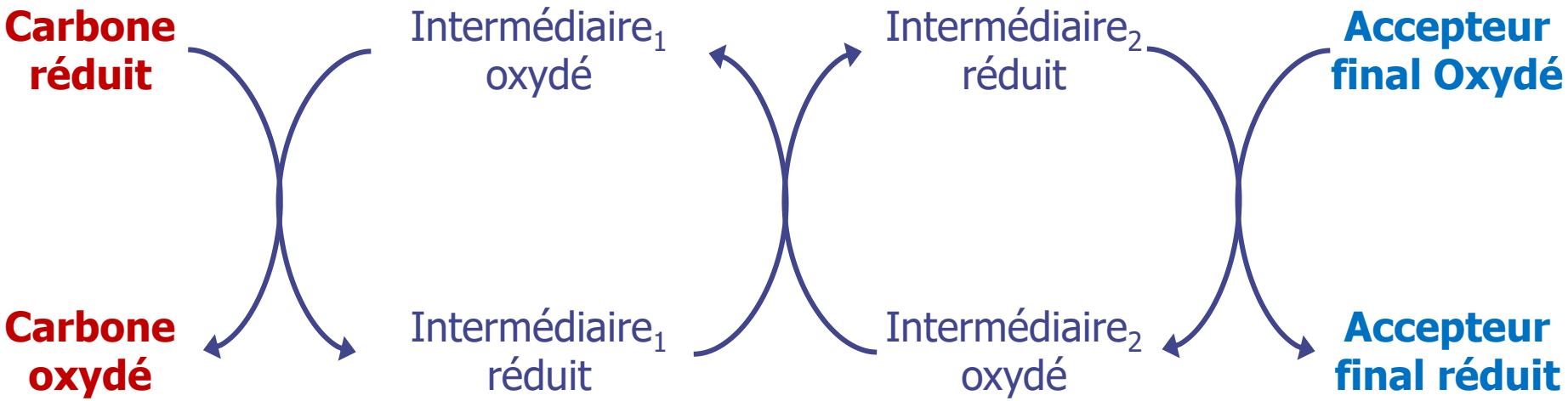
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6\ H_2O$$

$\Delta G'^0$ = - 2600 KJ/mole

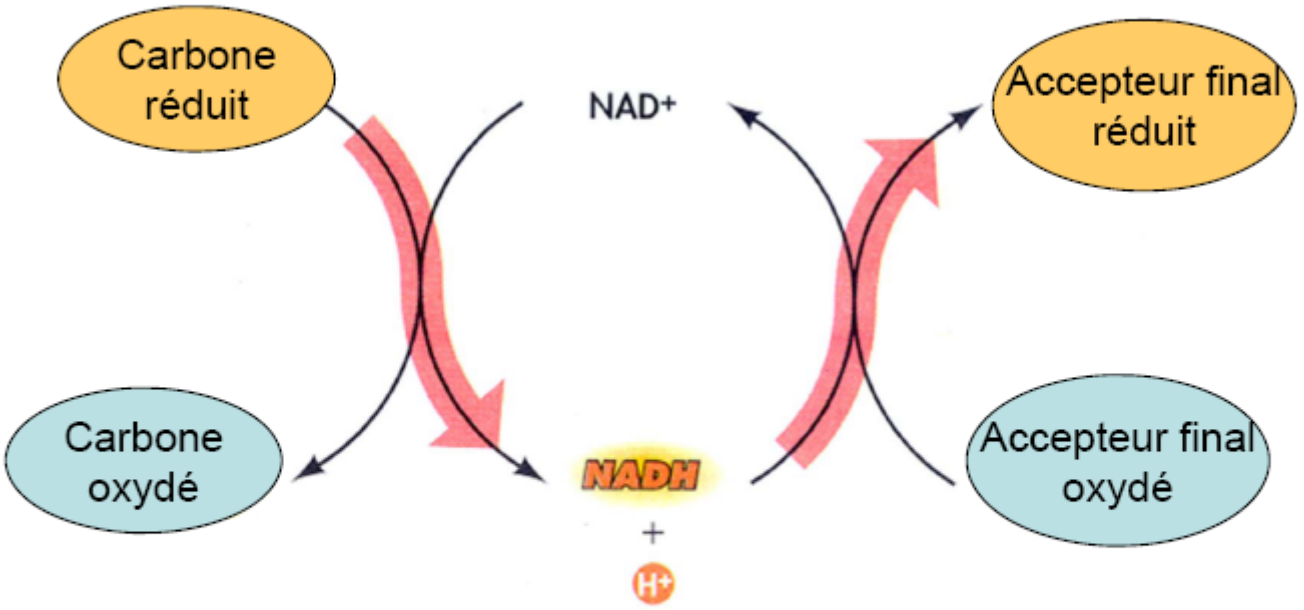

© Br


Carbone
réduit
Accepteur
final Oxydé
Carbone
oxydé
Accepteur
final réduit


Carbone
réduit
Accepteur
final Oxydé
Carbone
oxydé
Accepteur
final réduit


Carbone réduit
Carbone oxydé
Intermédiaire1 oxydé
Intermédiaire1 réduit
Intermédiaire2 réduit
Intermédiaire2 oxydé
Accepteur final Oxydé
Accepteur final réduit

NAD^+ / NADH : transporteur universel

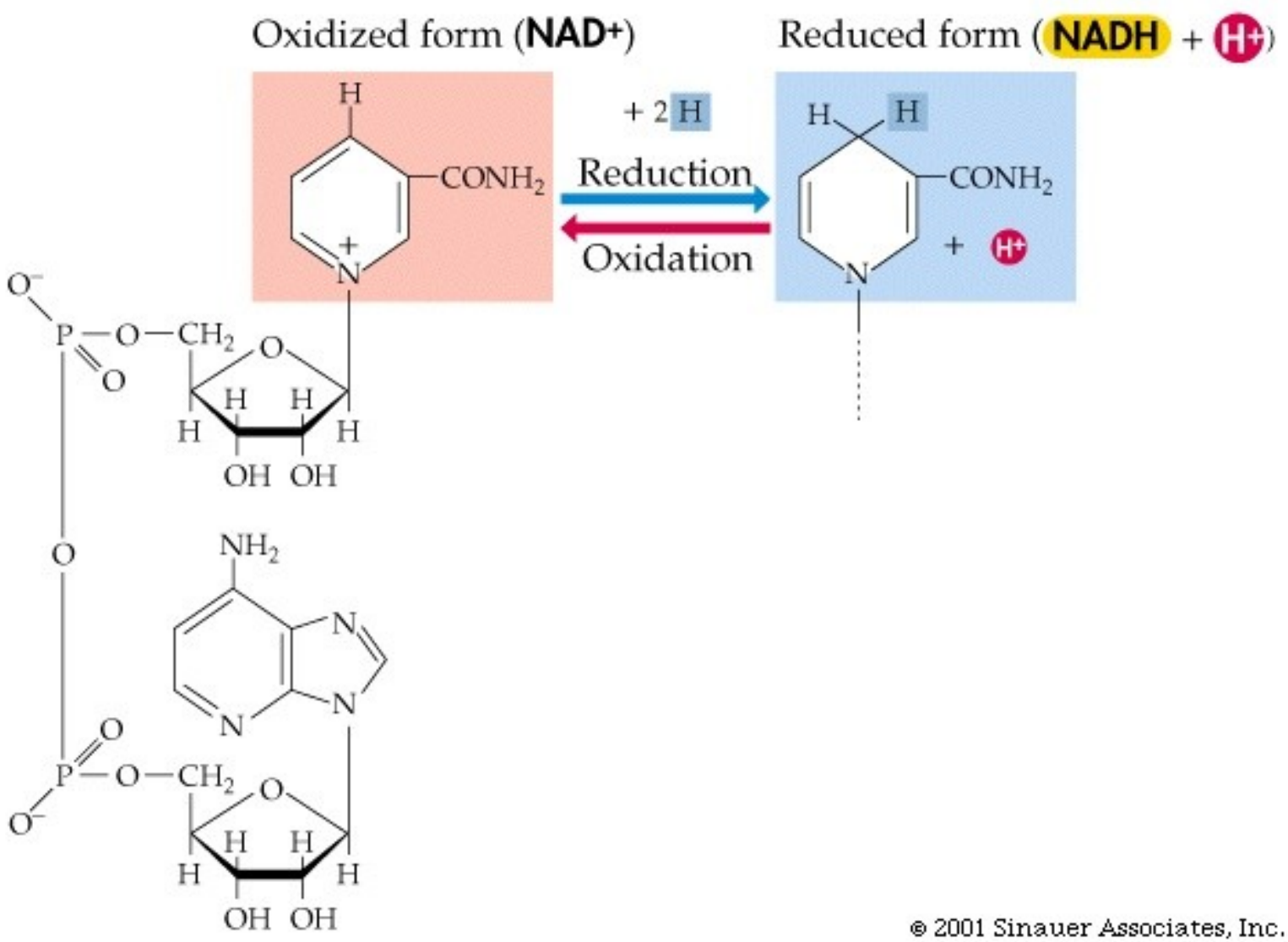


Grâce à sa capacité à transporter de l '**énergie libre et** des **électrons** le NAD^+ est un intermédiaire **universel** et essentiel dans les cellules

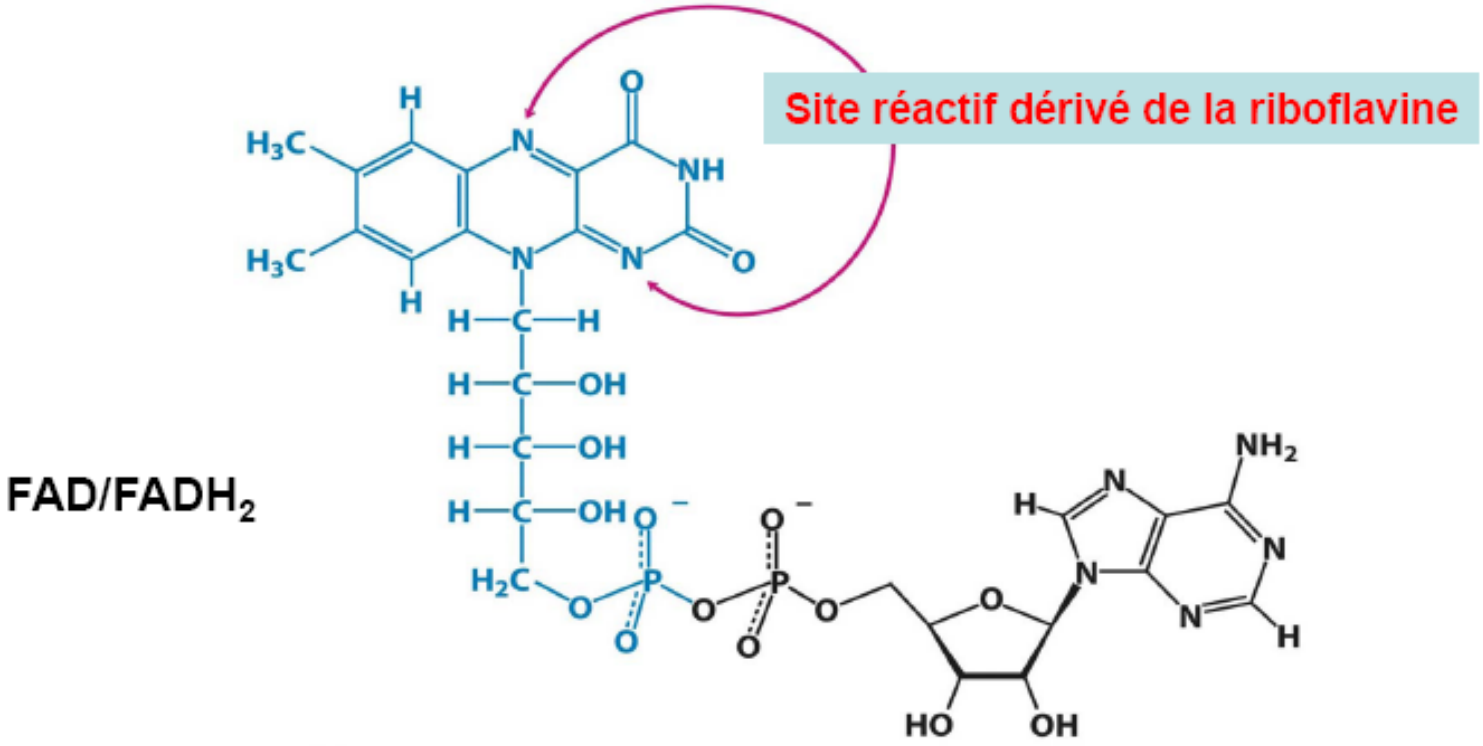
Exemple de coenzyme soluble

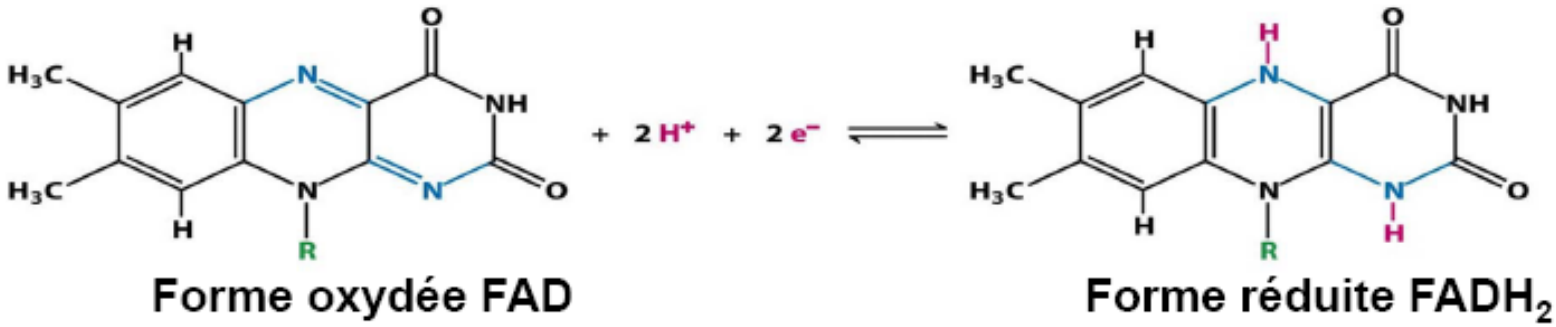
Famille	**Vitamine précurseur**	**exemples**
Pyridines nucléotides	B3 ou PP	NAD NADP

Exemple de coenzyme soluble



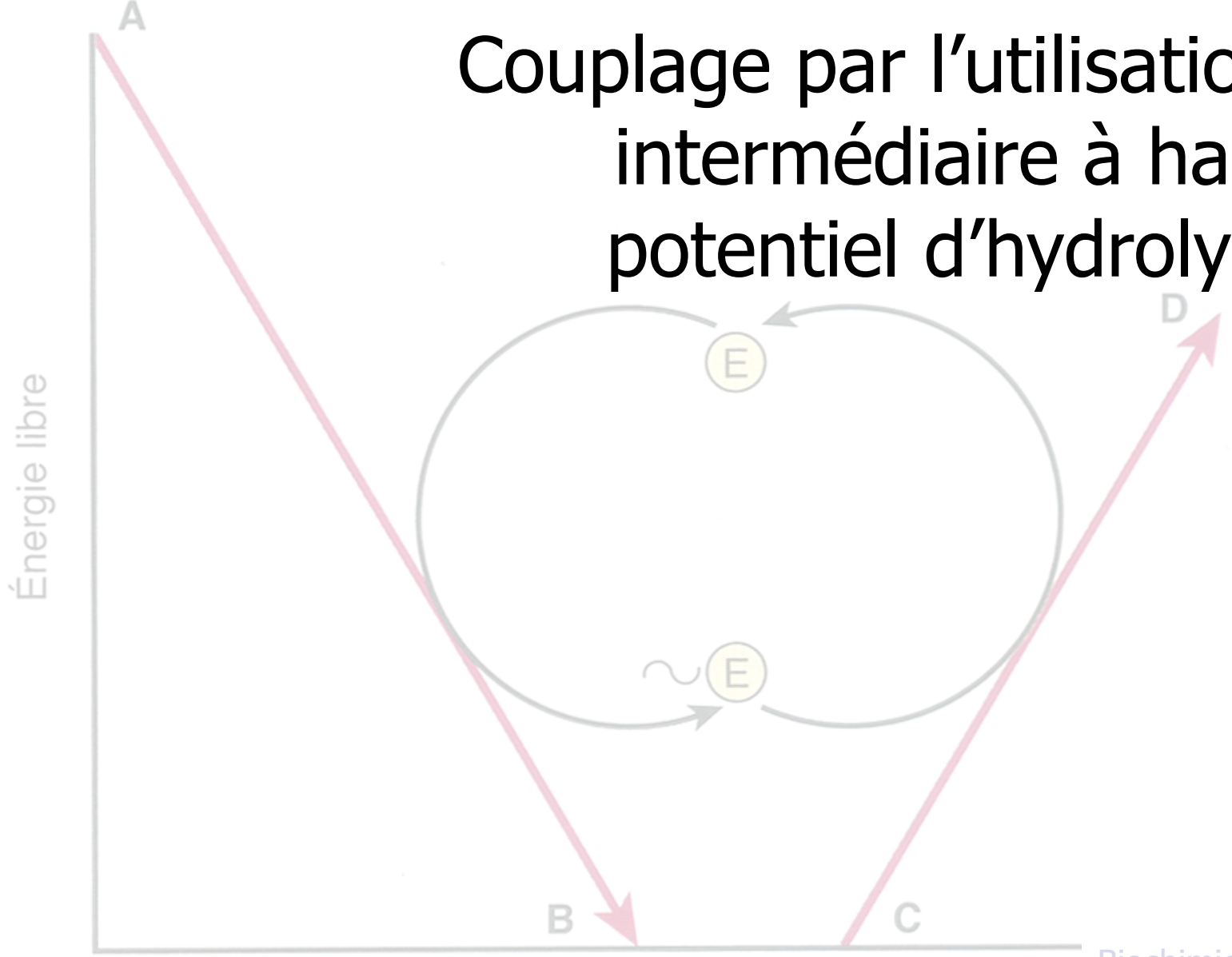
Autres transporteurs d'électrons





Transfert d'énergie libre d'une réaction exergonique à une réaction endergonique via un intermédiaire « riche en énergie »

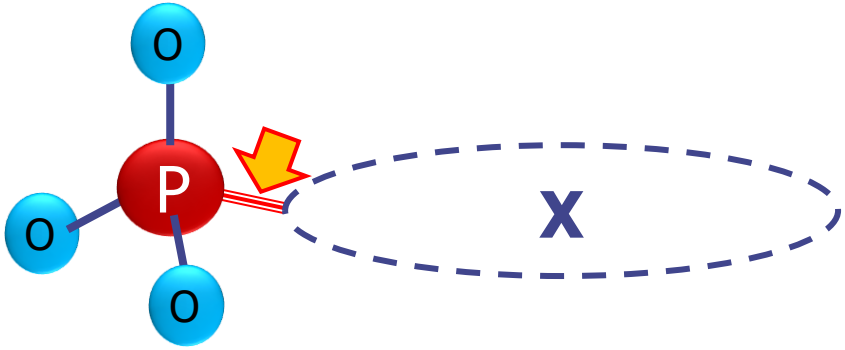
Couplage par l'utilisation d'un intermédiaire à haut potentiel d'hydrolyse



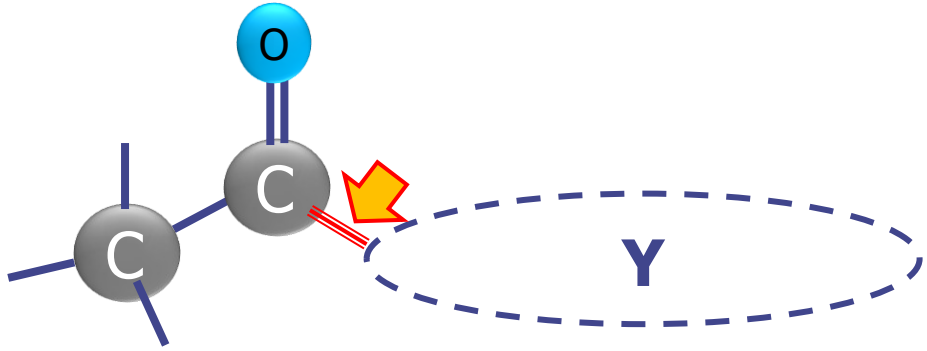
Biochimie de Harper.
4e édition. 2011. de boeck


14500 1200mAh 3.7V

Transporteurs activés
de groupe
Phosphoryle



Transporteurs activés
de groupe
Dicarboné(s)

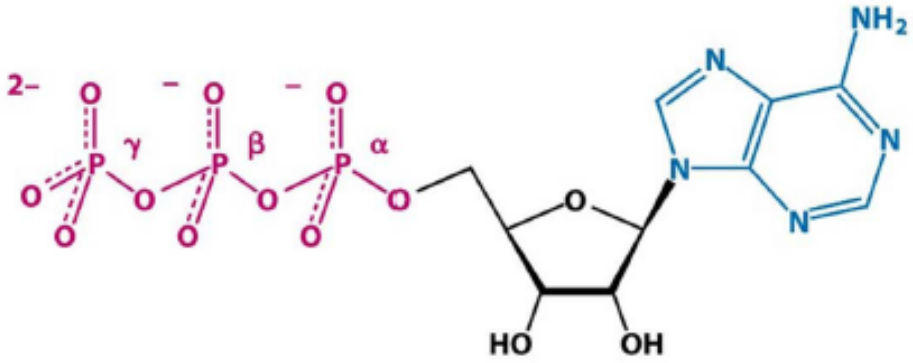



O
X

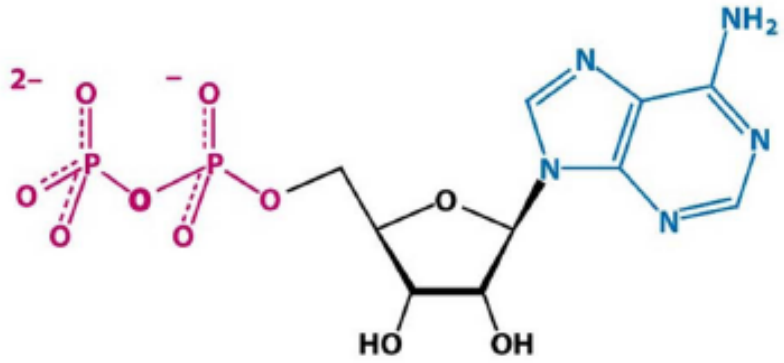
De l'énergie en boite

De l'énergie en boite

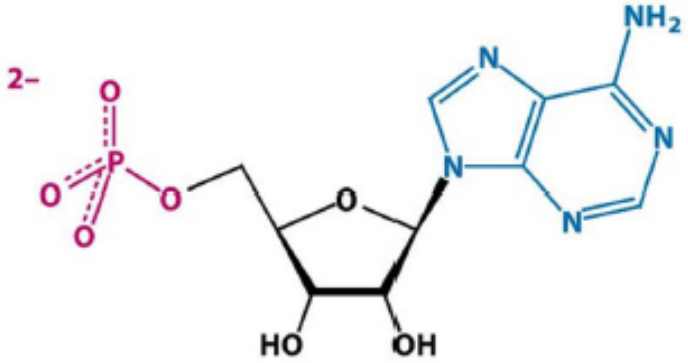
ATP : transporteur activé de groupe phosphoryle



Adenosine triphosphate (ATP)



Adenosine diphosphate (ADP)



Adenosine monophosphate (AMP)

Figure 15-3
Biochemistry, Sixth Edition

Autres transporteurs de groupe phosphoryle

TABLE 15.1 Energie libre standard d'hydrolyse des composés phosphorylés

Compound	kJ mol^{-1}	kcal mol^{-1}
ATP (to ADP)	−30.5	− 7.3

Table 15-1
Biochemistry, Sixth Edition

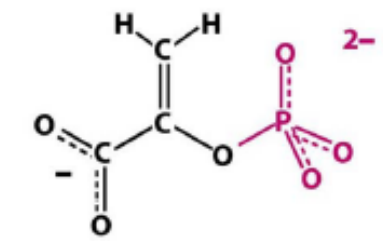
Autres transporteurs de groupe phosphoryle

TABLE 15.1 Energie libre standard d'hydrolyse des composés phosphorylés

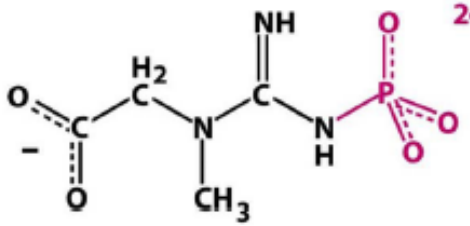
Compound	kJ mol^{-1}	kcal mol^{-1}
ATP (to ADP)	−30.5	− 7.3
Glucose 1-phosphate	−20.9	− 5.0
Pyrophosphate	−19.3	− 4.6
Glucose 6-phosphate	−13.8	− 3.3
Glycerol 3-phosphate	−9.2	− 2.2

Table 15-1
Biochemistry, Sixth Edition

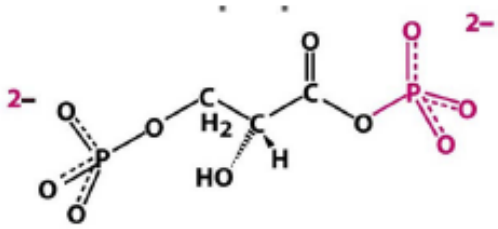
Autres transporteurs de groupe phosphoryle



Phosphoenolpyruvate (PEP)



Creatine phosphate



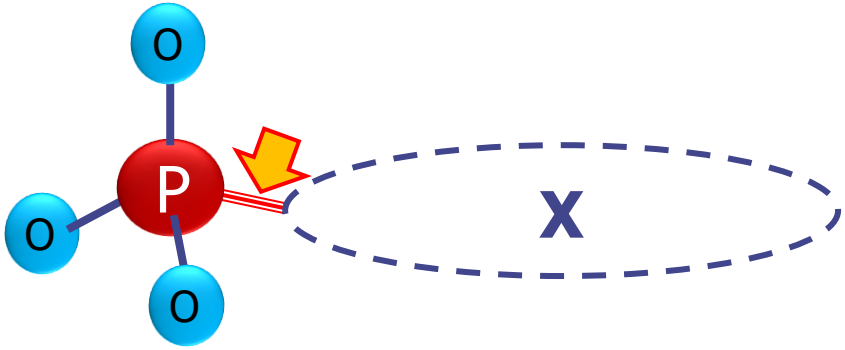
1,3-Bisphosphoglycerate (1,3-BPG)

TABLE 15.1 Energie libre standard d'hydrolyse des composés phosphorylés

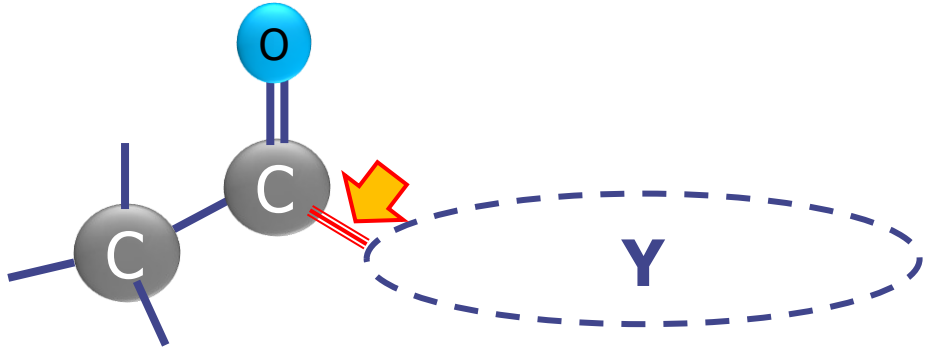
Compound	kJ mol^{-1}	kcal mol^{-1}
Phosphoenolpyruvate	−61.9	−14.8
1,3-Bisphosphoglycerate	−49.4	−11.8
Creatine phosphate	−43.1	−10.3
ATP (to ADP)	−30.5	− 7.3
Glucose 1-phosphate	−20.9	− 5.0
Pyrophosphate	−19.3	− 4.6
Glucose 6-phosphate	−13.8	− 3.3
Glycerol 3-phosphate	−9.2	− 2.2

Table 15-1
Biochemistry, Sixth Edition

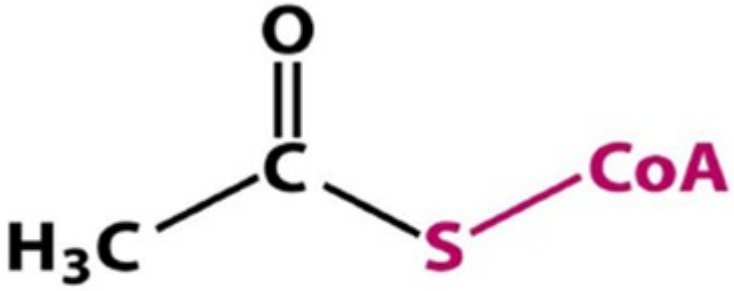
Transporteurs activés
de groupe
Phosphoryle



Transporteurs activés
de groupe
Dicarboné(s)



Transporteur activé de groupe dicarbonés



Acétyl CoA (Coenzyme A)

$$\text{Acétyl CoA} + H_2O \rightleftharpoons \text{acétate} + \text{CoA} + H^+$$

$$\Delta G°' = -31.4 \text{ kJ/mol}$$

Transporteur activé de groupe dicarbonés

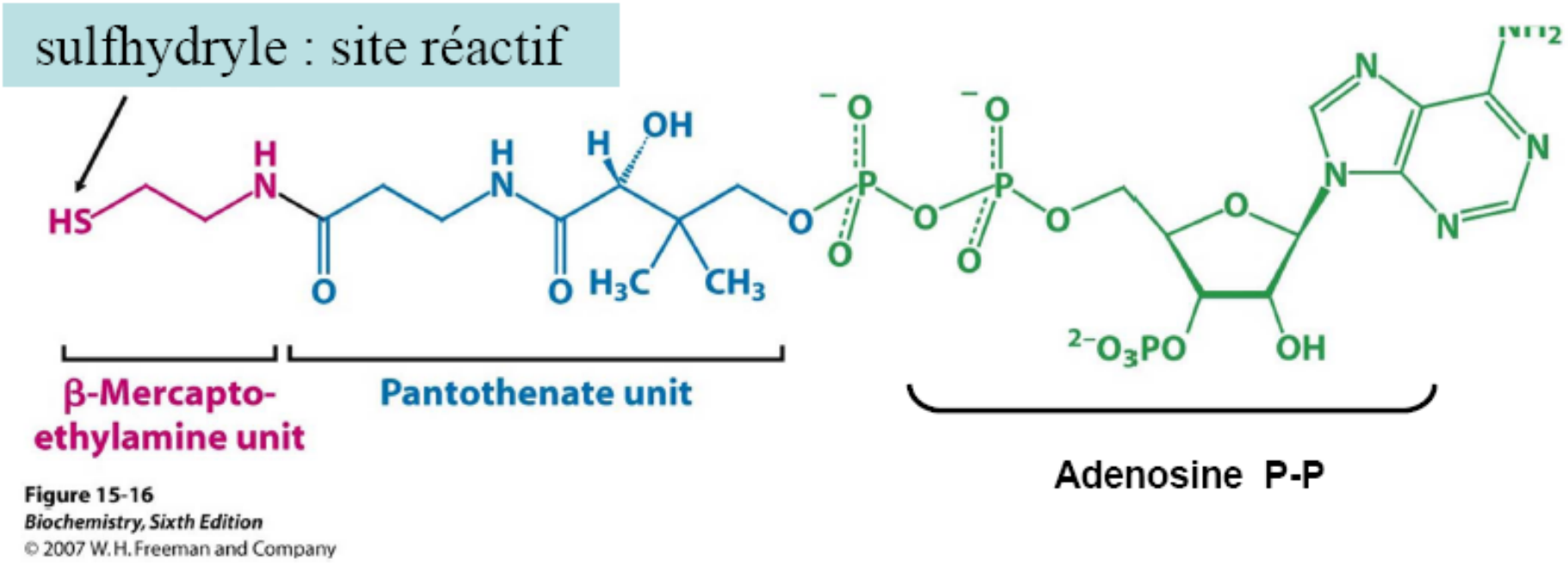


Figure 15-16
Biochemistry, Sixth Edition

Coenzyme A : CoA ou CoA-SH

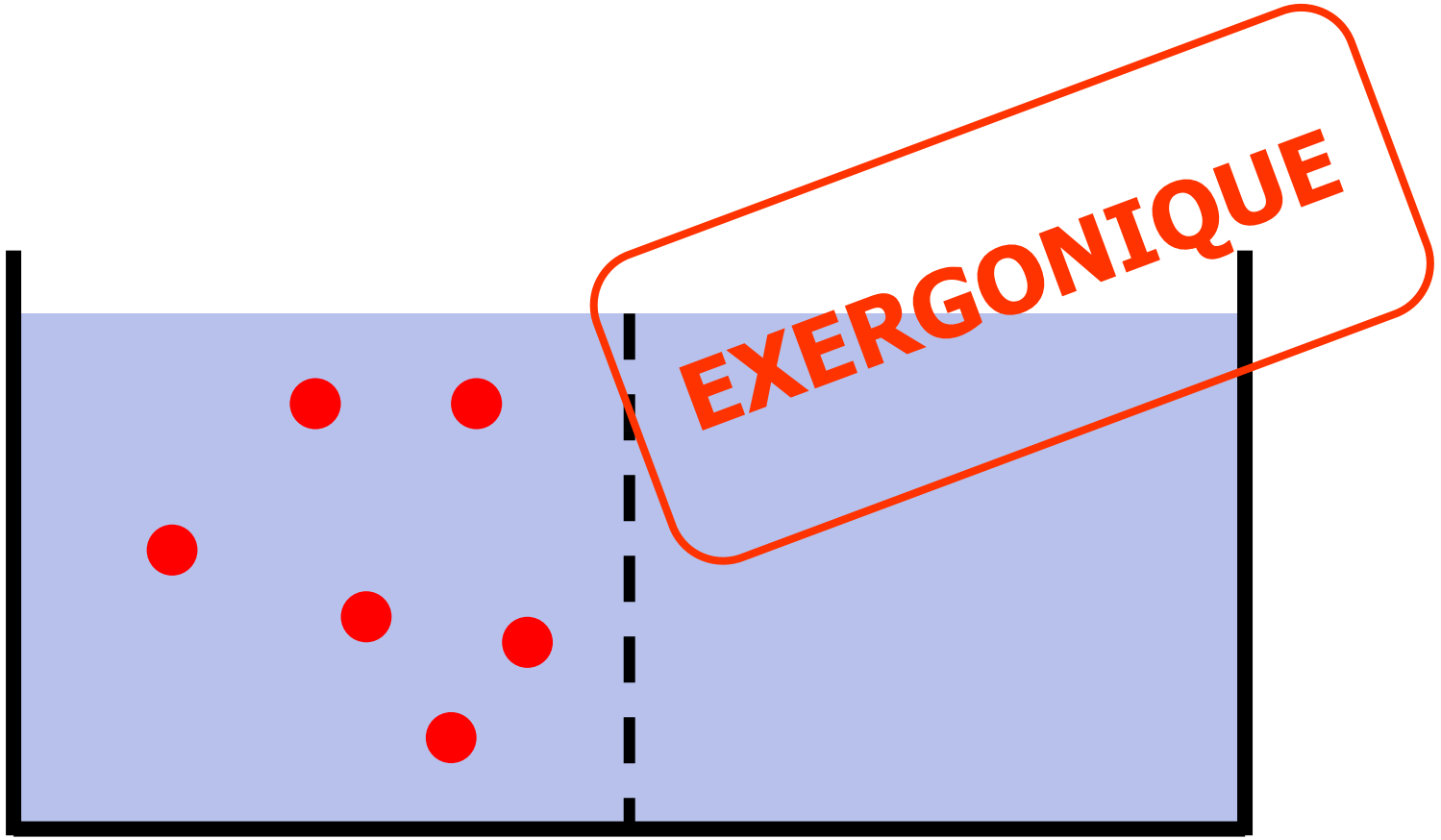
De l'énergie en boite

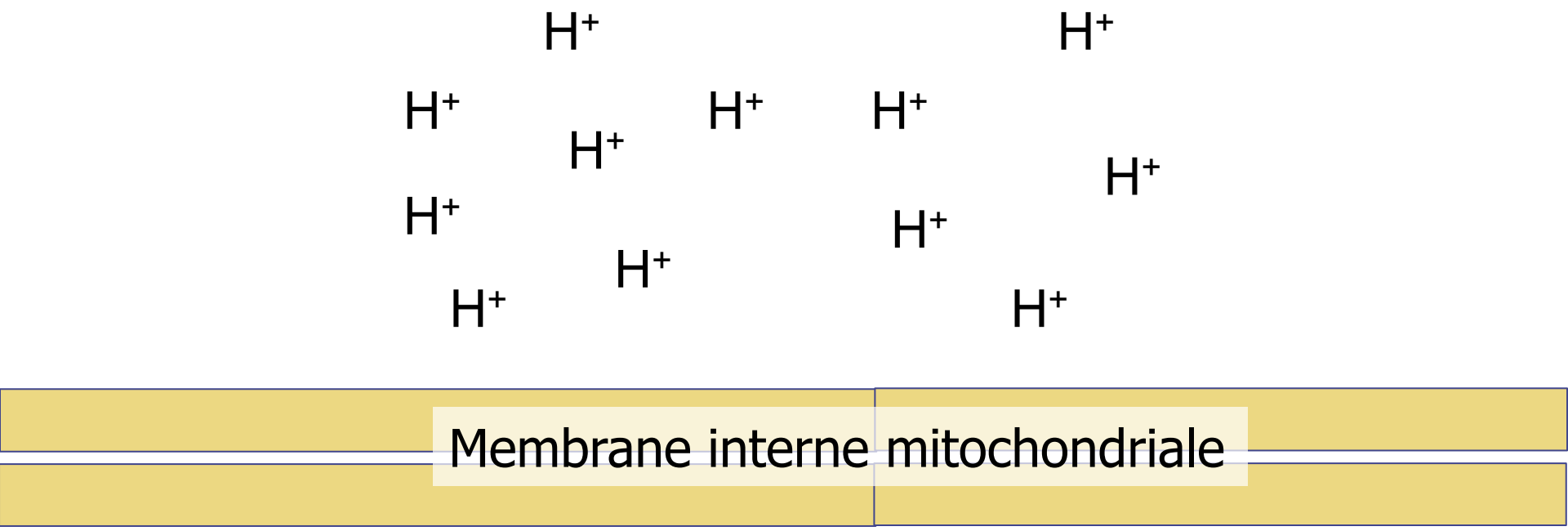
Travail Chimique
Travail Osmotique
Travail Mécanique

ATP
ou Acétyl CoA

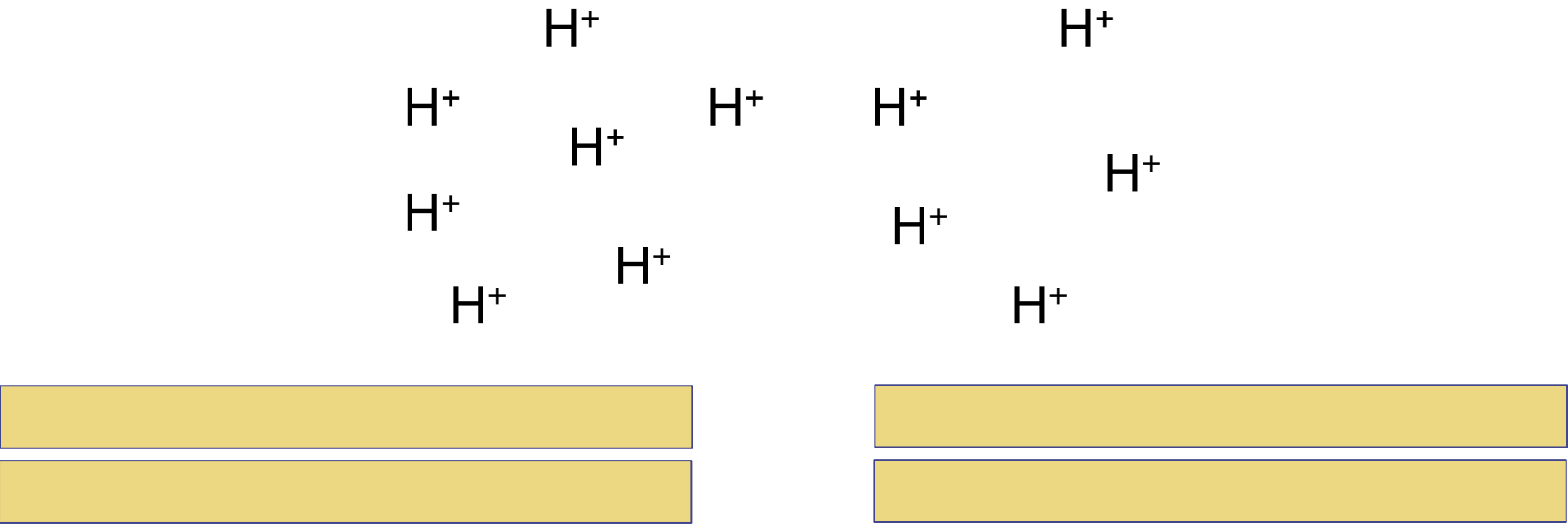
ADP + Pi
ou Acétate + CoA

?

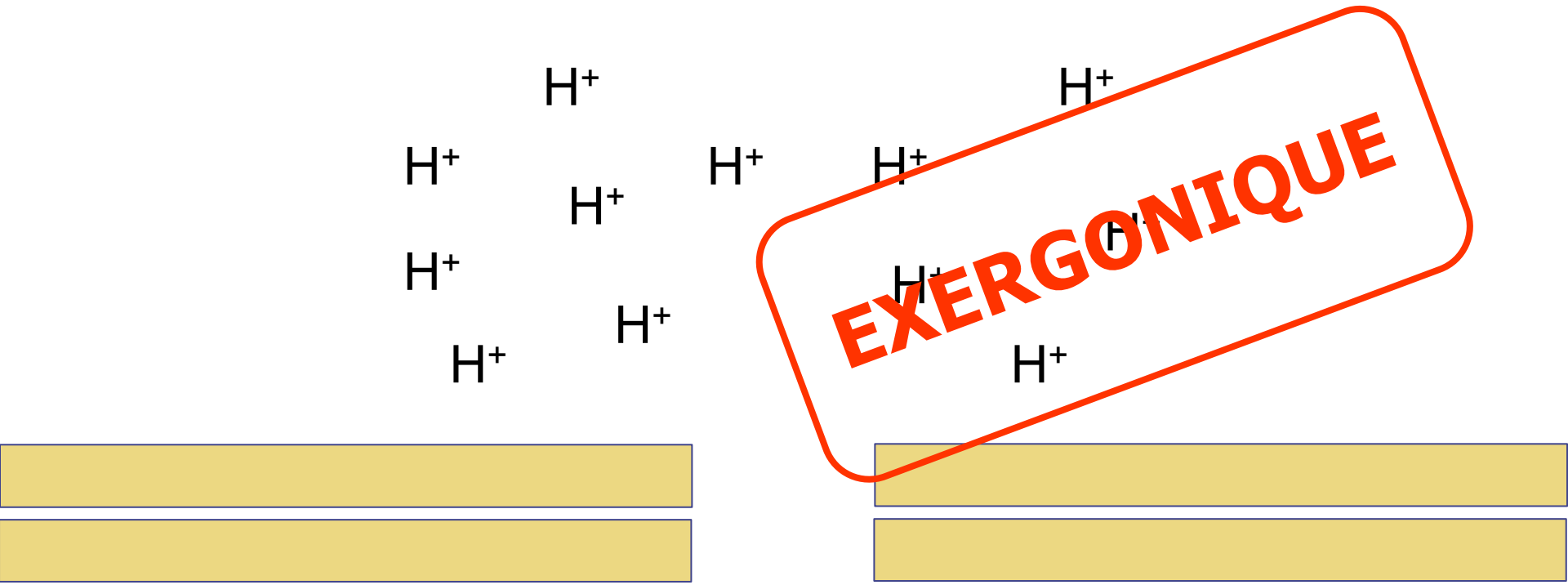

EXERGONIQUE



Matrice mitochondriale

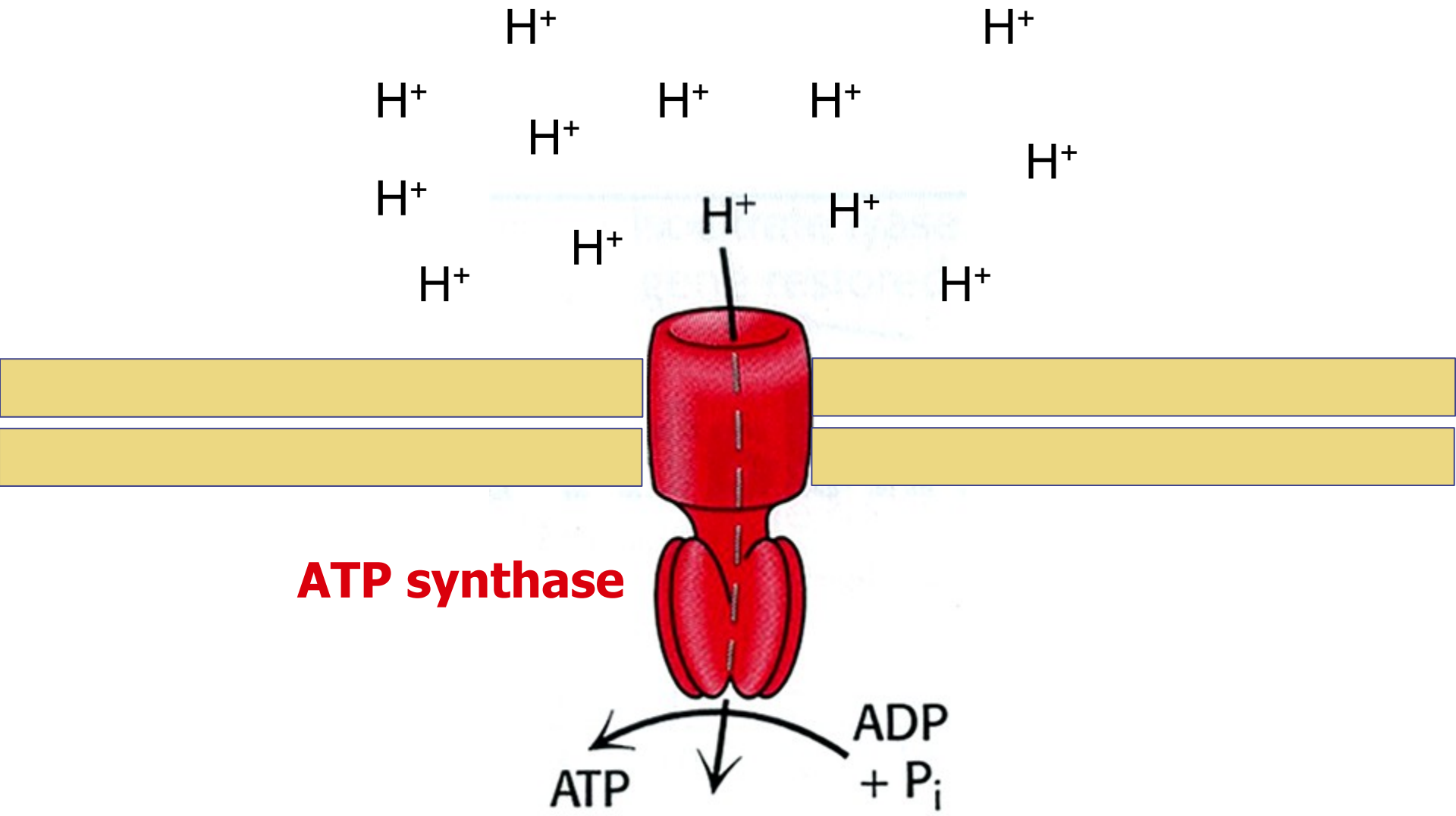


Matrice mitochondriale

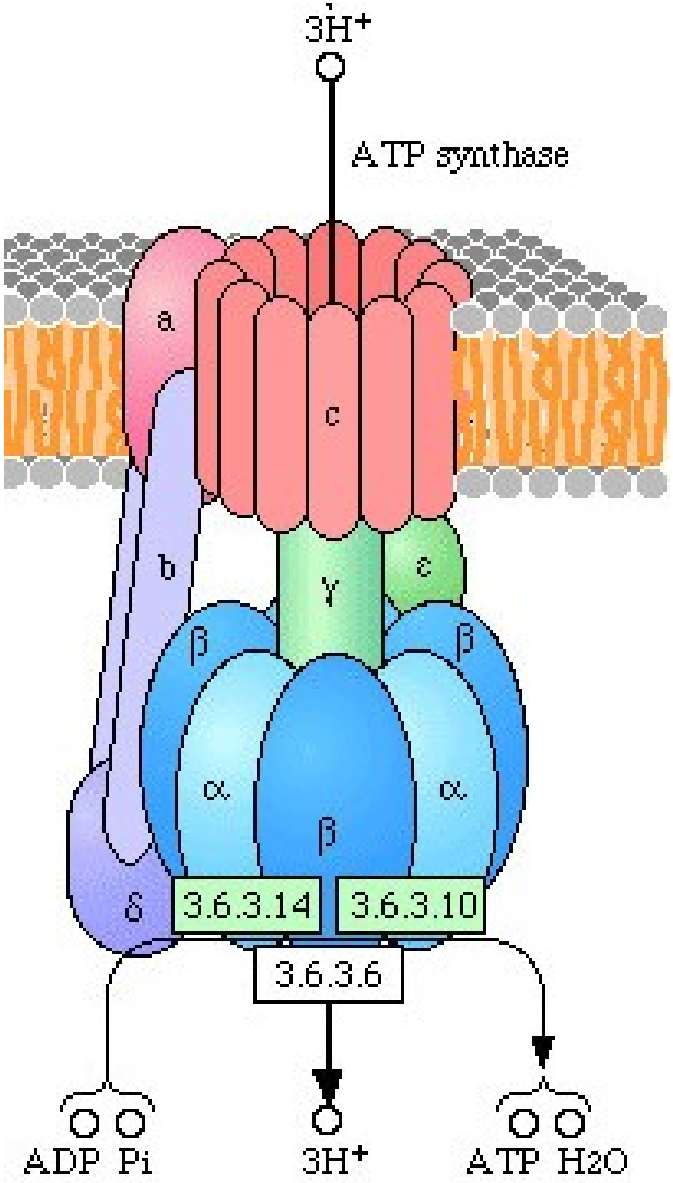


Matrice mitochondriale

Couplage



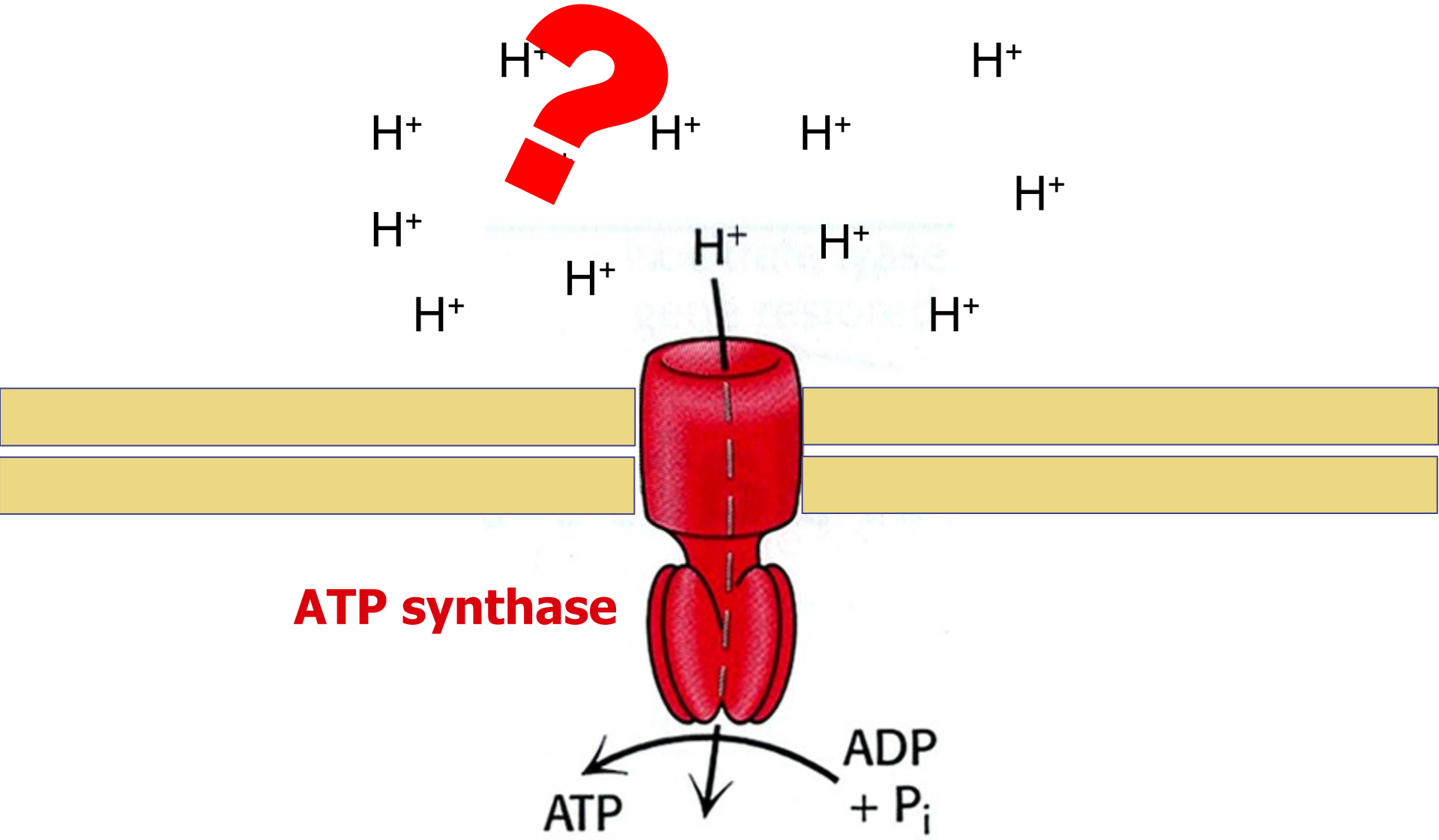
ATP Synthase

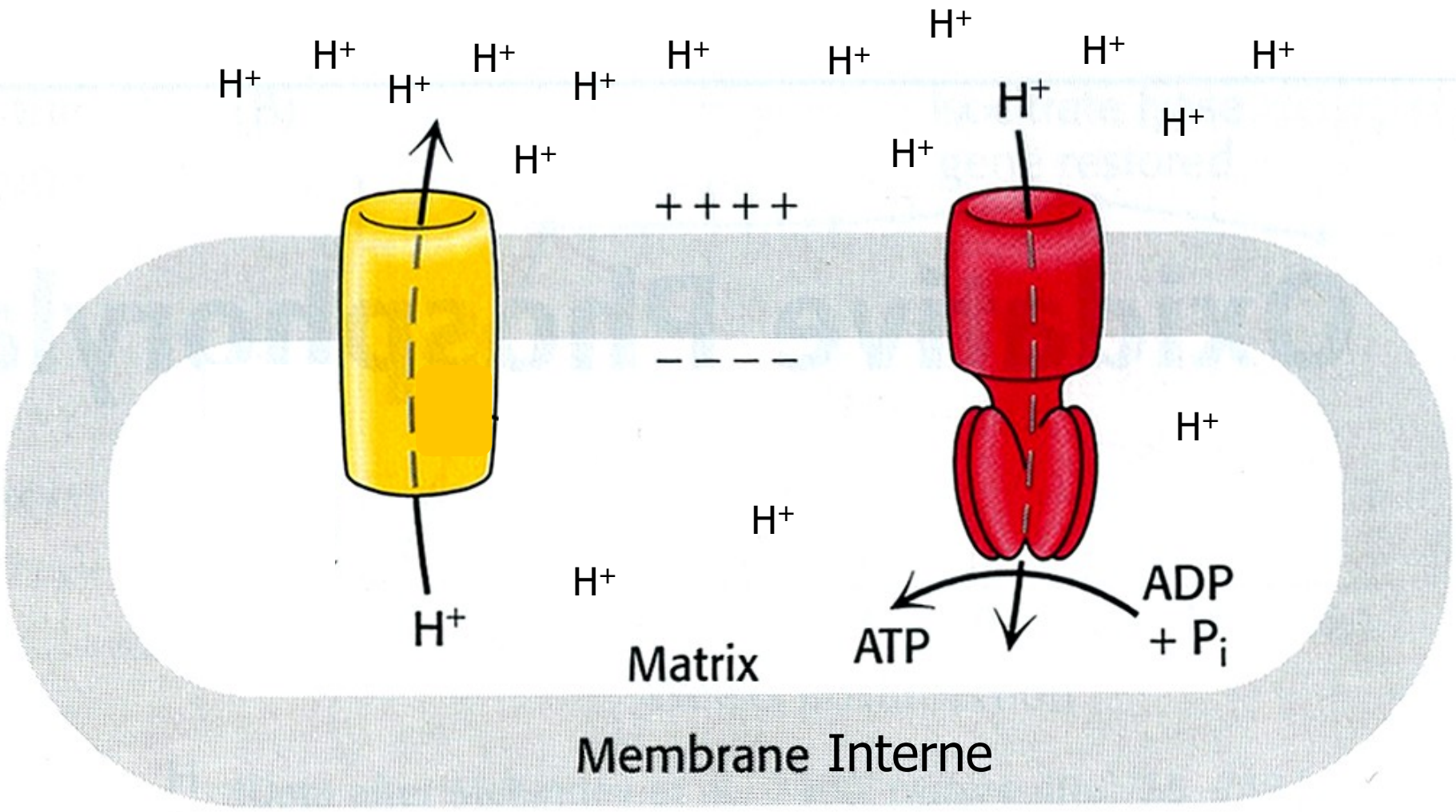


ATP Synthase

https://www.youtube.com/watch?v=3y1dO4nNaKY

Couplage

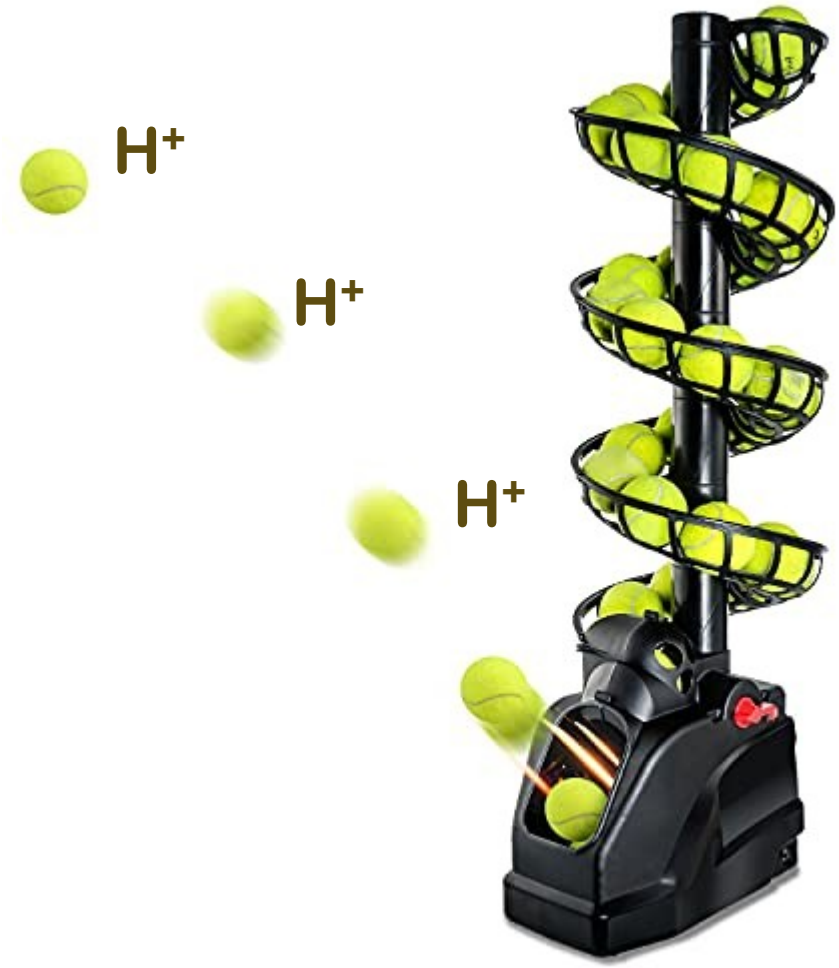


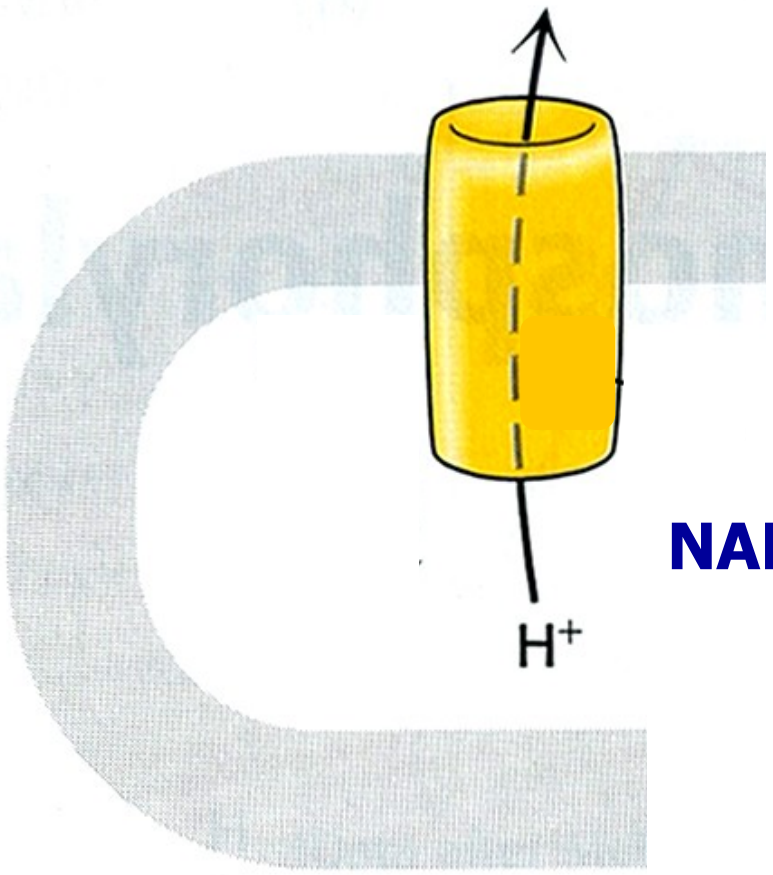

H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
++++

ADP
+ Pi
ATP
Matrix
Membrane Interne

La chaine respiratoire

La chaine de transport des électrons

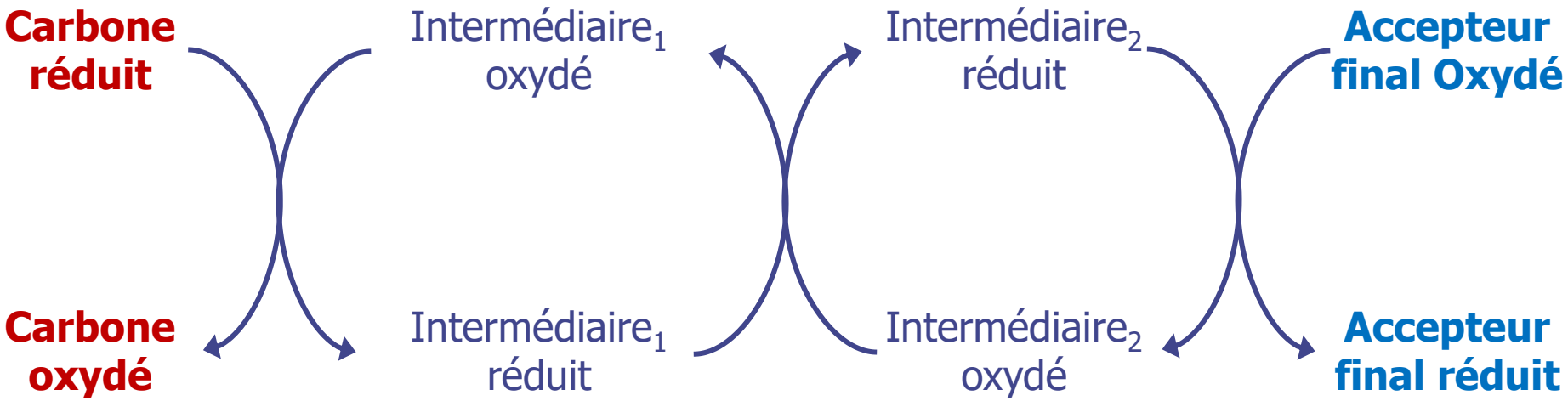

H+
H+
H+

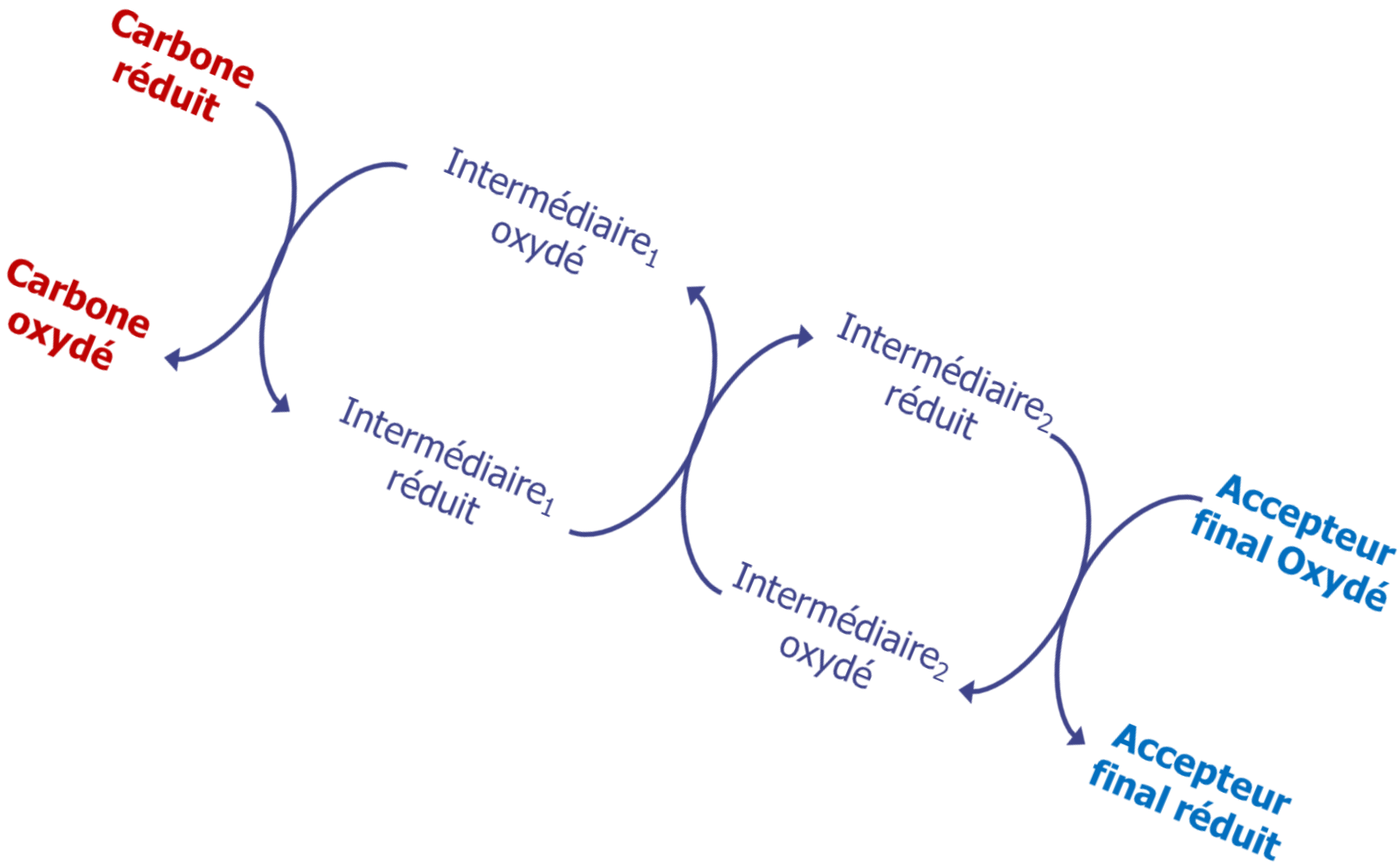


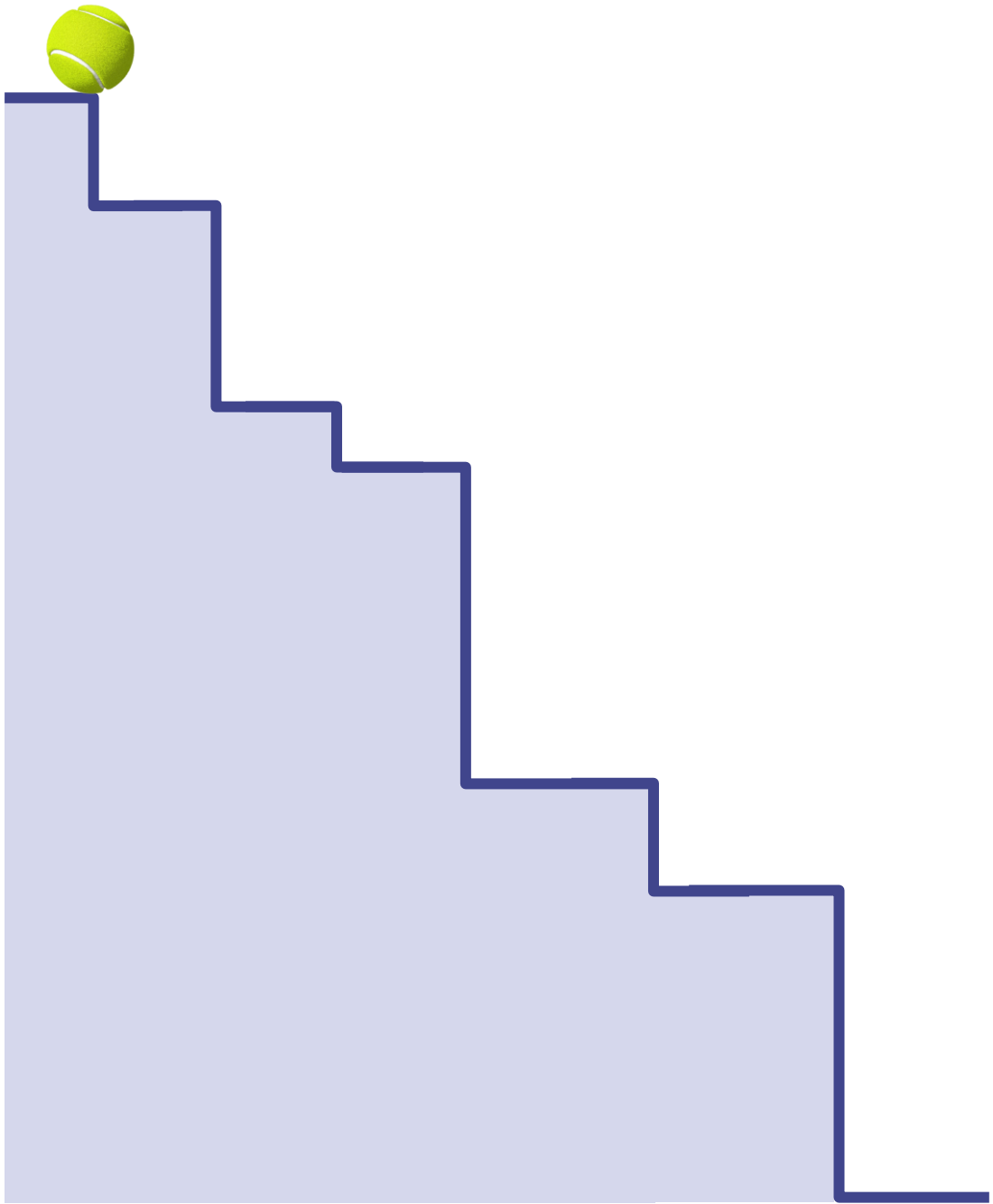
Système	E'_0 Volts
H^+/H_2	– 0,42
NAD^+/NADH	– 0,32
Lipoate ; oxydé/réduit	– 0,29
Acétoacétate/3-hydroxybutyrate	– 0,27
Pyruvate/lactate	– 0,19
Oxaloacétate/malate	– 0,17
Fumarate/succinate	+ 0,03
Cytochrome *b* ; Fe^{3+}/Fe^{2+}	+ 0,08
Ubi[illegible]one ; ox/red	+ 0,10
Cyto[illegible] Fe^{3+}/F	+ 0,22
Cytoch[illegible]	
	+ 0,82

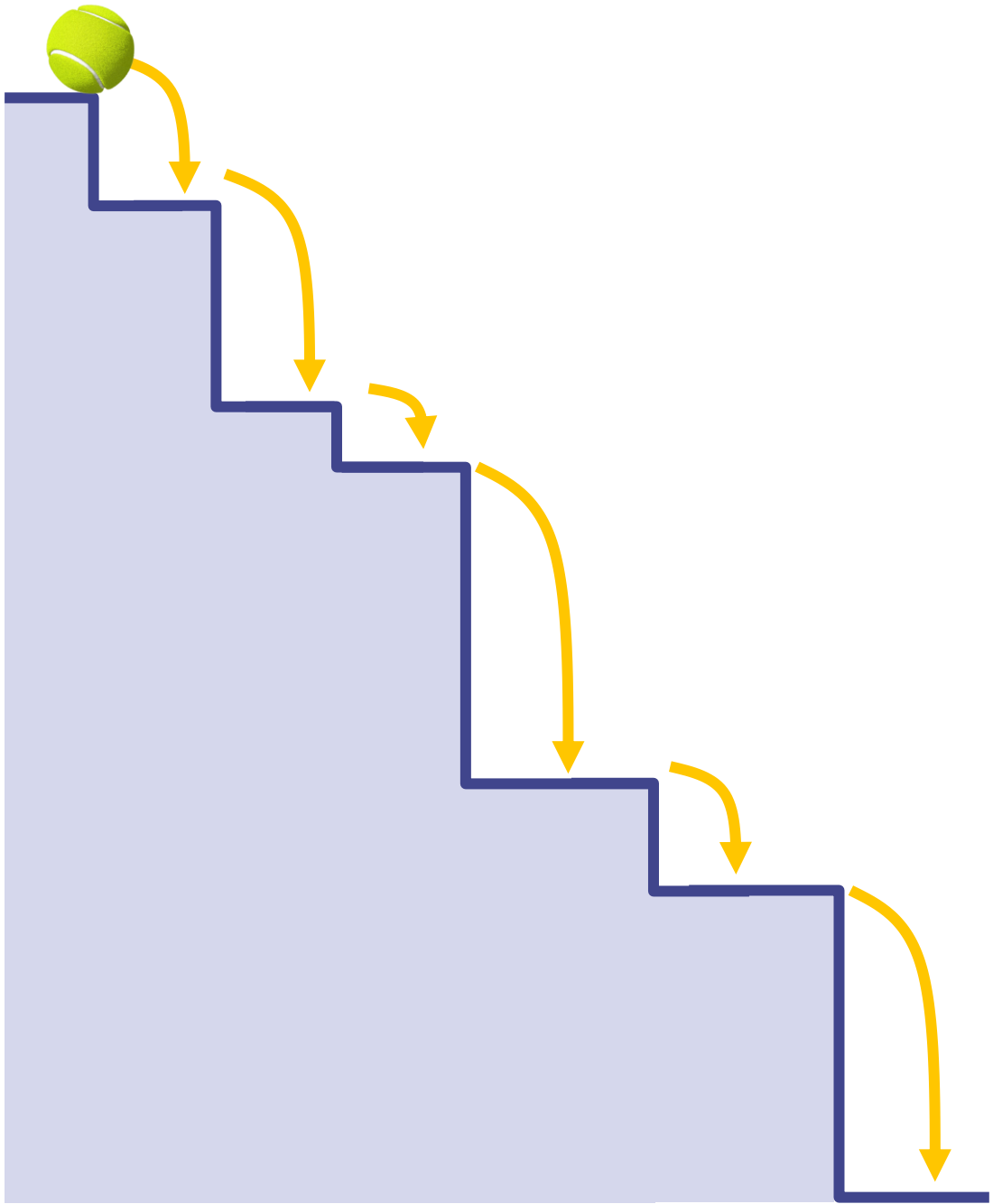
NADH + H^+ + ½ O_2 → NAD^+ + H_2O

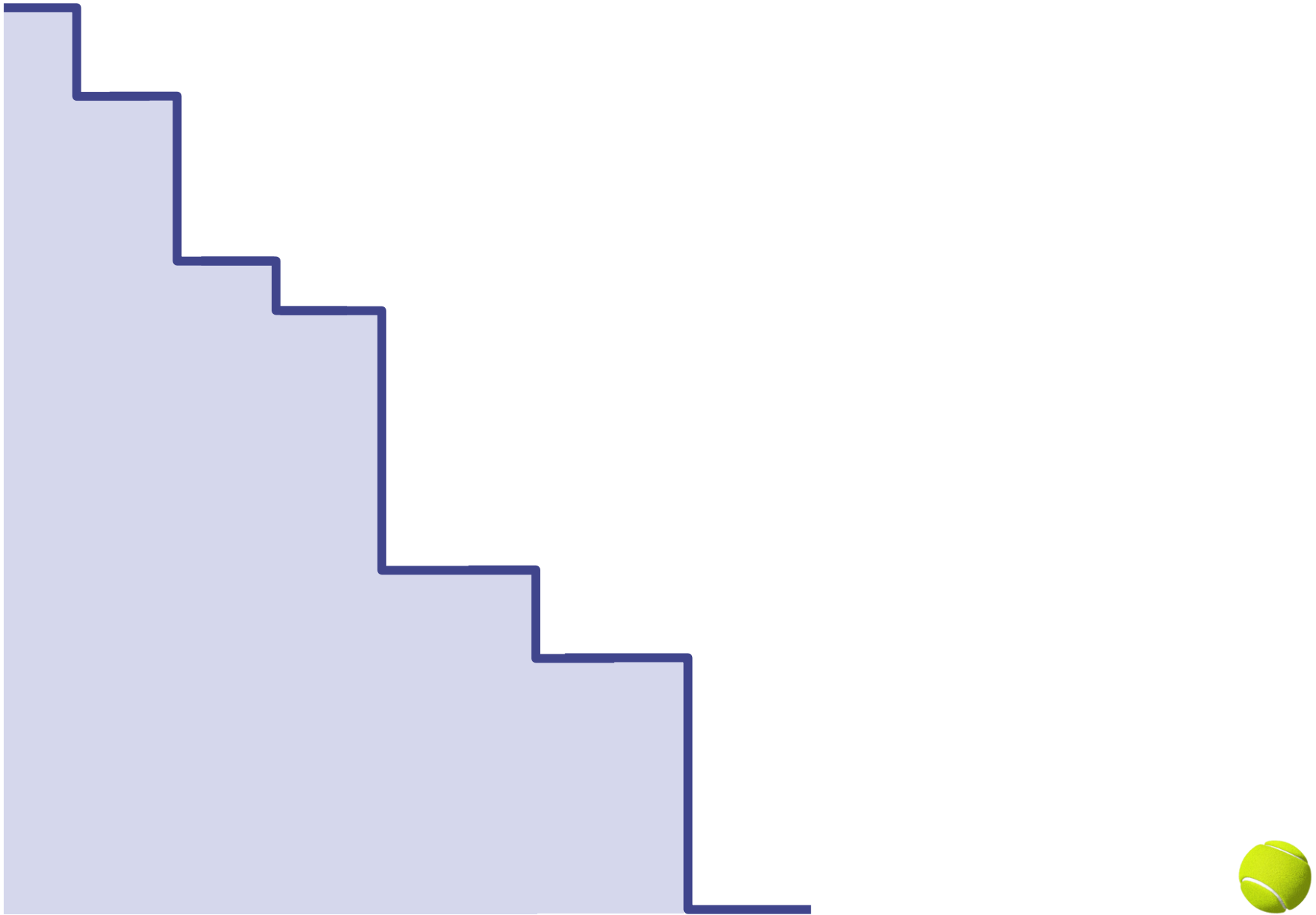

© Br

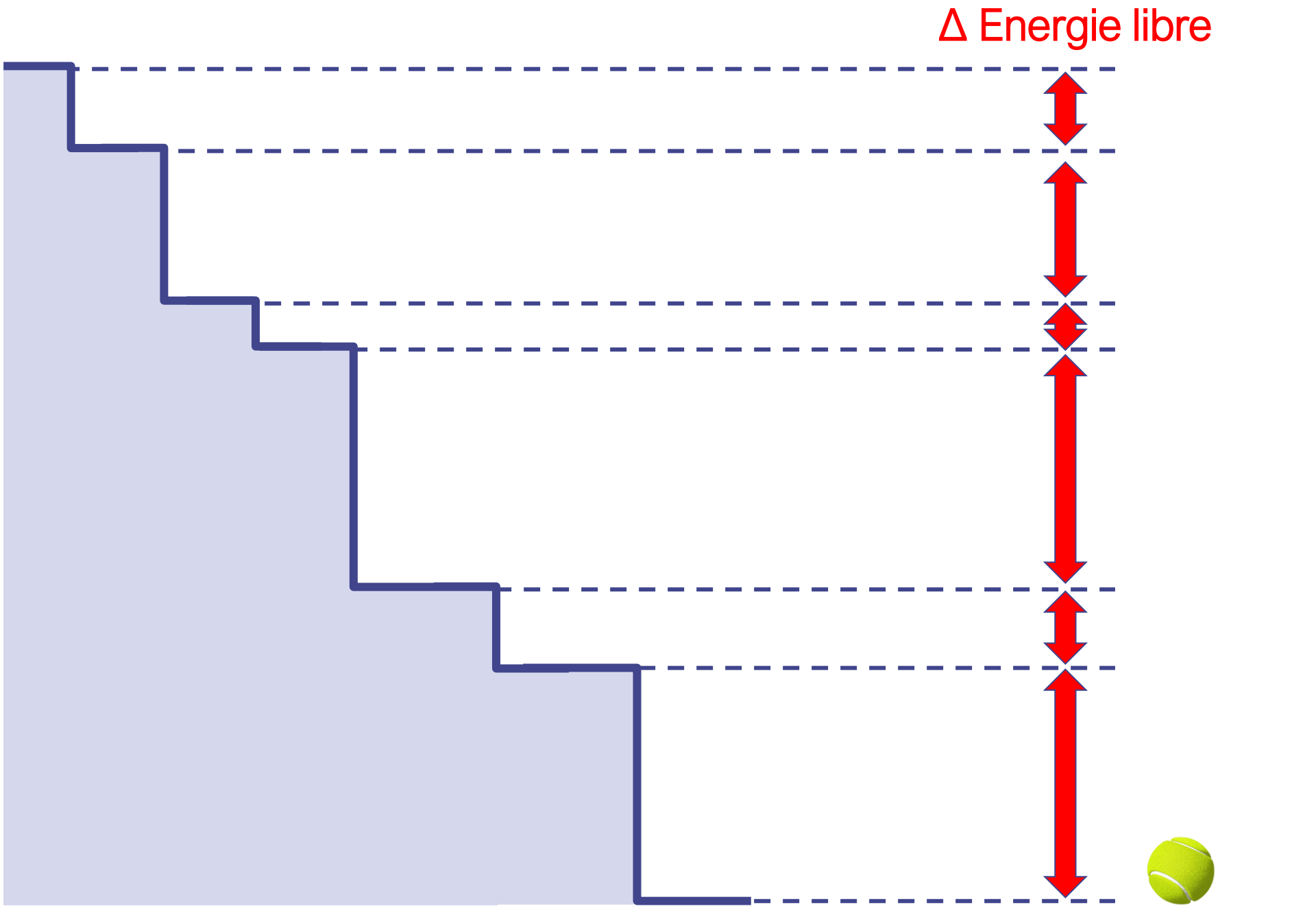

Carbone réduit
Carbone oxydé
Intermédiaire1 oxydé
Intermédiaire1 réduit
Intermédiaire2 réduit
Intermédiaire2 oxydé
Accepteur final Oxydé
Accepteur final réduit

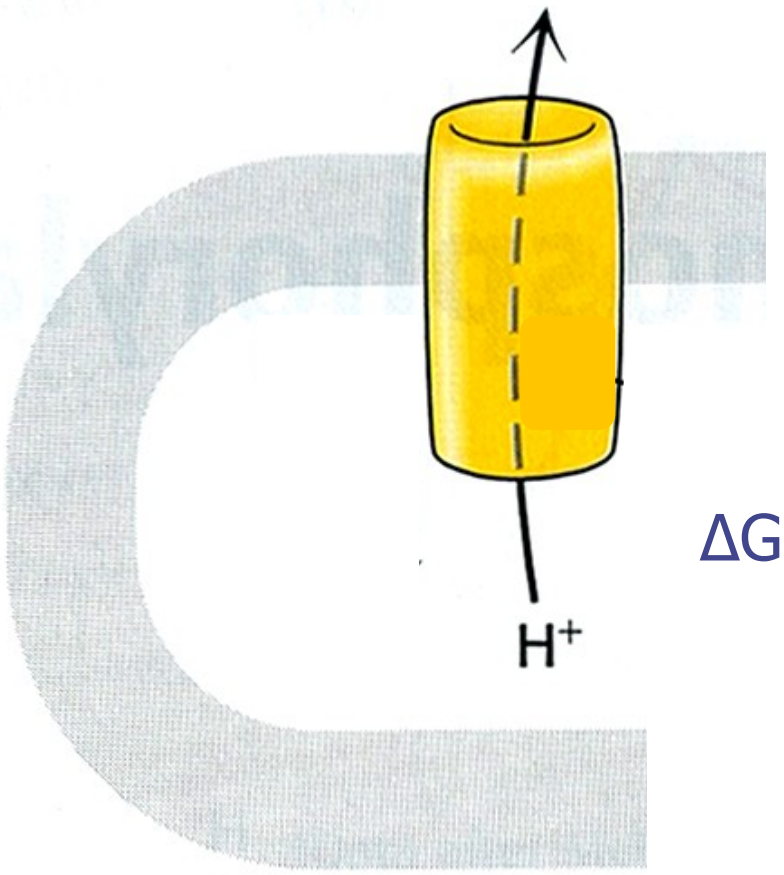

Carbone réduit
Carbone oxydé
Intermédiaire1 oxydé
Intermédiaire1 réduit
Intermédiaire2 réduit
Intermédiaire2 oxydé
Accepteur final Oxydé
Accepteur final réduit



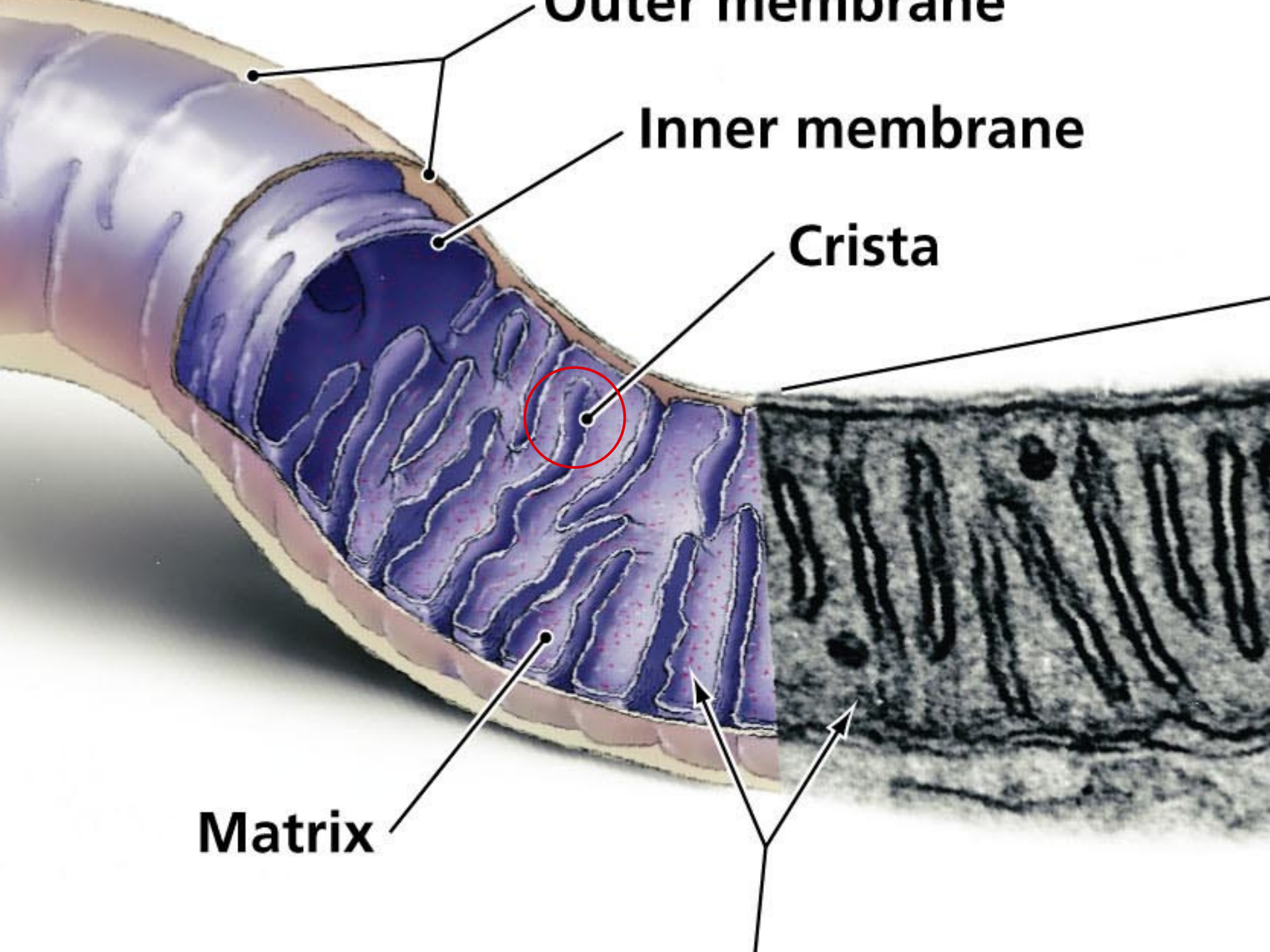


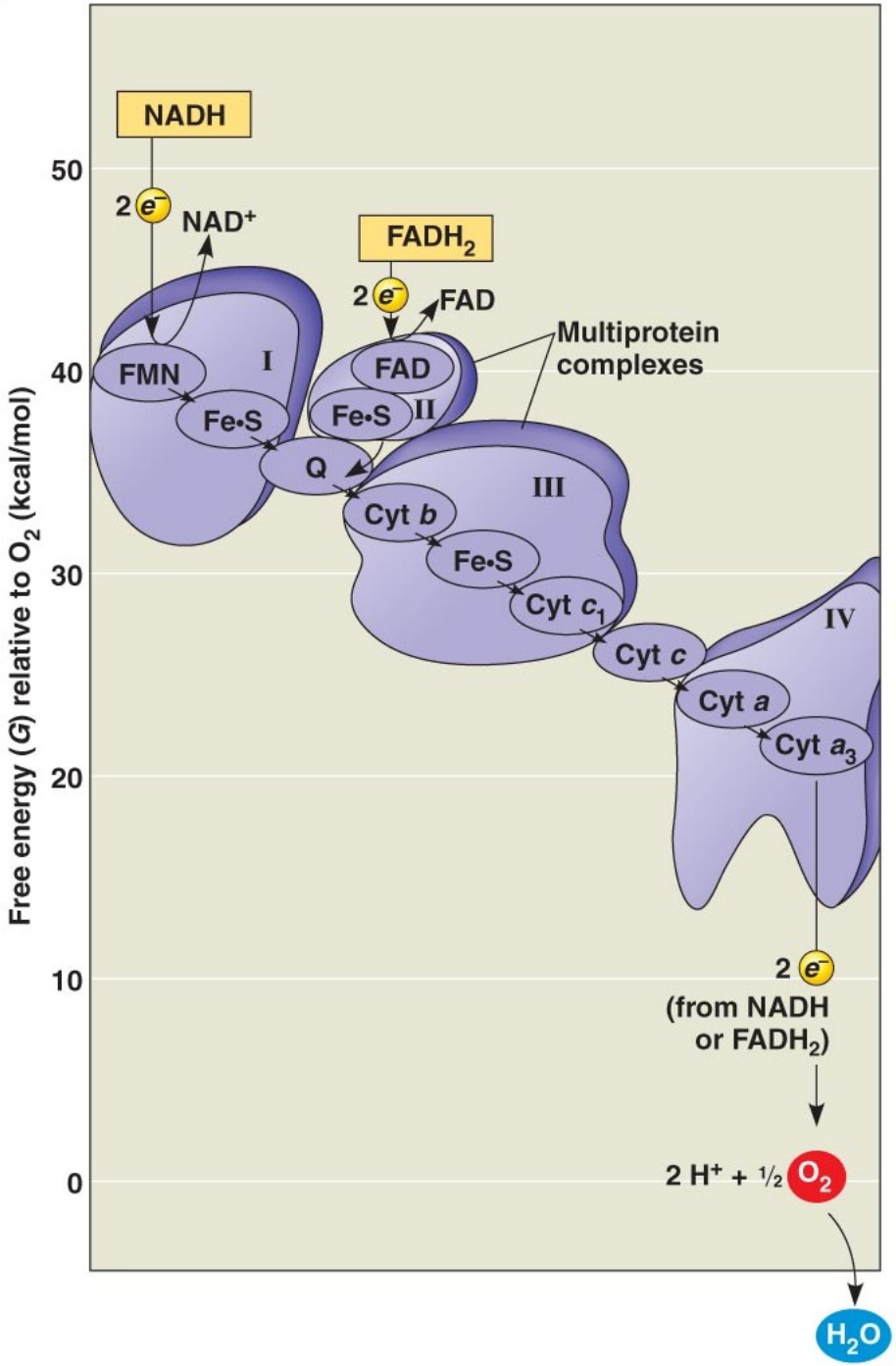


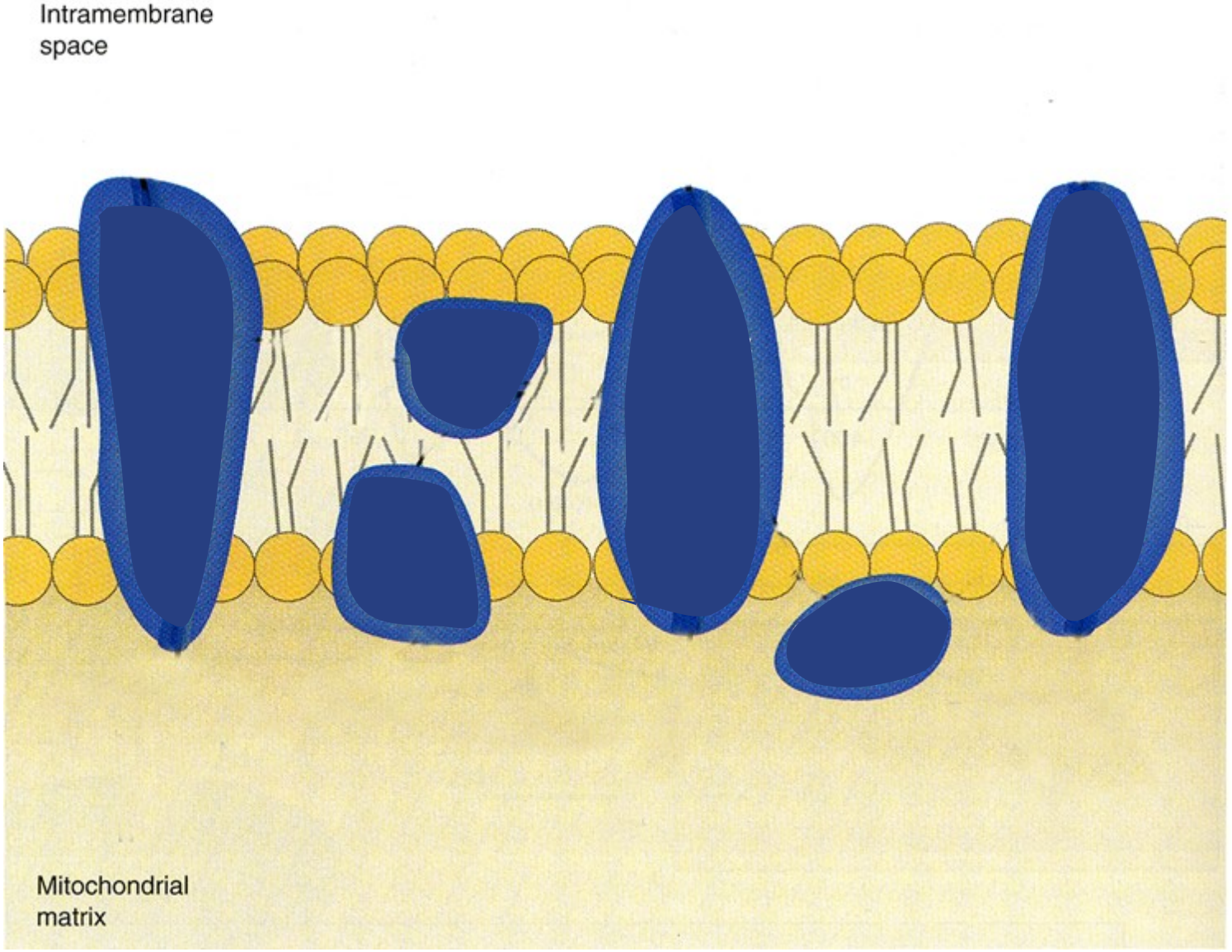

Δ Energie libre

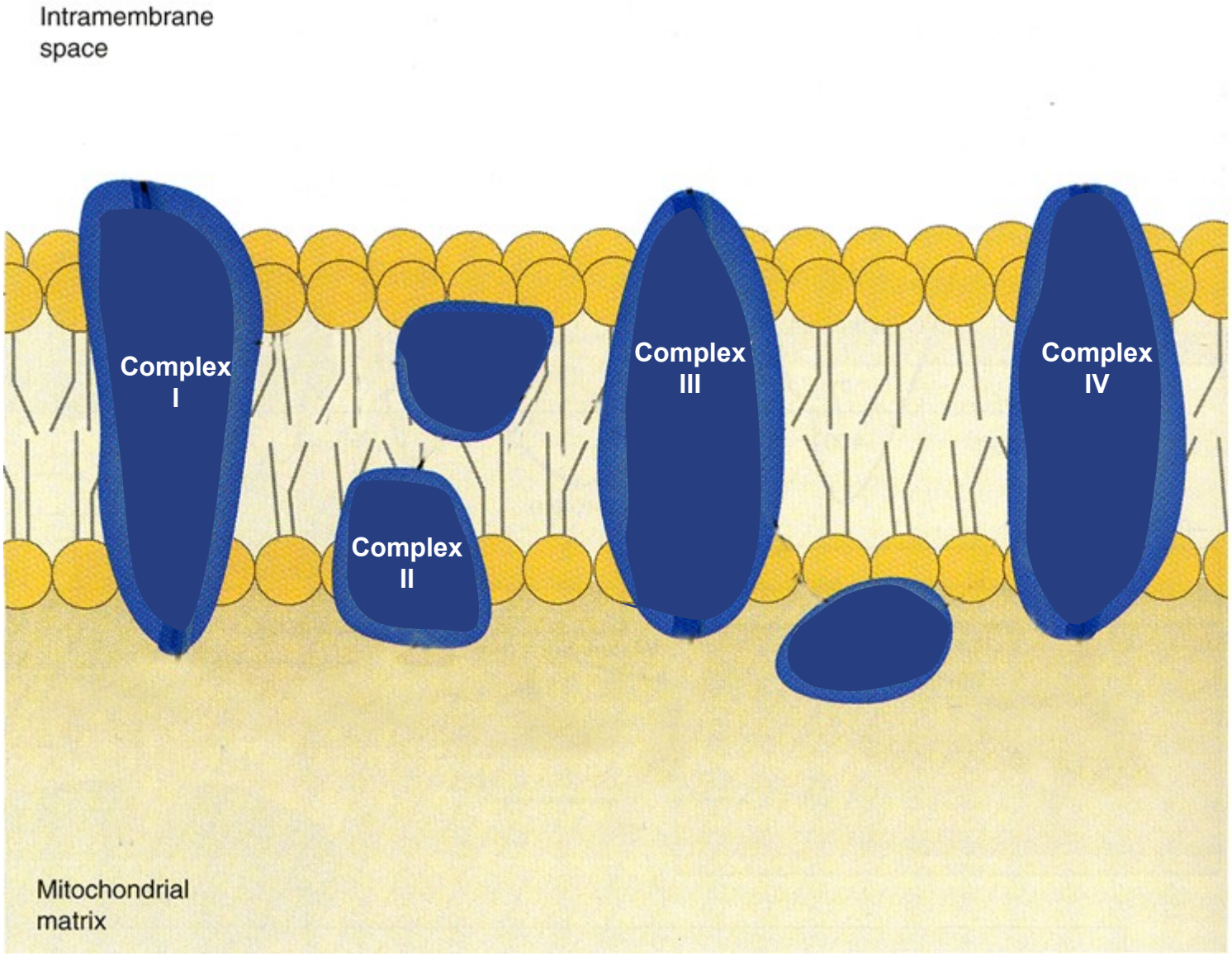


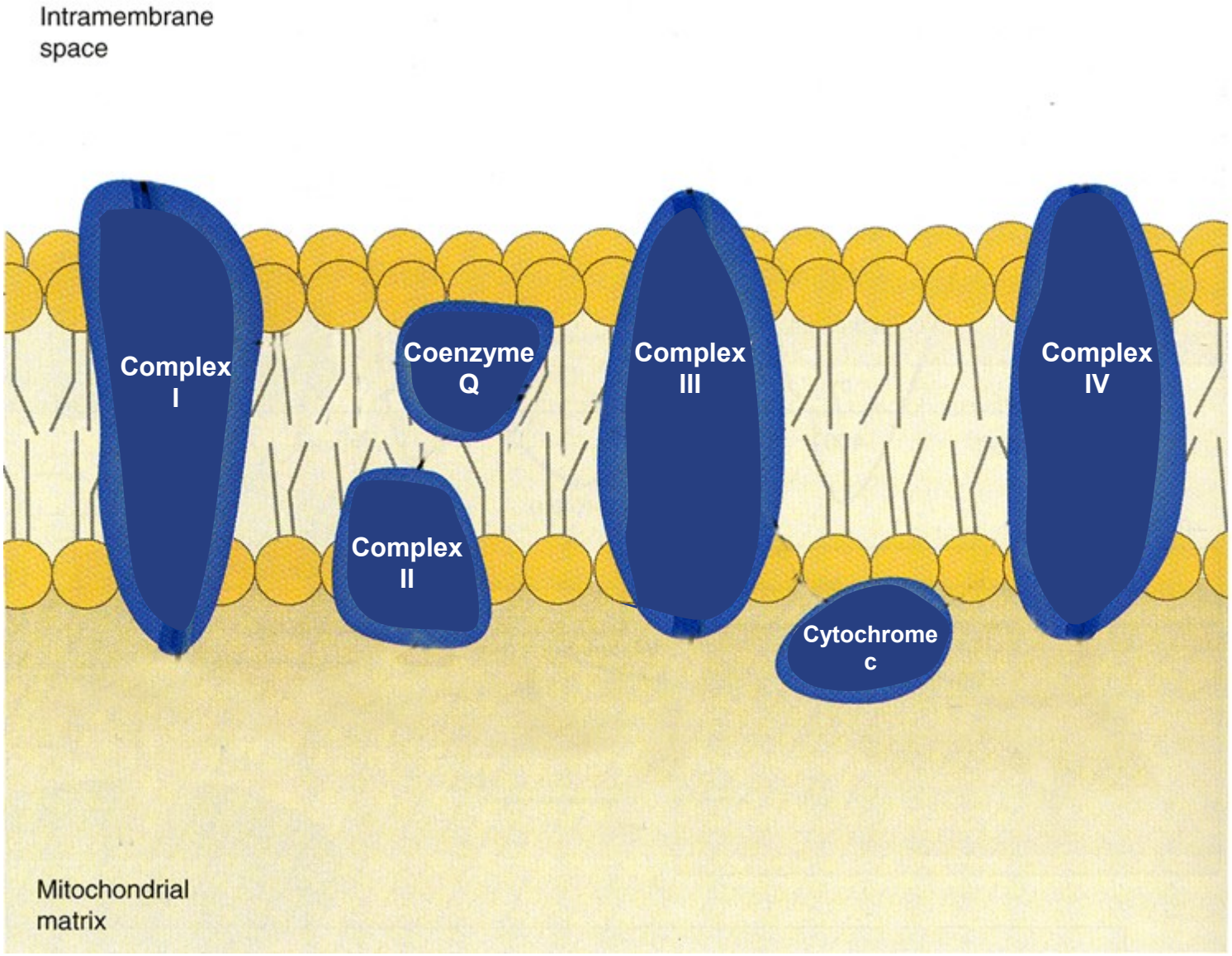
$\Delta G'_0$ suffisante

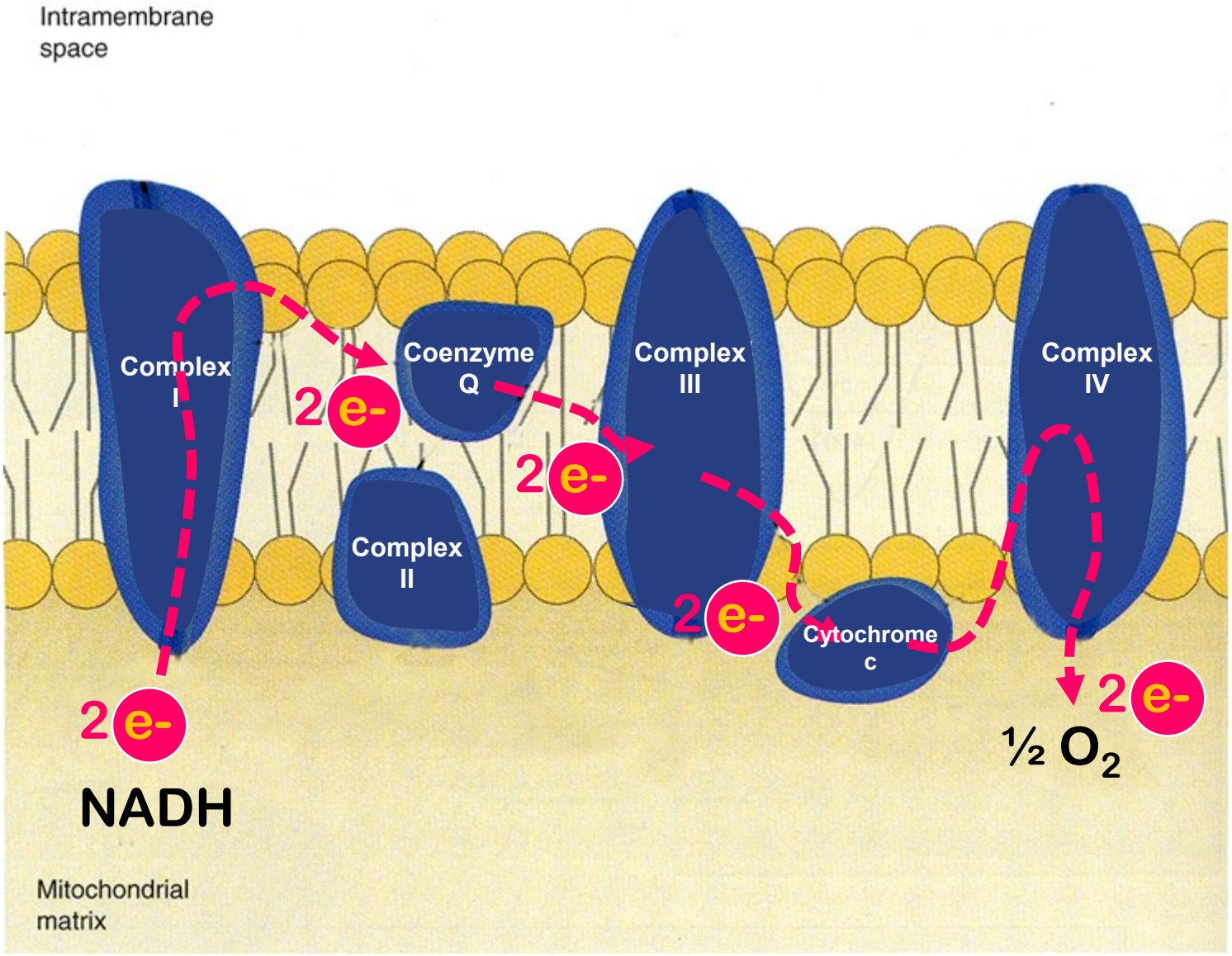

Outer membrane
Inner membrane
Crista
Matrix

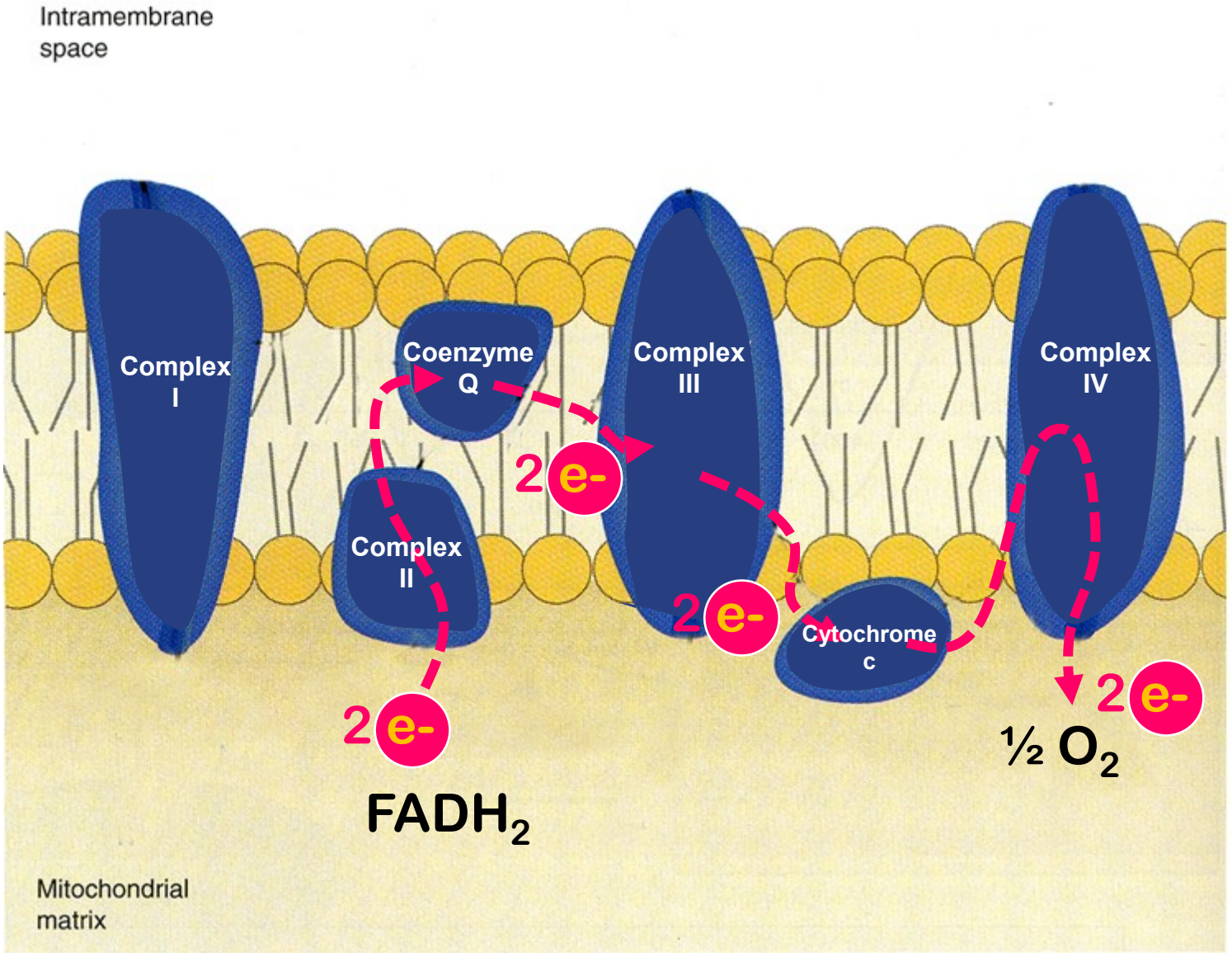


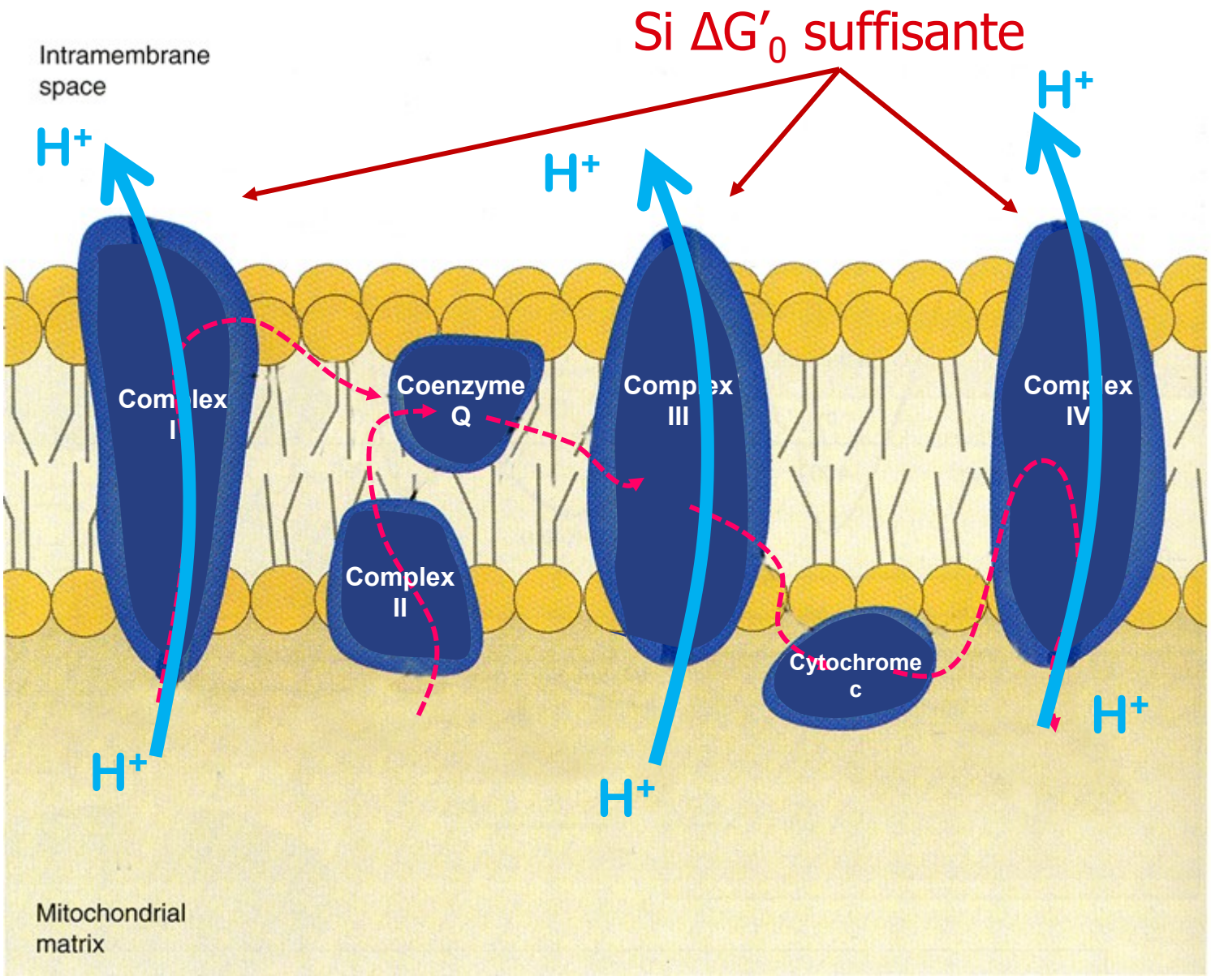

Intramembrane
space
Mitochondrial
matrix

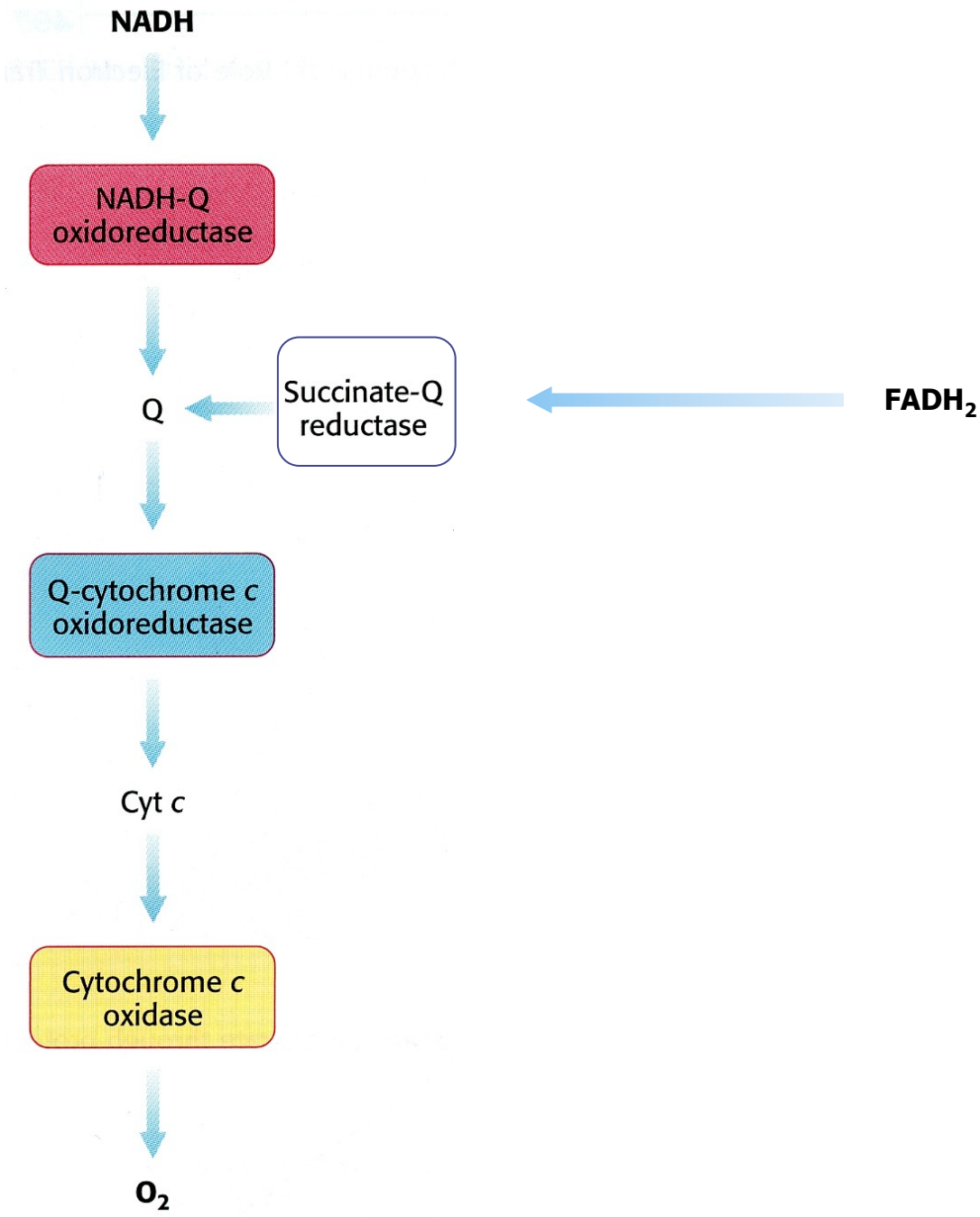

Intramembrane space
Complex I
Complex II
Complex III
Complex IV
Mitochondrial matrix


Intramembrane space
Complex I
Coenzyme Q
Complex II
Complex III
Cytochrome c
Complex IV
Mitochondrial matrix

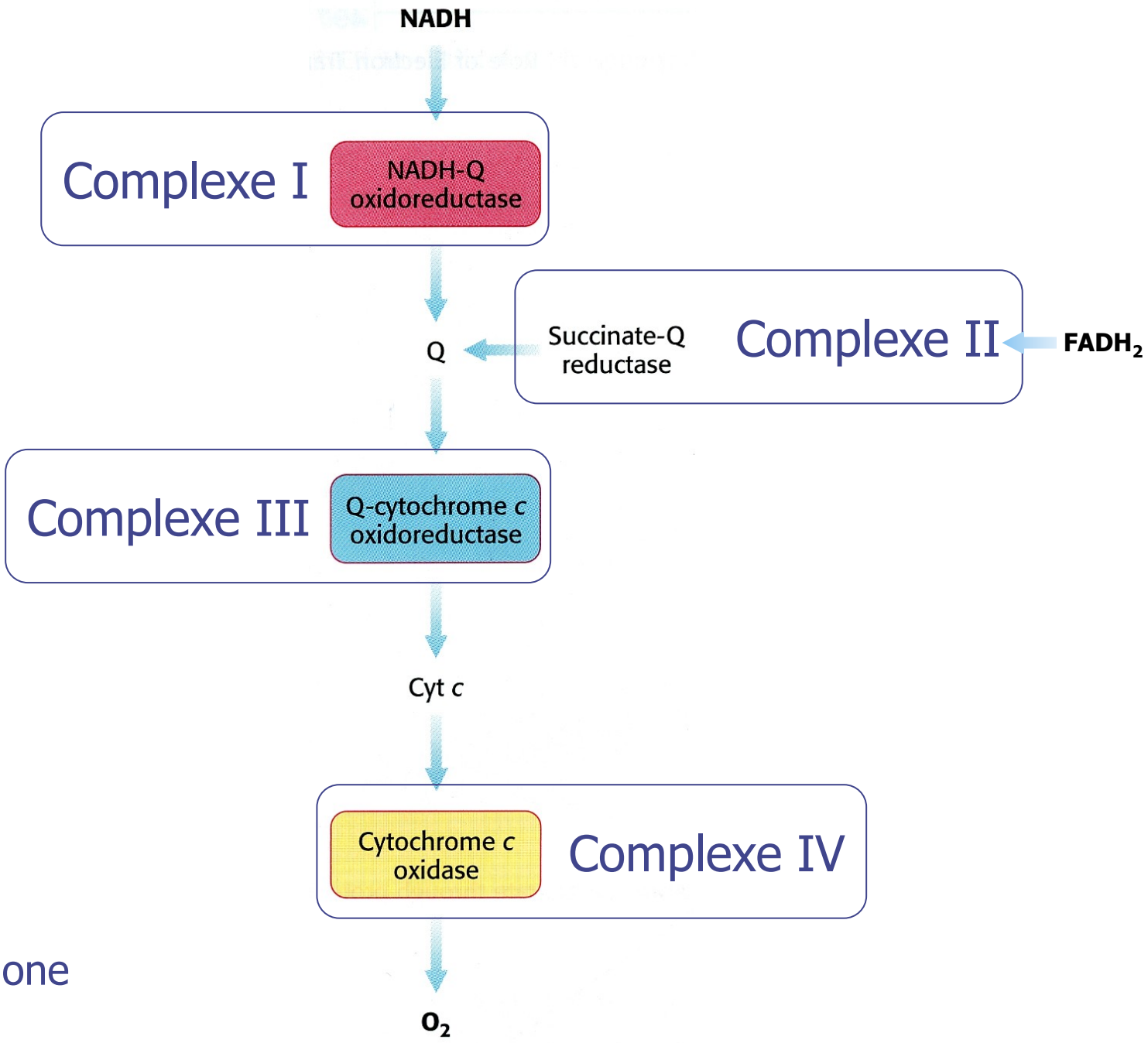

Intramembrane space
Complex I
2 e-
Coenzyme Q
Complex III
Complex IV
2 e-
Complex II
2 e-
Cytochrome c
2 e-
½ O2
2 e-
NADH
Mitochondrial matrix


Intramembrane space
Complex I
Coenzyme Q
Complex II
Complex III
Complex IV
2 e-
2 e-
Cytochrome c
2 e-
2 e-
½ O2
FADH2
Mitochondrial matrix

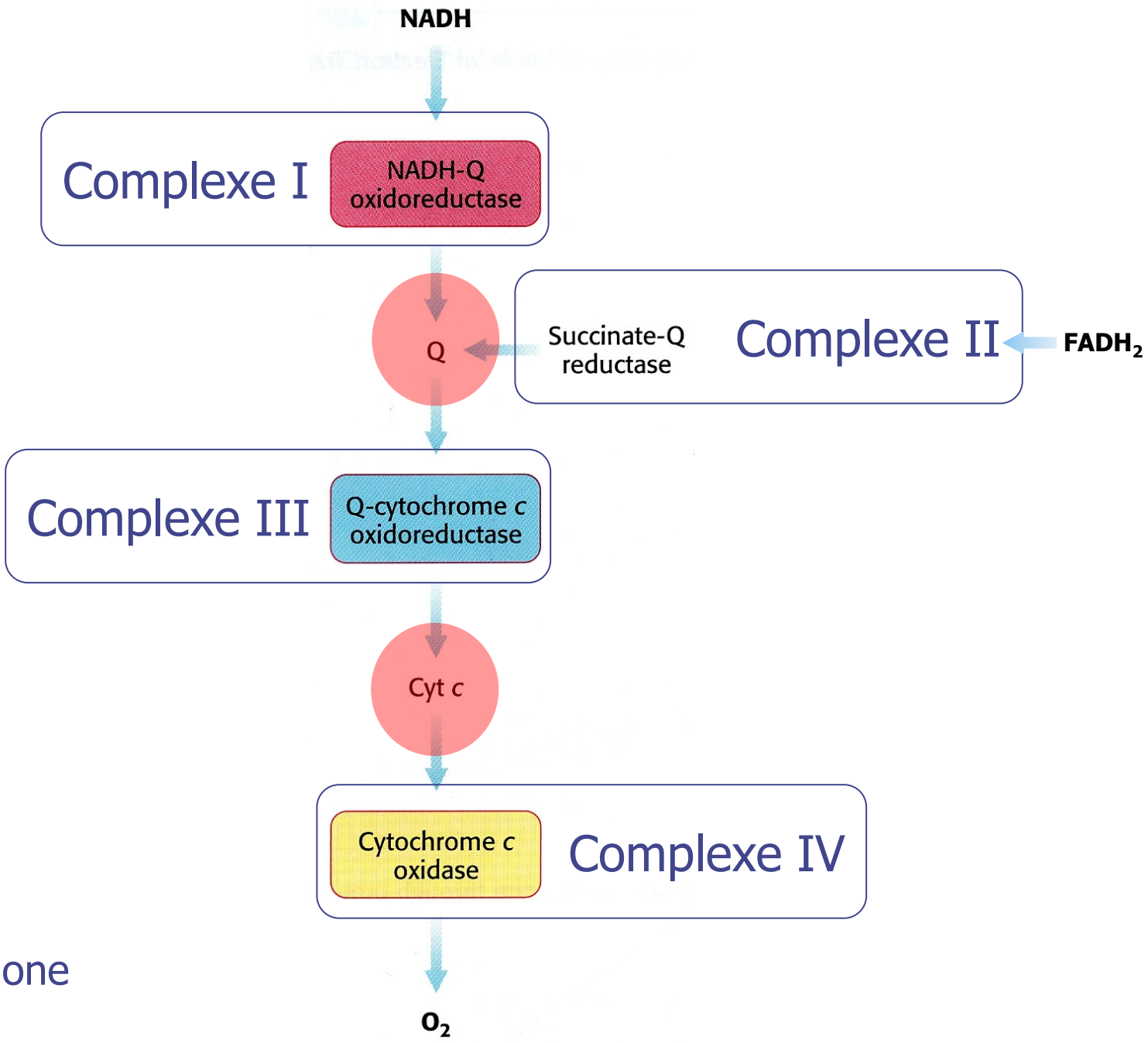

Si $\Delta G'_0$ suffisante
Intramembrane space
H+
H+
H+
H+
H+
H+
Complex I
Coenzyme Q
Complex II
Complex III
Cytochrome c
Complex IV
Mitochondrial matrix



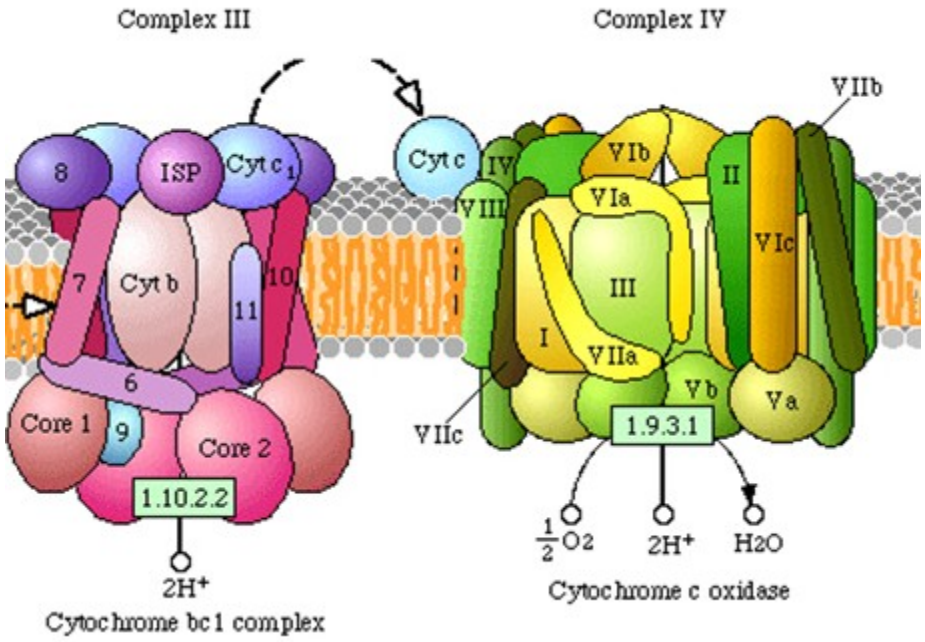
Q = Ubiquinone

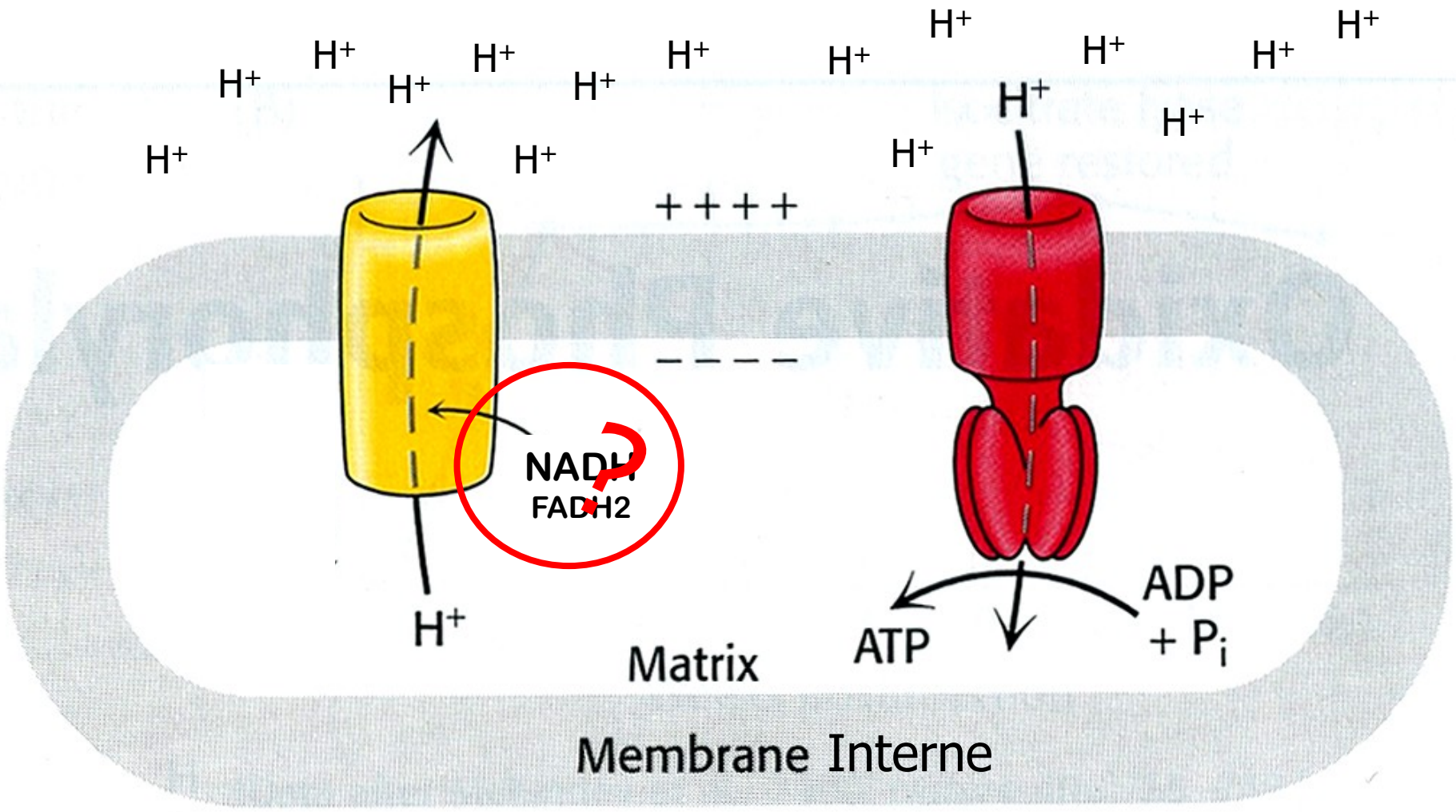


Q = Ubiquinone



Q = Ubiquinone


Complex III
Complex IV
8
ISP
Cyt c1
Cyt c
IV
VIIb
VIb
II
VIII
VIa
VIc
7
Cyt b
10
11
III
I
VIIa
6
Vb
Va
Core 1
9
Core 2
VIIc
1.9.3.1
1.10.2.2
½O2
2H+
H2O
2H+
Cytochrome bc1 complex
Cytochrome c oxidase

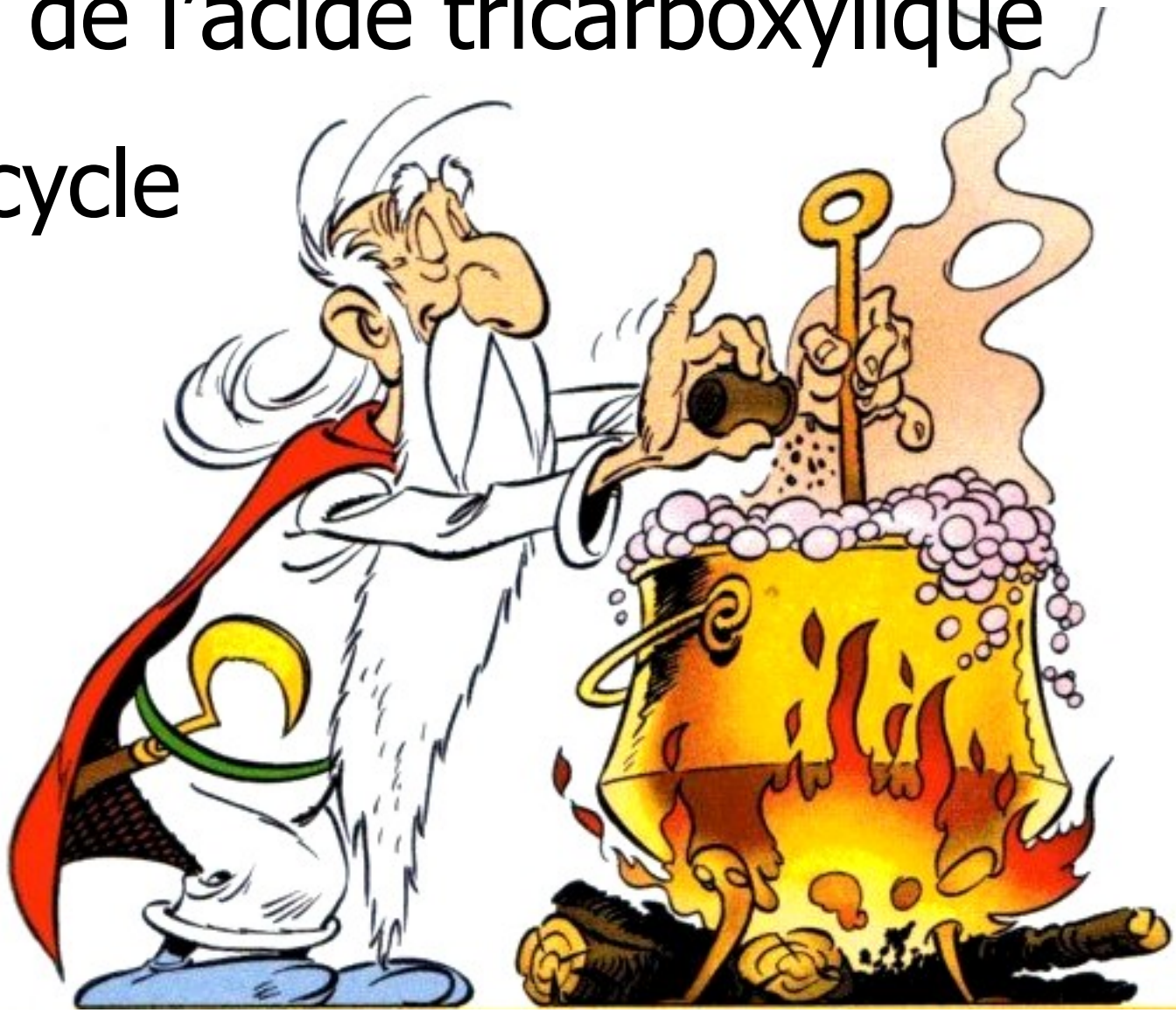

H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
H+
++++

NADH
FADH2
?
H+
Matrix
ATP
ADP
+ Pi
Membrane Interne

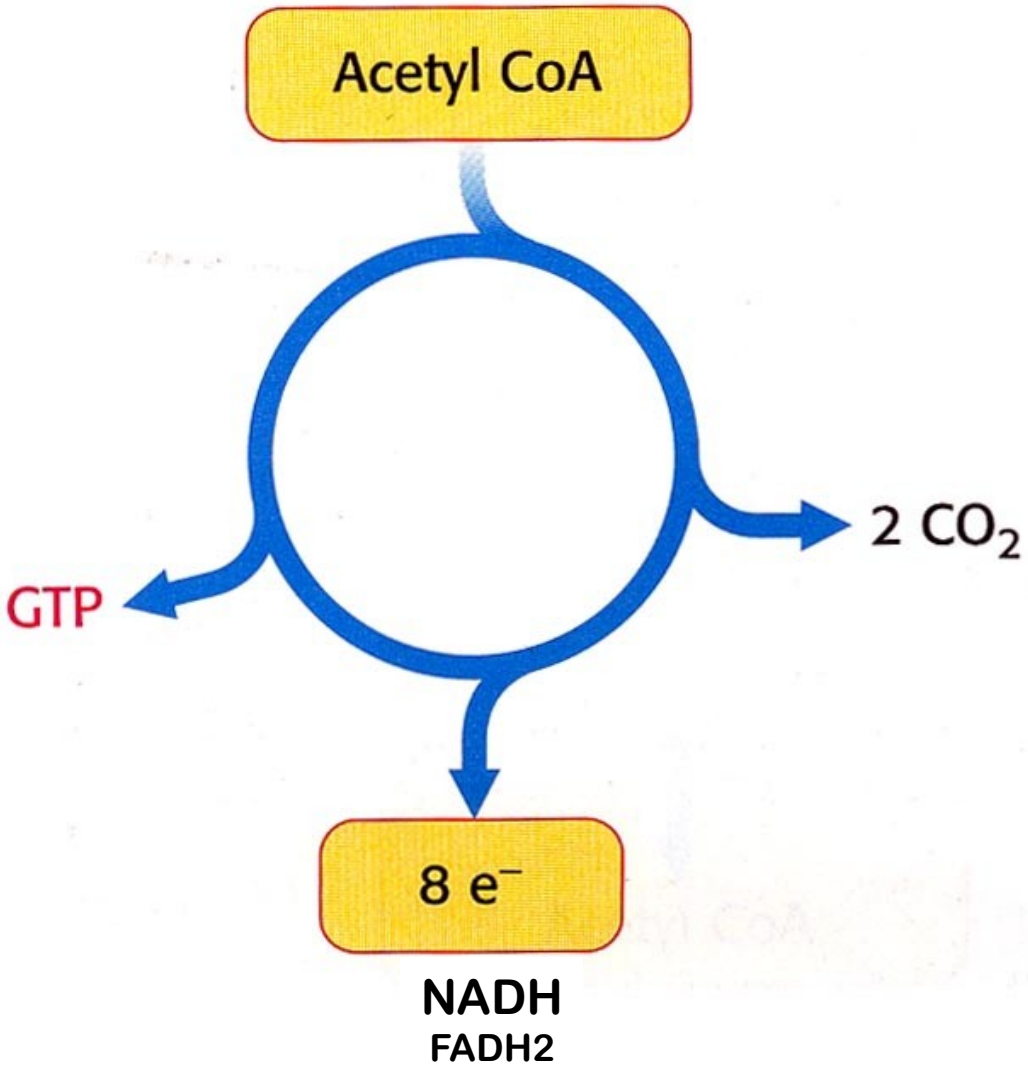
Cycle de l’acide citrique

Cycle de l’acide tricarboxylique

TCA cycle



Nobel laureate Hans Adolf Krebs
1900 - 1981



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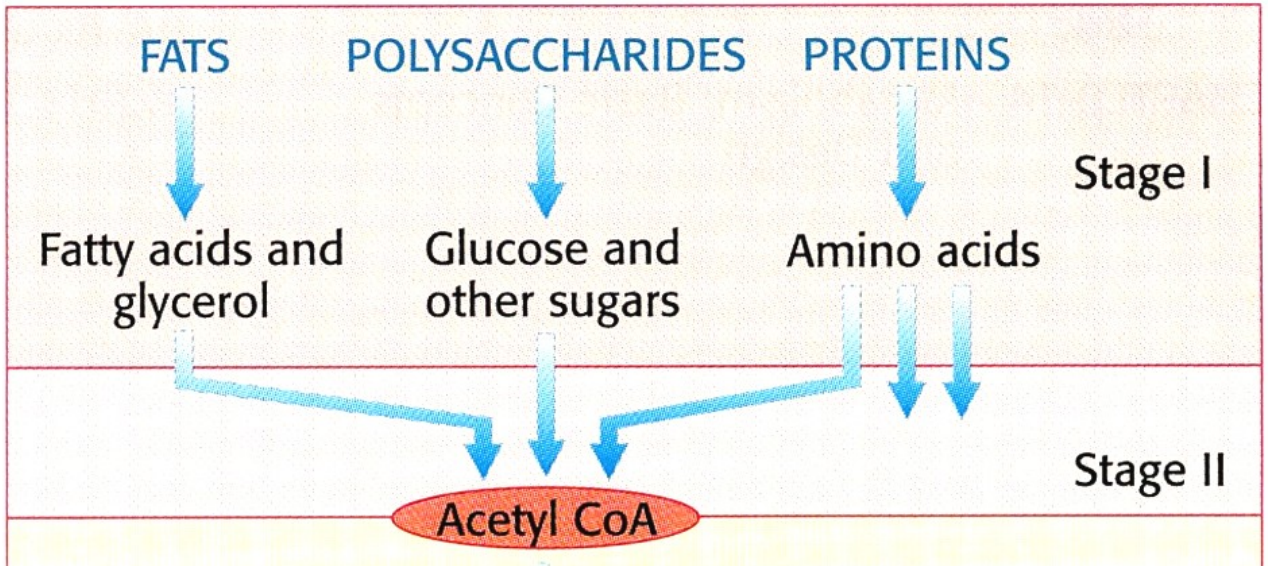
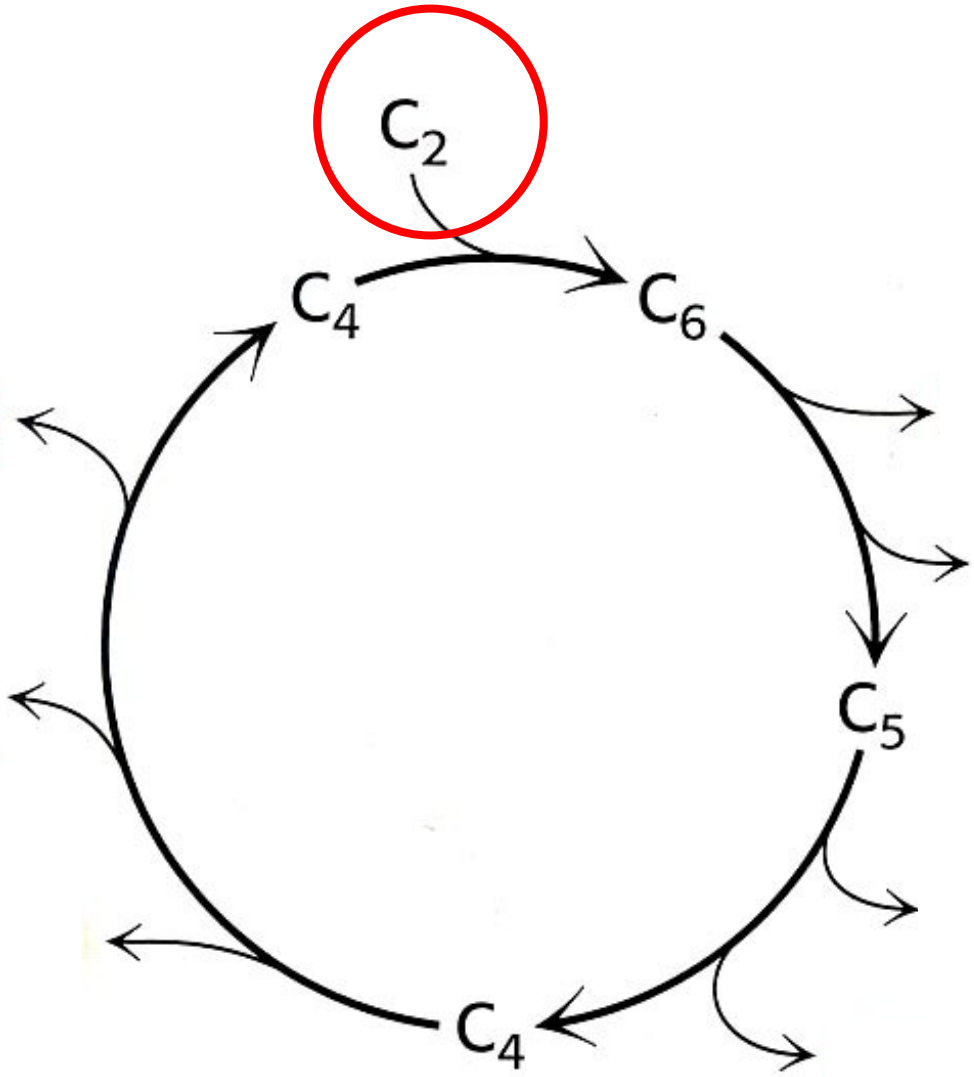

FATS
POLYSACCHARIDES
PROTEINS
Stage I
Fatty acids and glycerol
Glucose and other sugars
Amino acids
Stage II
Acetyl CoA



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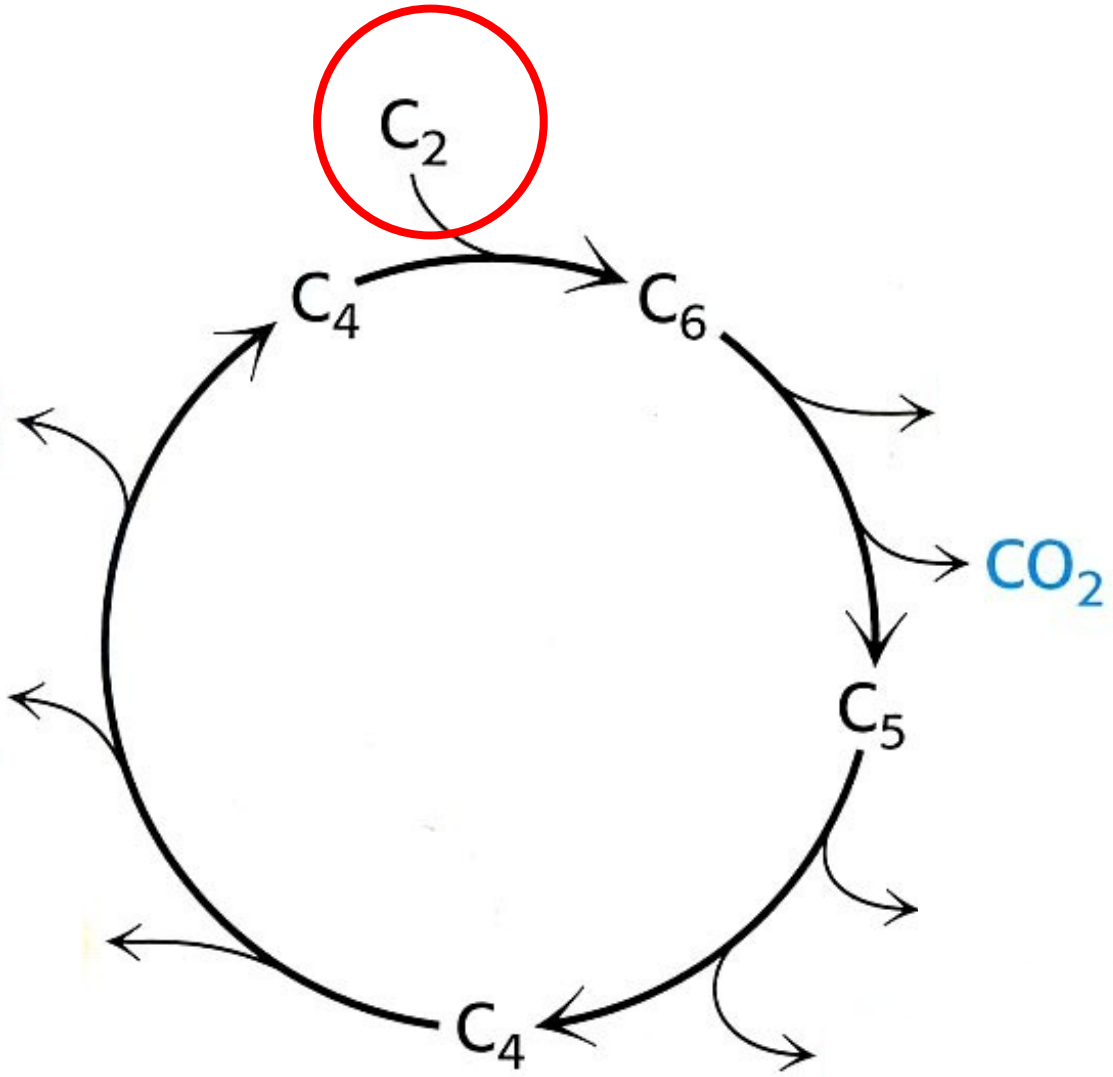

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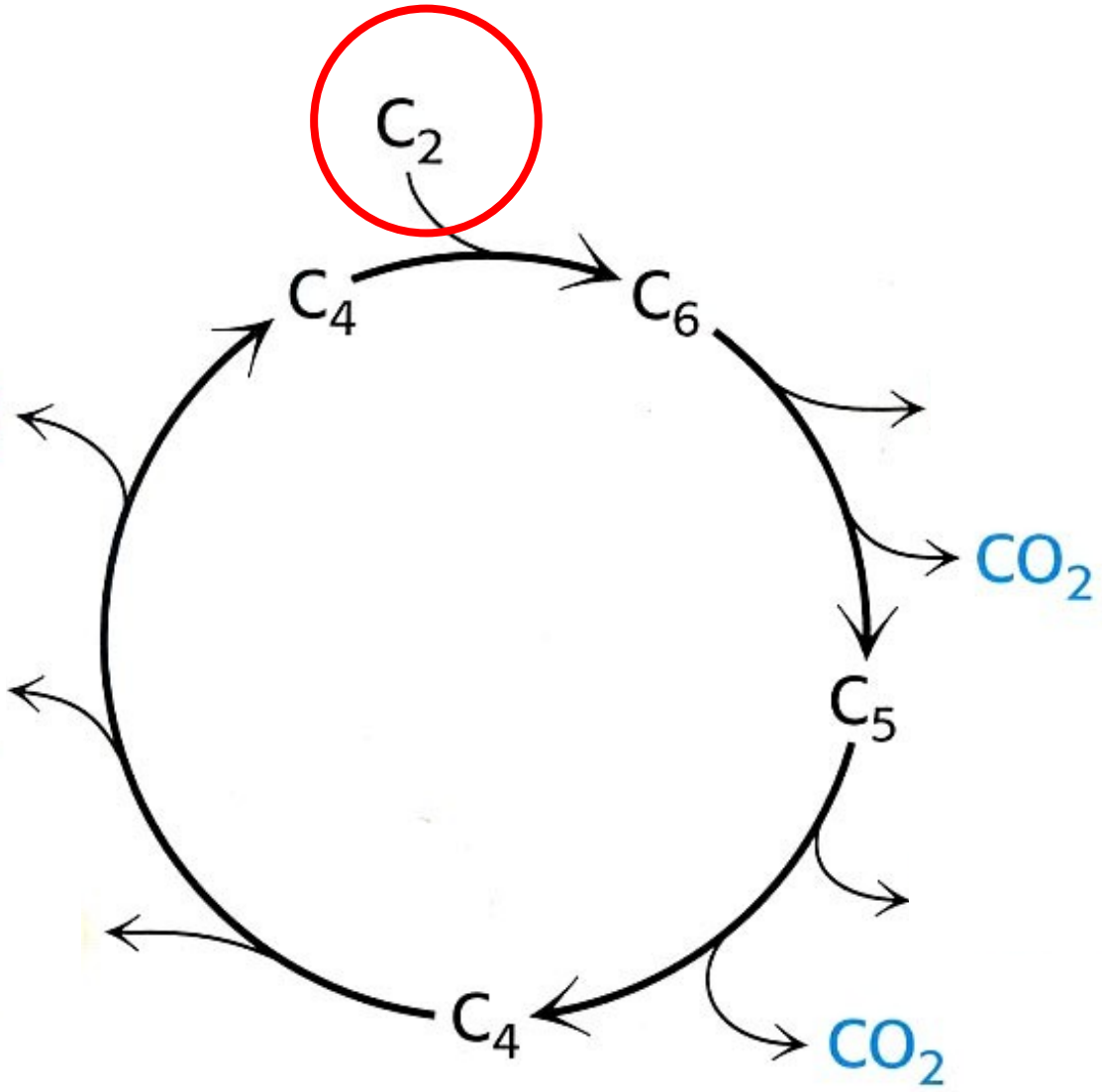

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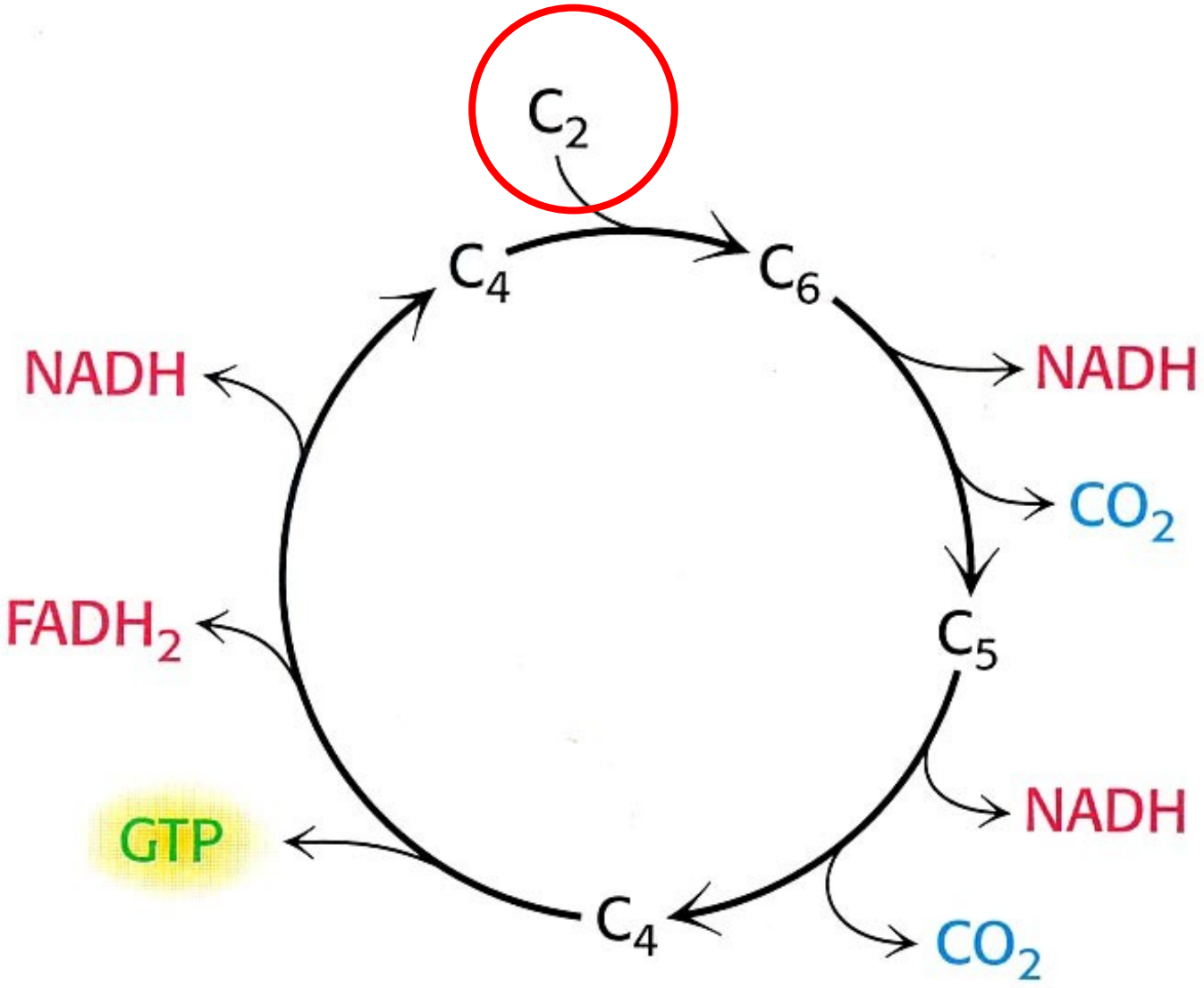

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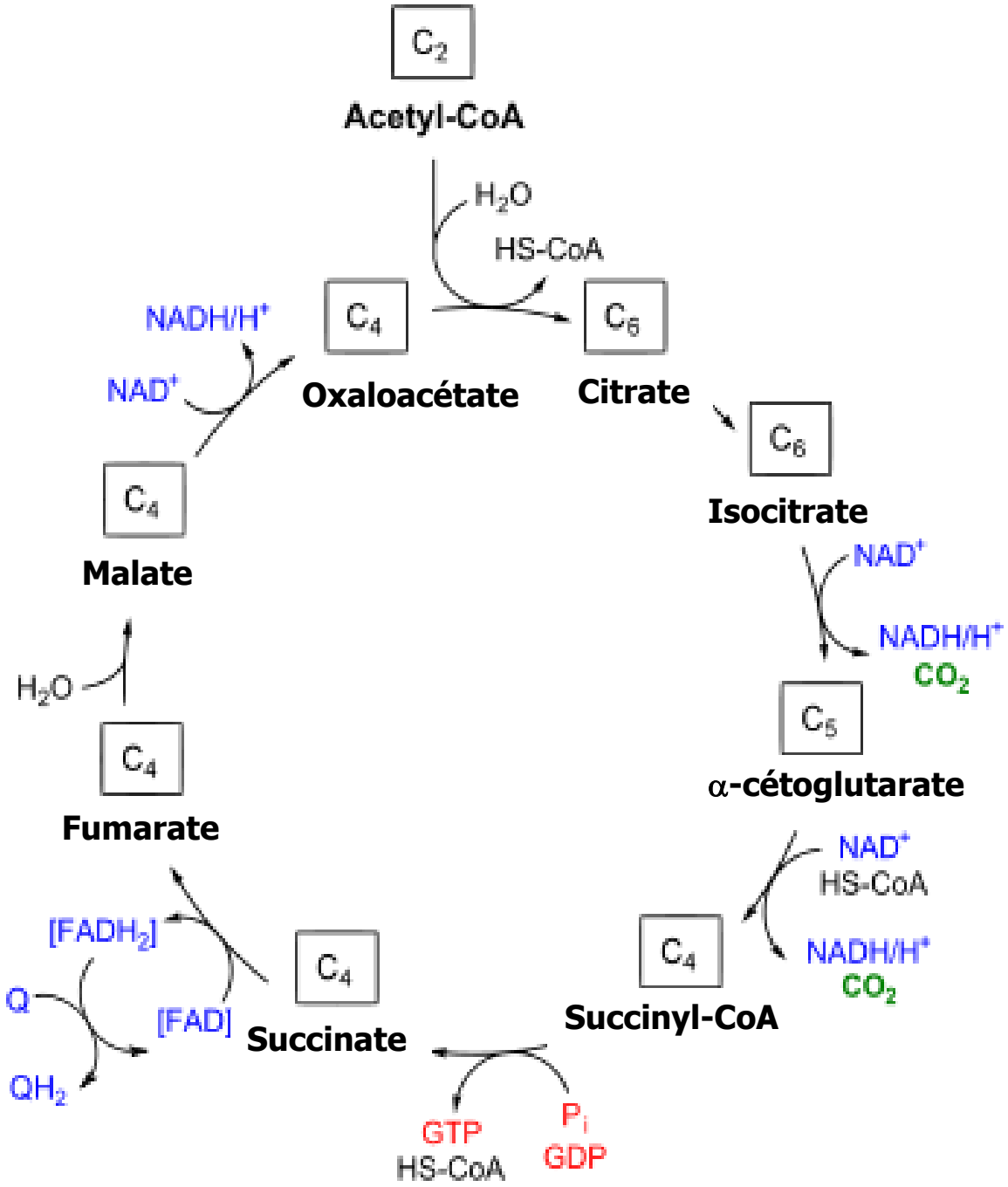
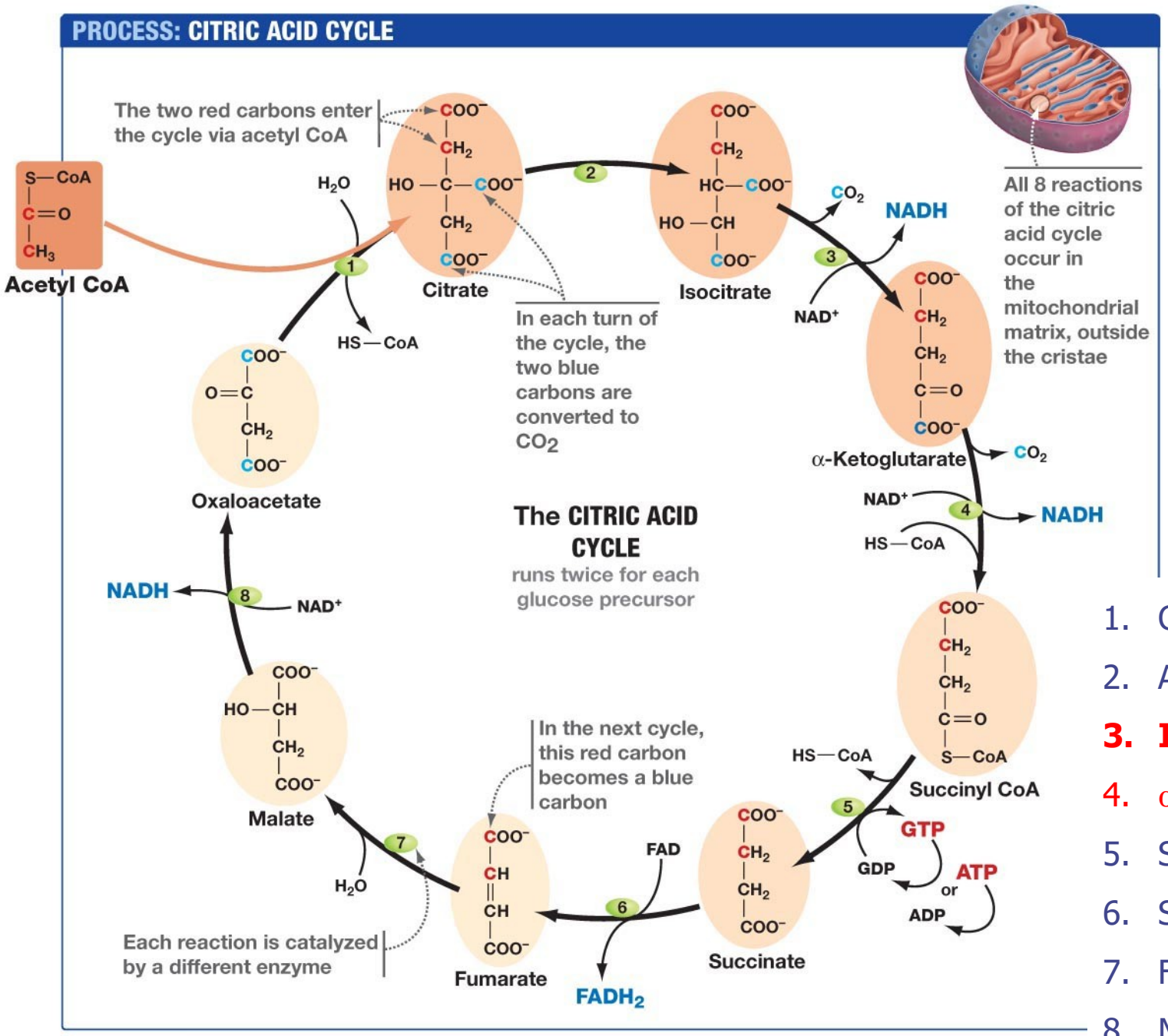
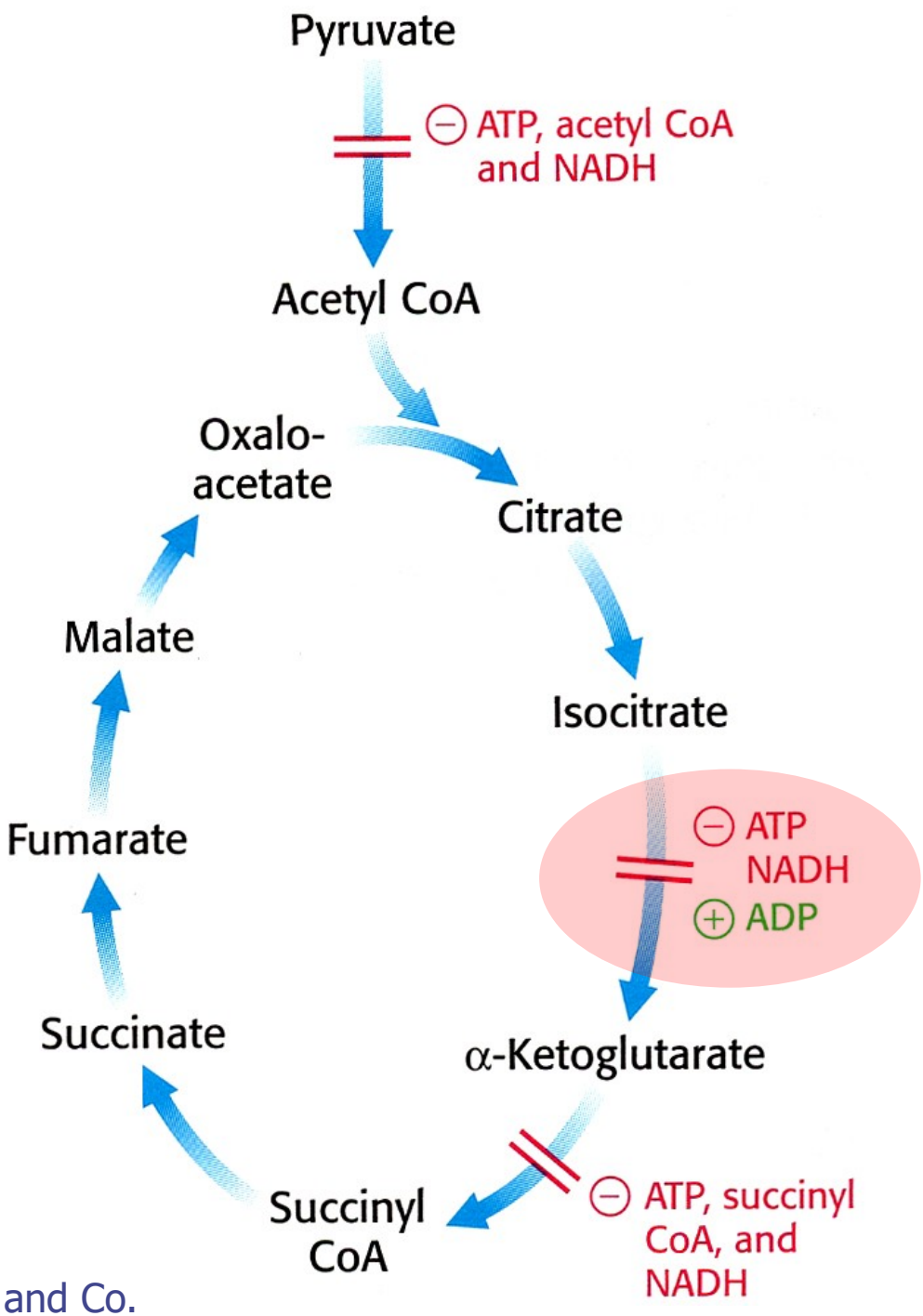

C2
Acetyl-CoA
H2O
HS-CoA
C4
Oxaloacétate
C6
Citrate
NADH/H+
NAD+
C4
Malate
C6
Isocitrate
NAD+
NADH/H+
CO2
C5
α-cétoglutarate
H2O
C4
Fumarate
NAD+
HS-CoA
NADH/H+
CO2
C4
Succinyl-CoA
[FADH2]
Q
[FAD]
QH2
C4
Succinate
GTP
HS-CoA
Pi
GDP



1. Citrate synthase
2. Aconitase
3. **Isocitrate DH**
4. α-cétoglutarate DH
5. Succinate thiokinase
6. Succinate DH
7. Fumarase
8. Malate DH



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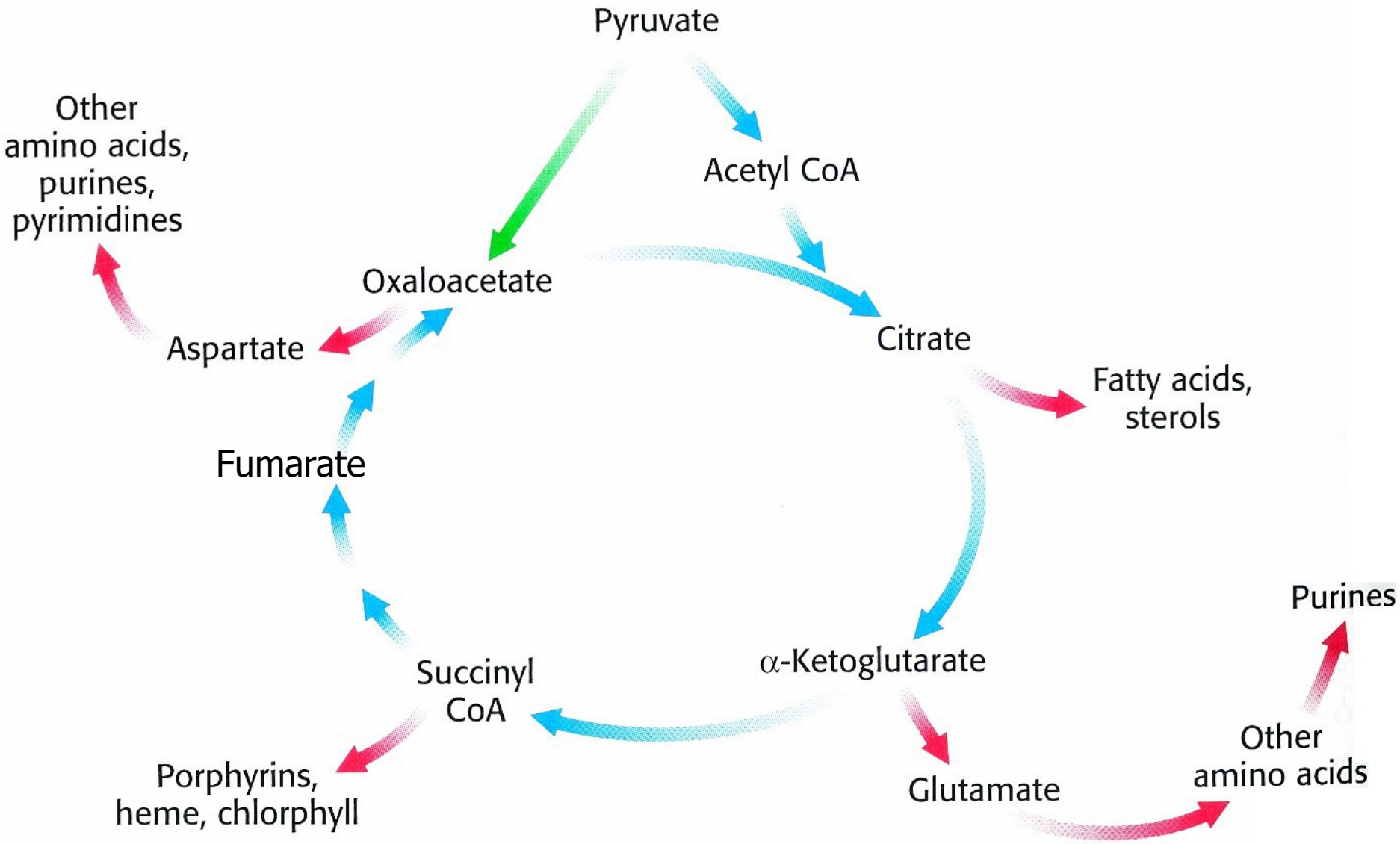
Le cycle de Krebs : une voie Amphibolique



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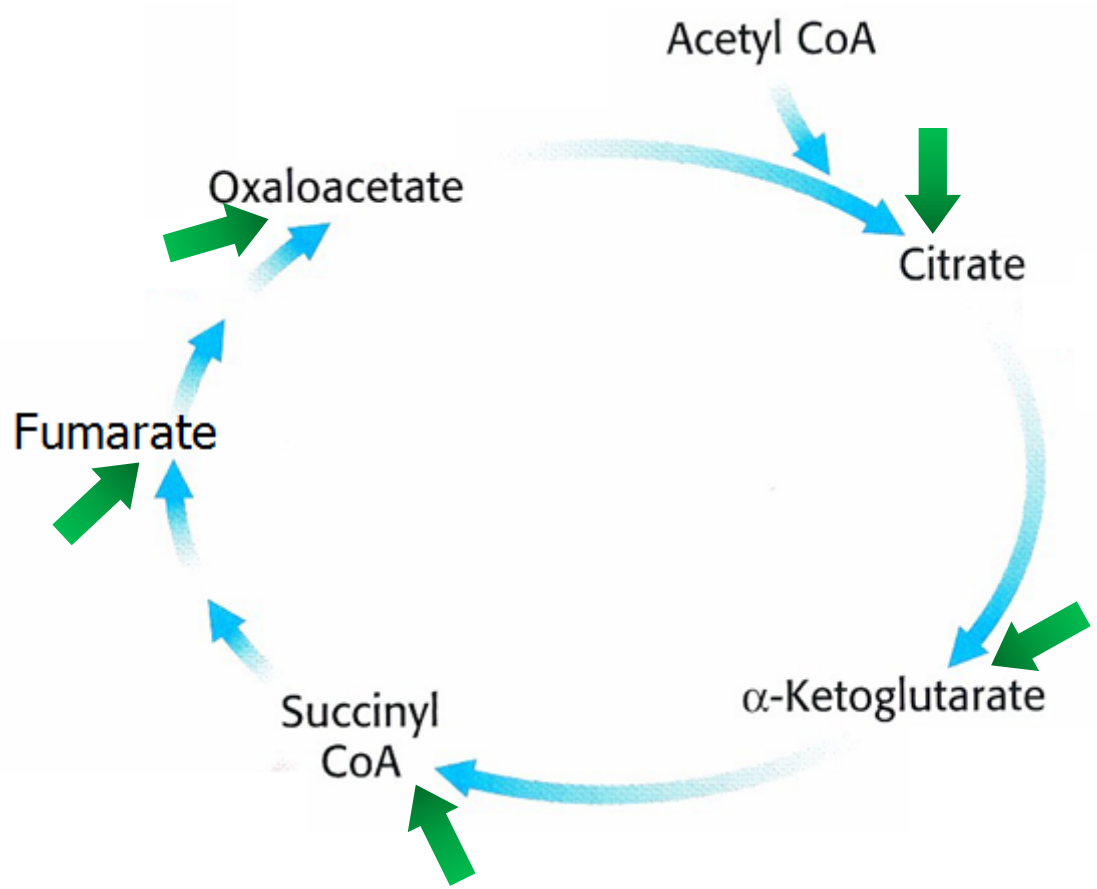
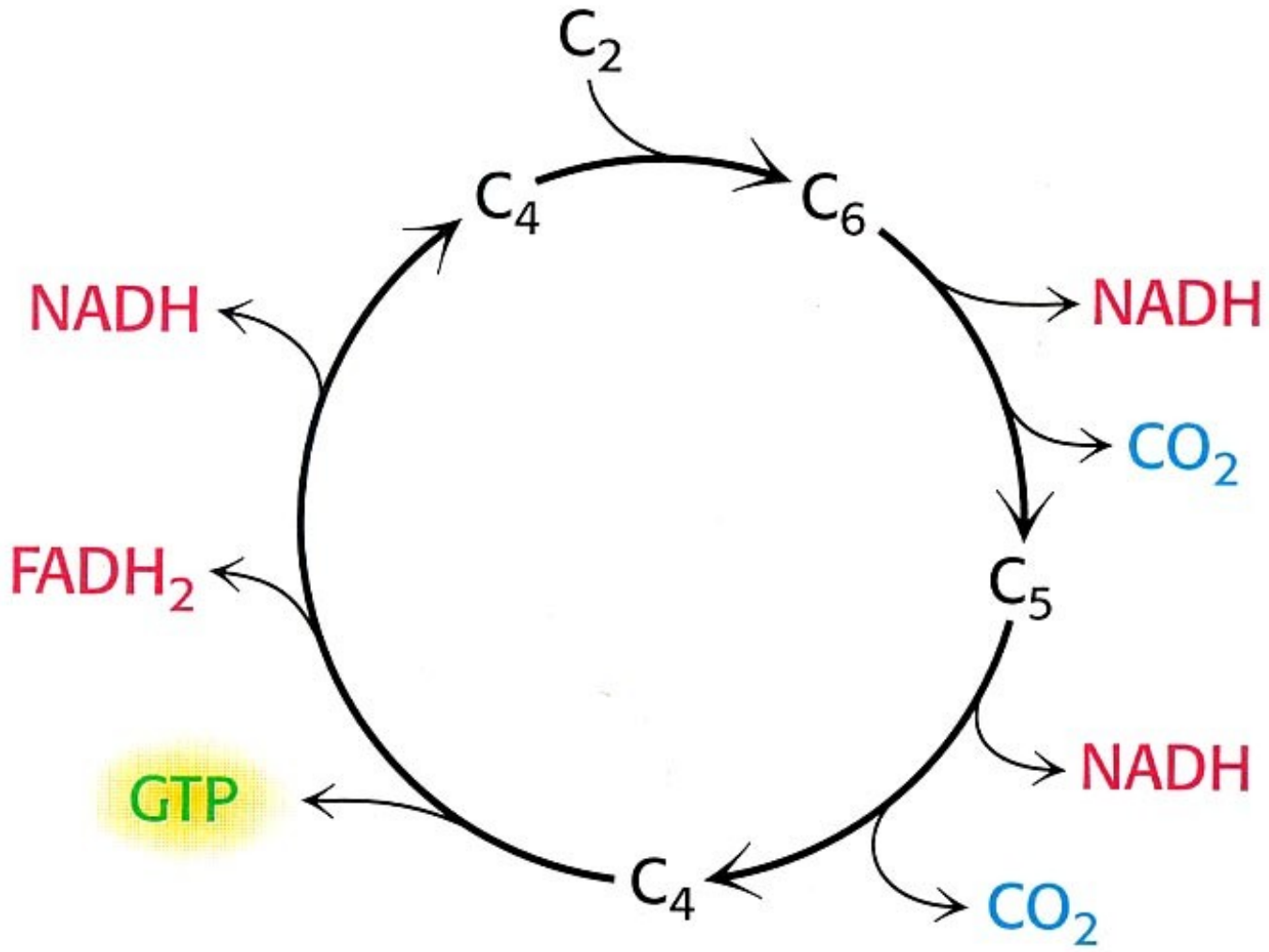
Le cycle de Krebs : une voie Amphibolique





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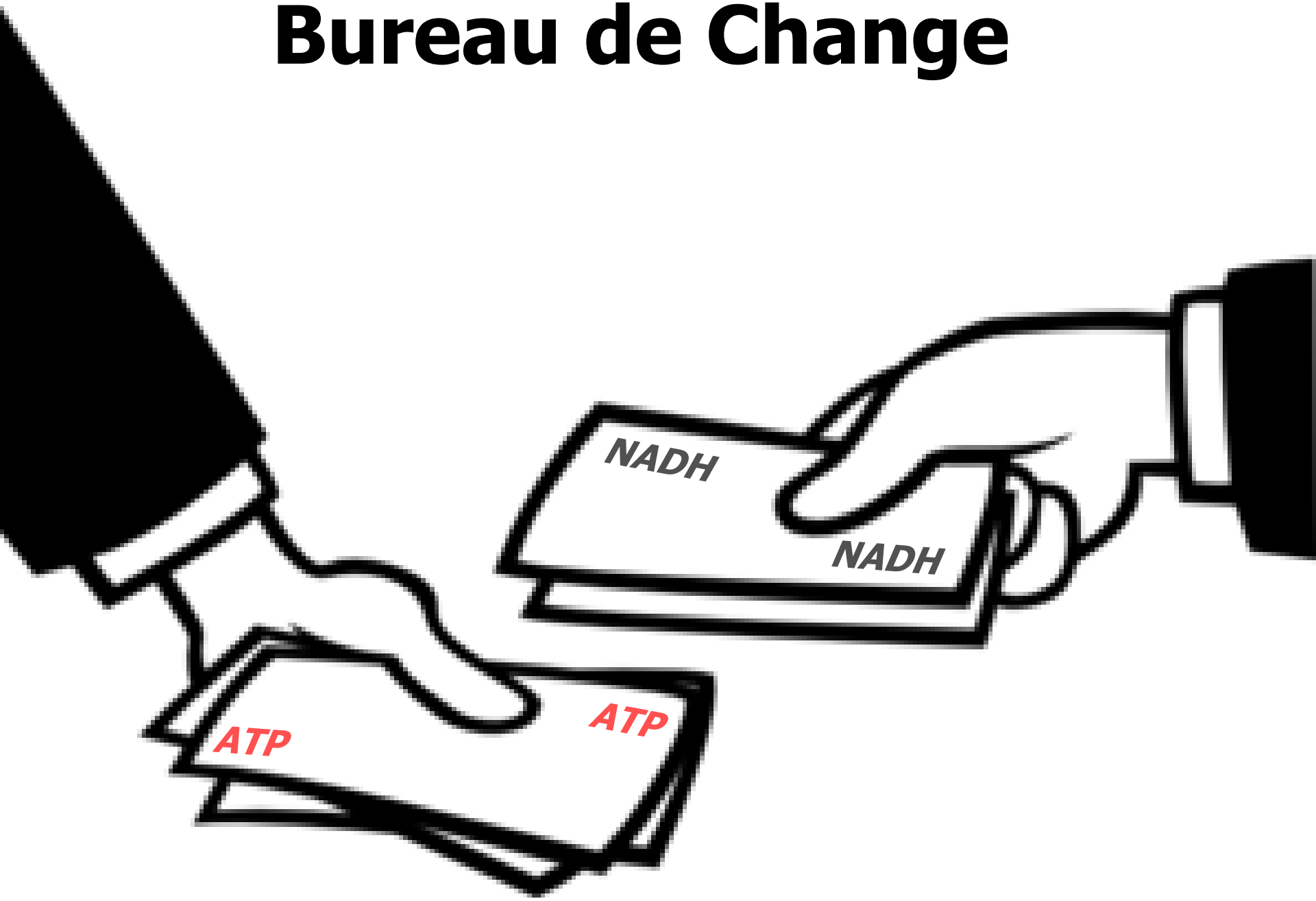
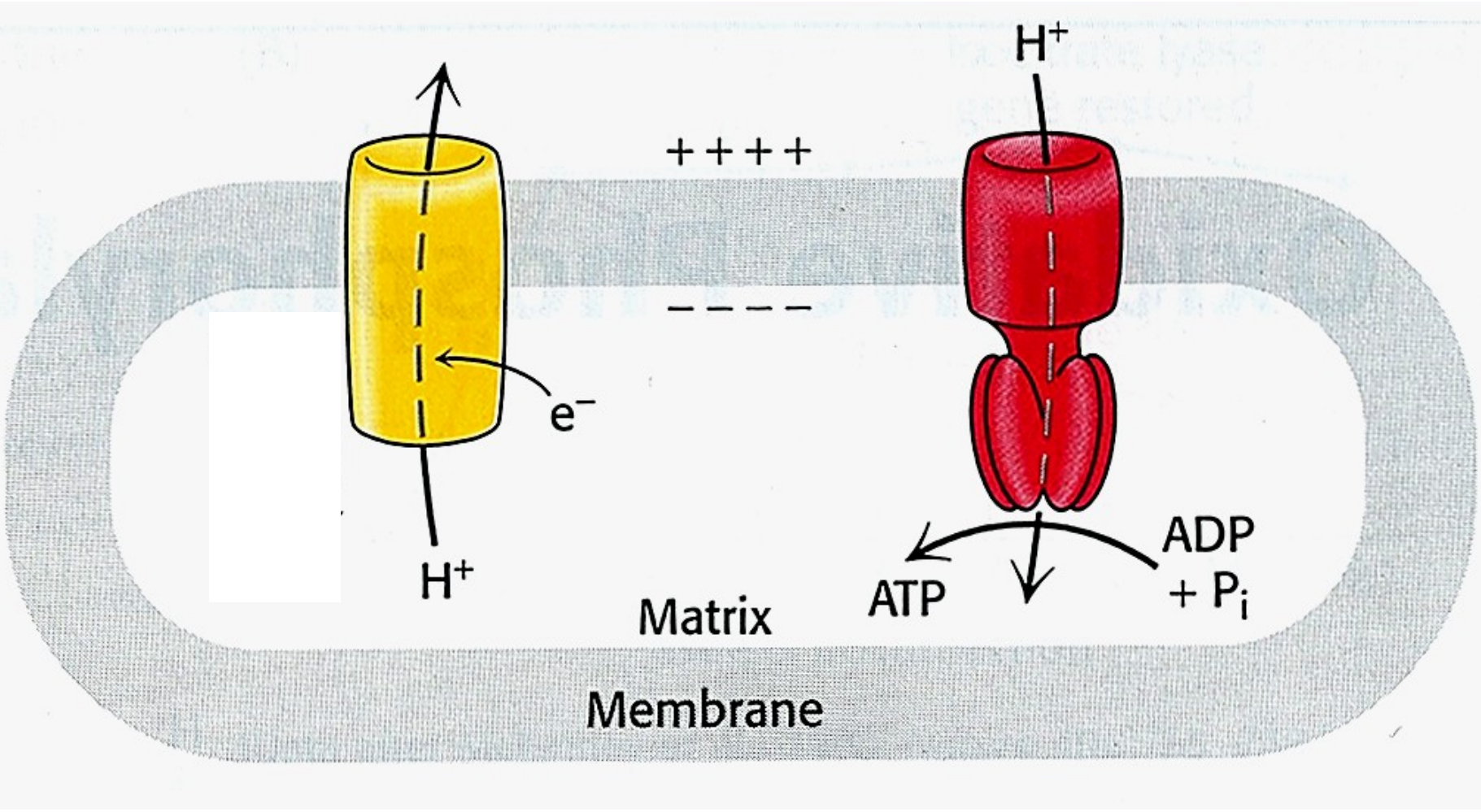
Bureau de Change



Chaine de transport des e-

ATP synthase

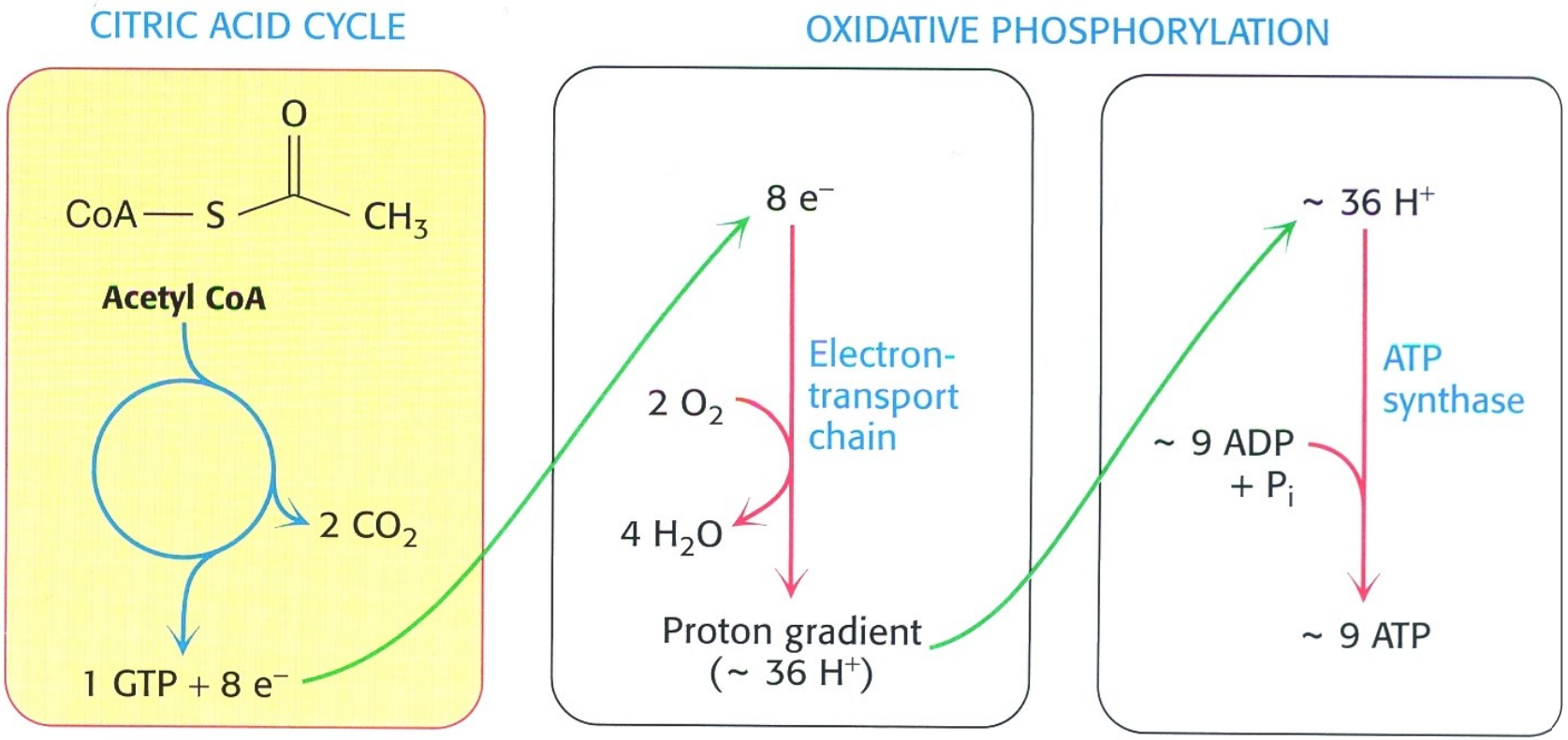


Phosphorylation oxydative

Taux de Change

Monnaie	Achat	
 1 NADH	= 03	ATP
 1 $FADH_2$	= 02	ATP
 1 GTP	= 01	ATP

La respiration cellulaire



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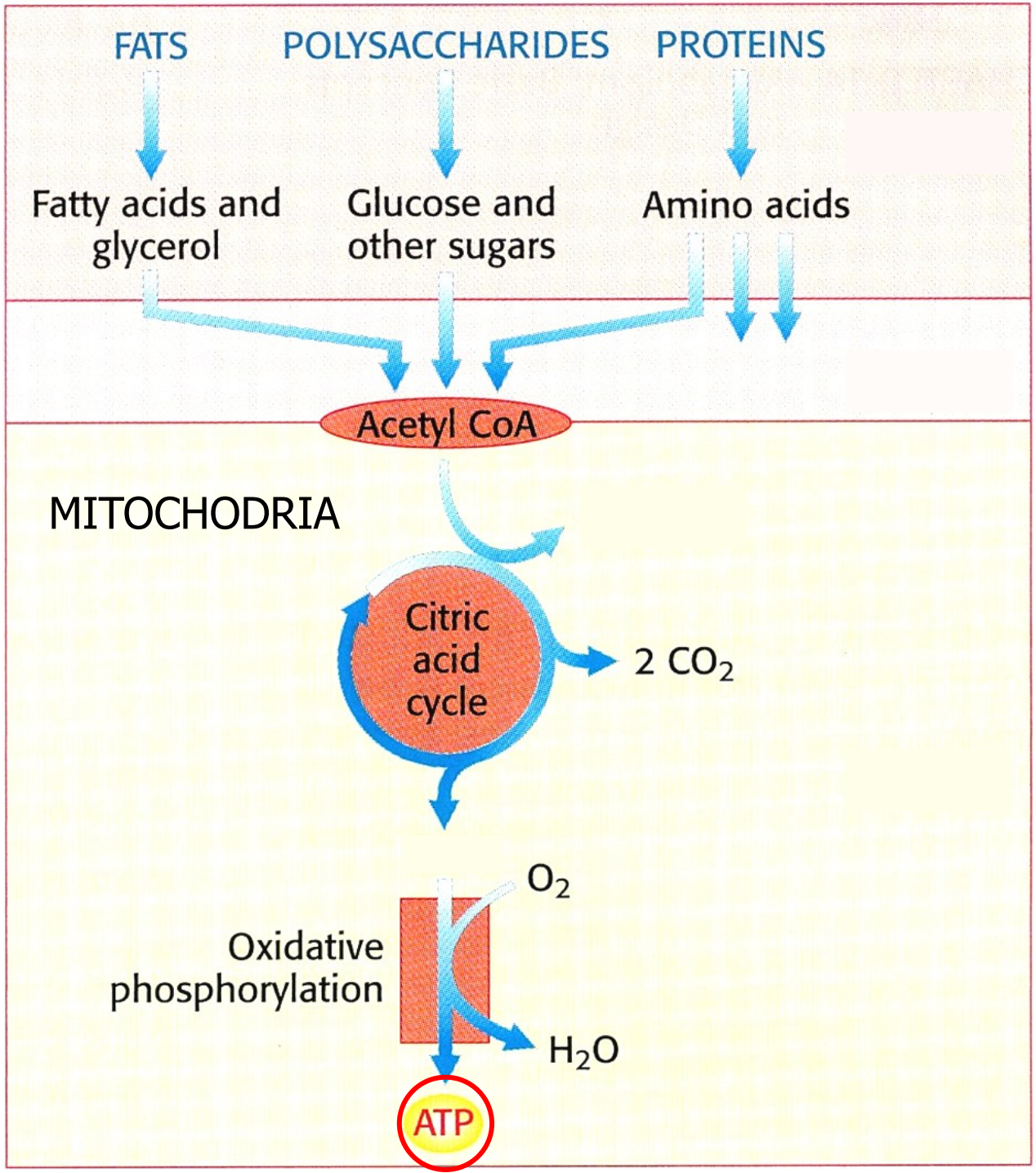

FATS
POLYSACCHARIDES
PROTEINS
Fatty acids and glycerol
Glucose and other sugars
Amino acids
Acetyl CoA
MITOCHODRIA
Citric acid cycle
2 CO_2
O_2
Oxidative phosphorylation
H_2O
ATP

Défaillances bioénergétique

Troubles visuels,

Céphalées

Difficultés intellectuelles,

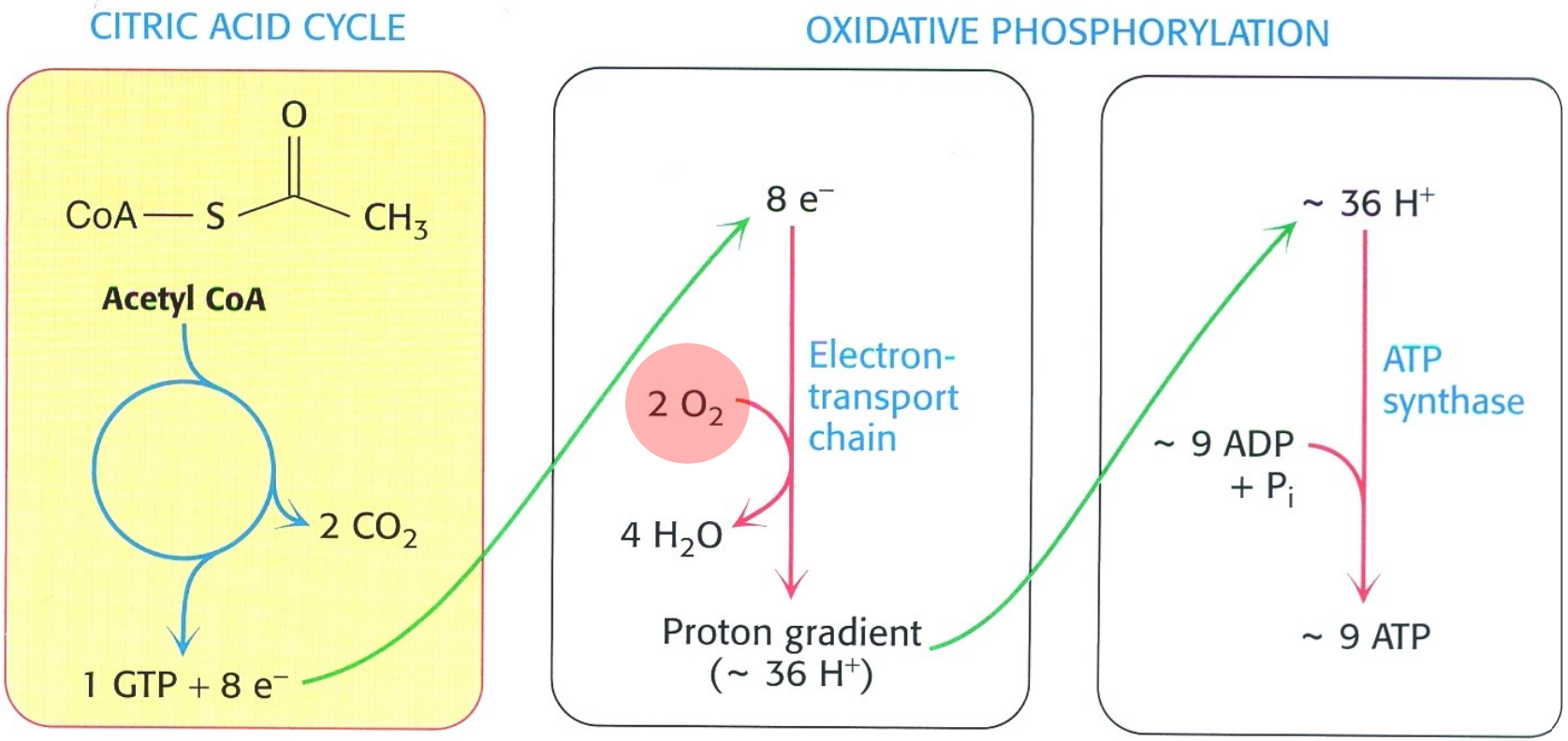
Faiblesse musculaire,

Hypothermie,

Défaillance des organes vitaux,

…

La respiration cellulaire



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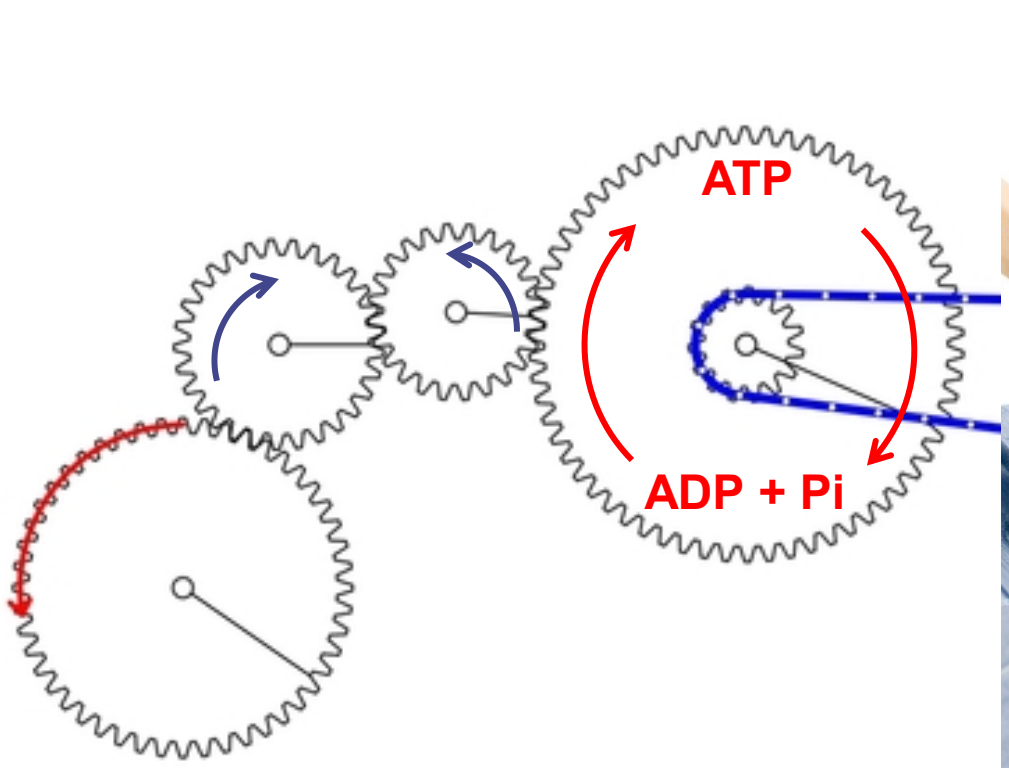
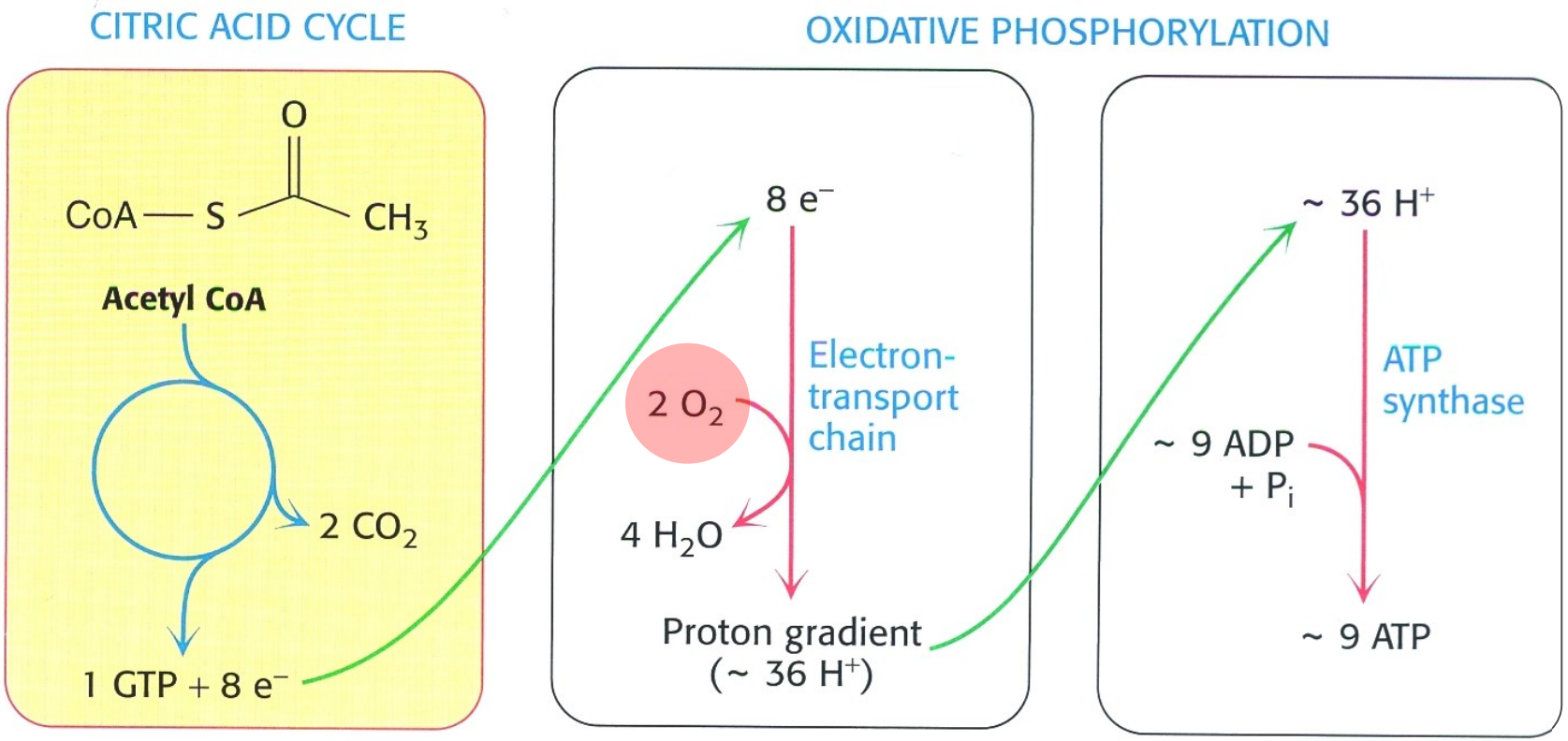

ATP
ADP + Pi

La respiration cellulaire



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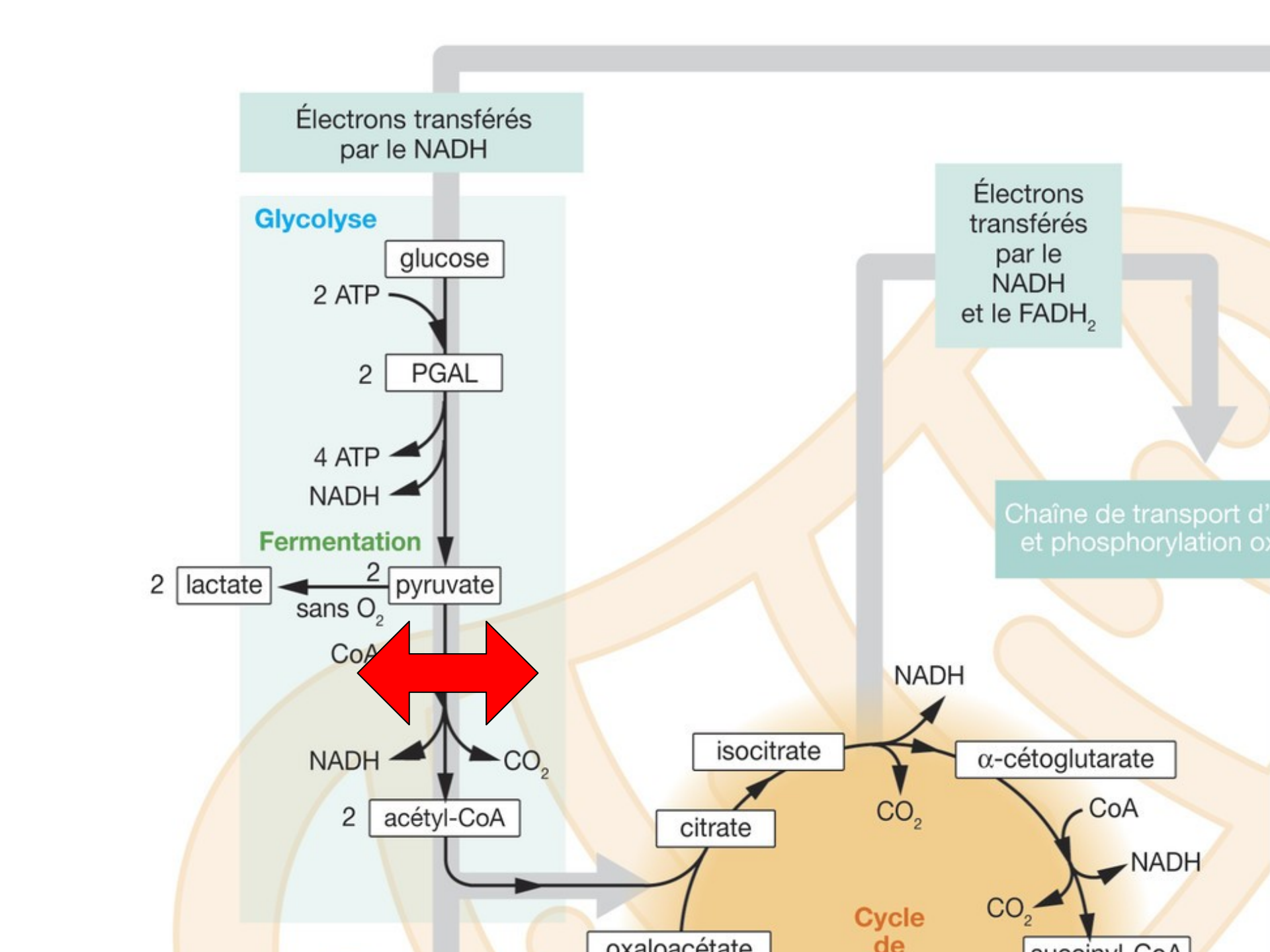
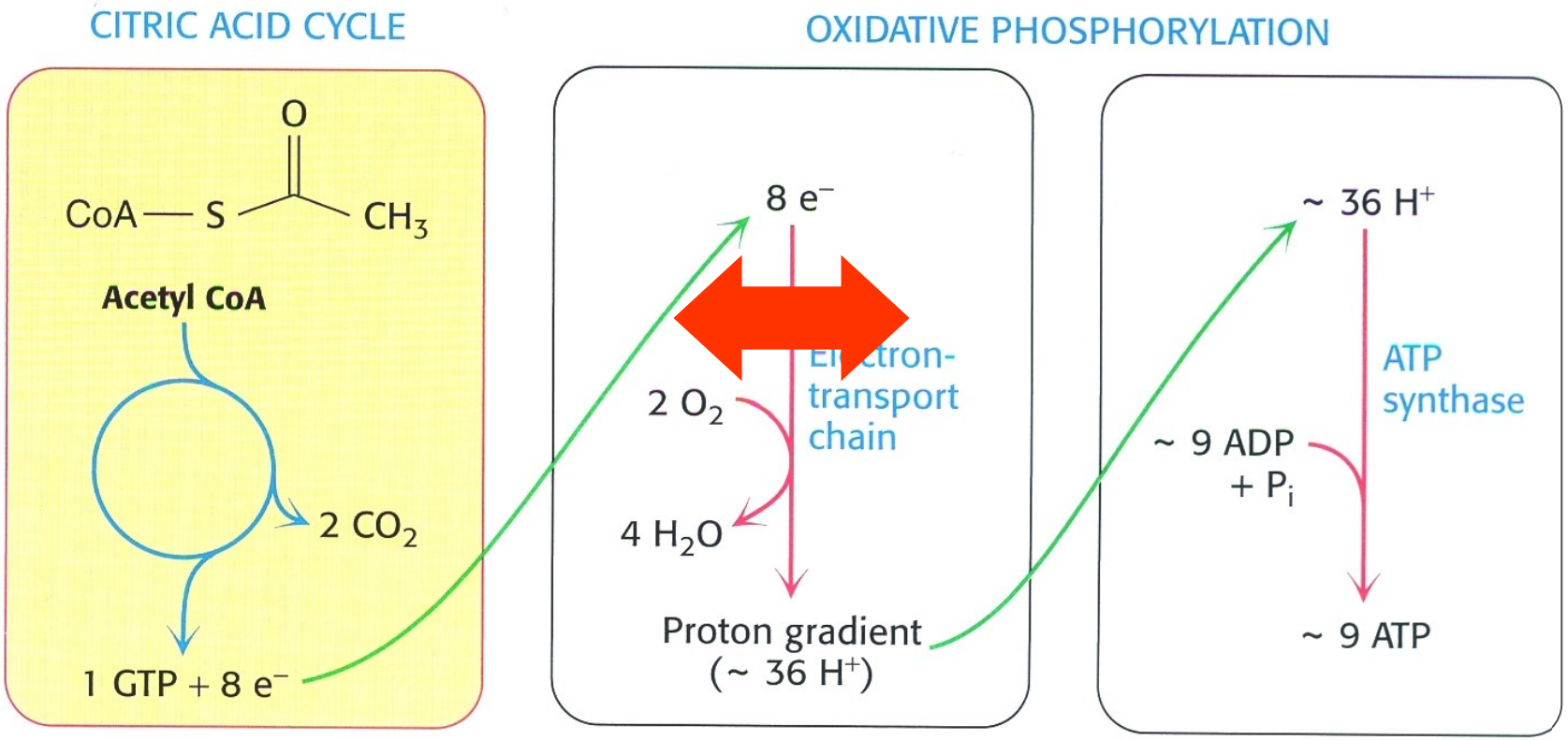

Électrons transférés par le NADH
Glycolyse
glucose
2 ATP
2
PGAL
4 ATP
NADH
Fermentation
2
2 lactate
pyruvate
sans O_2
CoA
NADH
CO_2
2
acétyl-CoA
Électrons transférés par le NADH et le $FADH_2$
Chaîne de transport d'
et phosphorylation ox
NADH
isocitrate
α-cétoglutarate
CO_2
CoA
citrate
NADH
CO_2
Cycle de
oxaloacétate
succinyl-CoA

La respiration cellulaire



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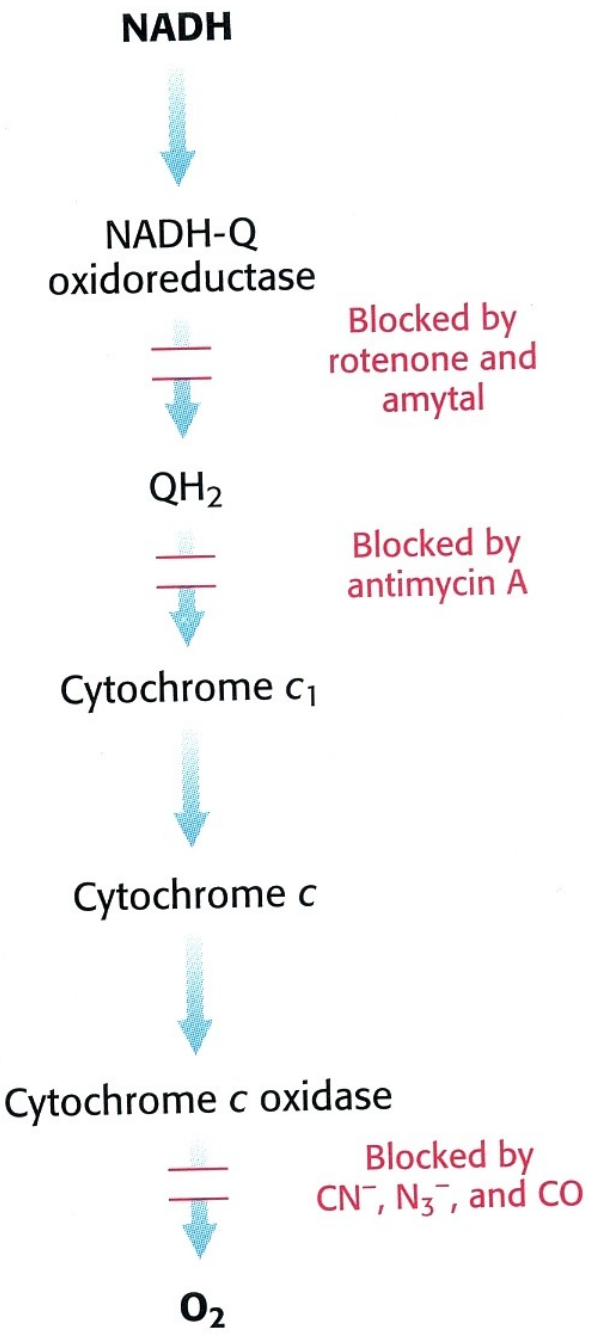
Inhibiteurs

Inhibiteurs



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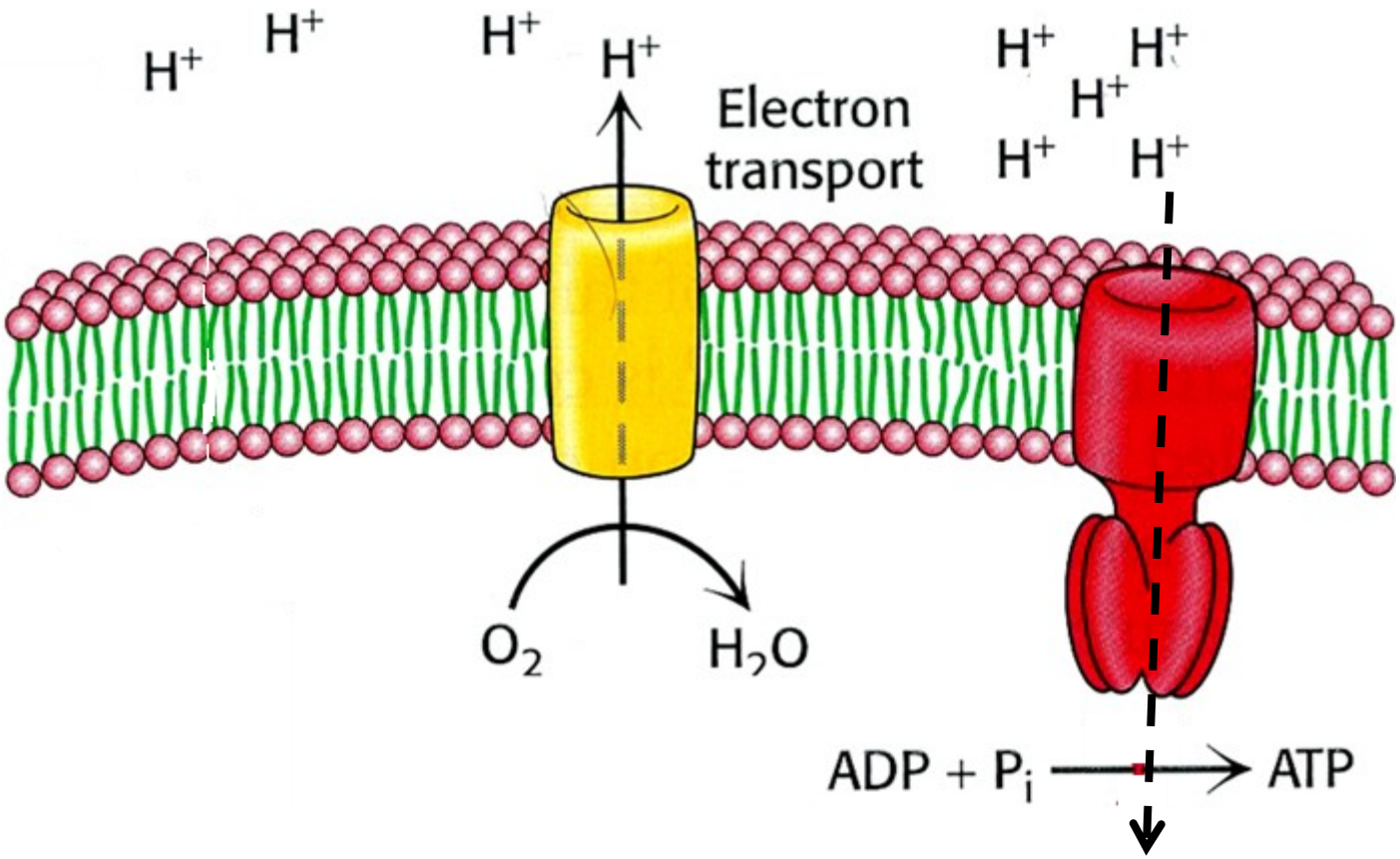
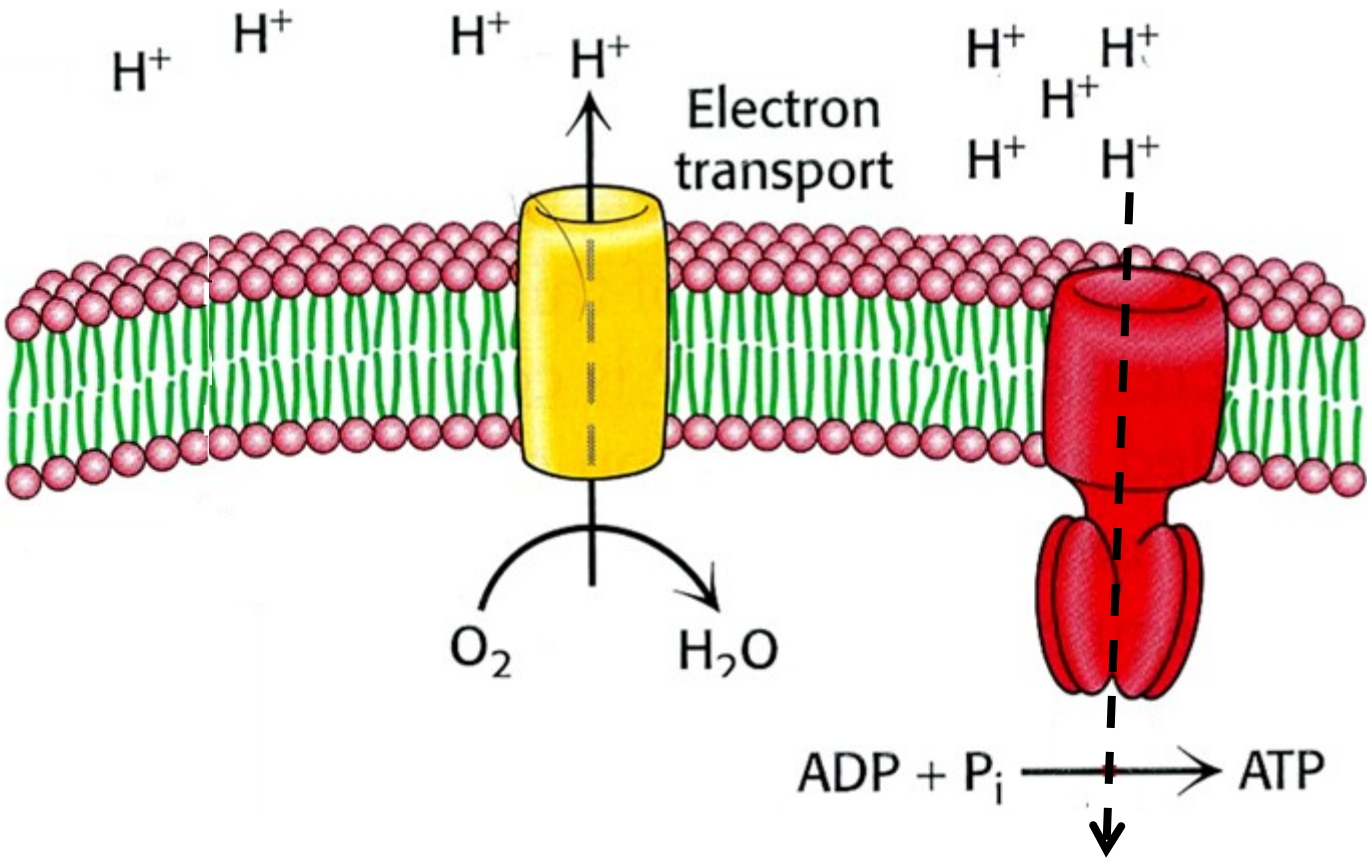
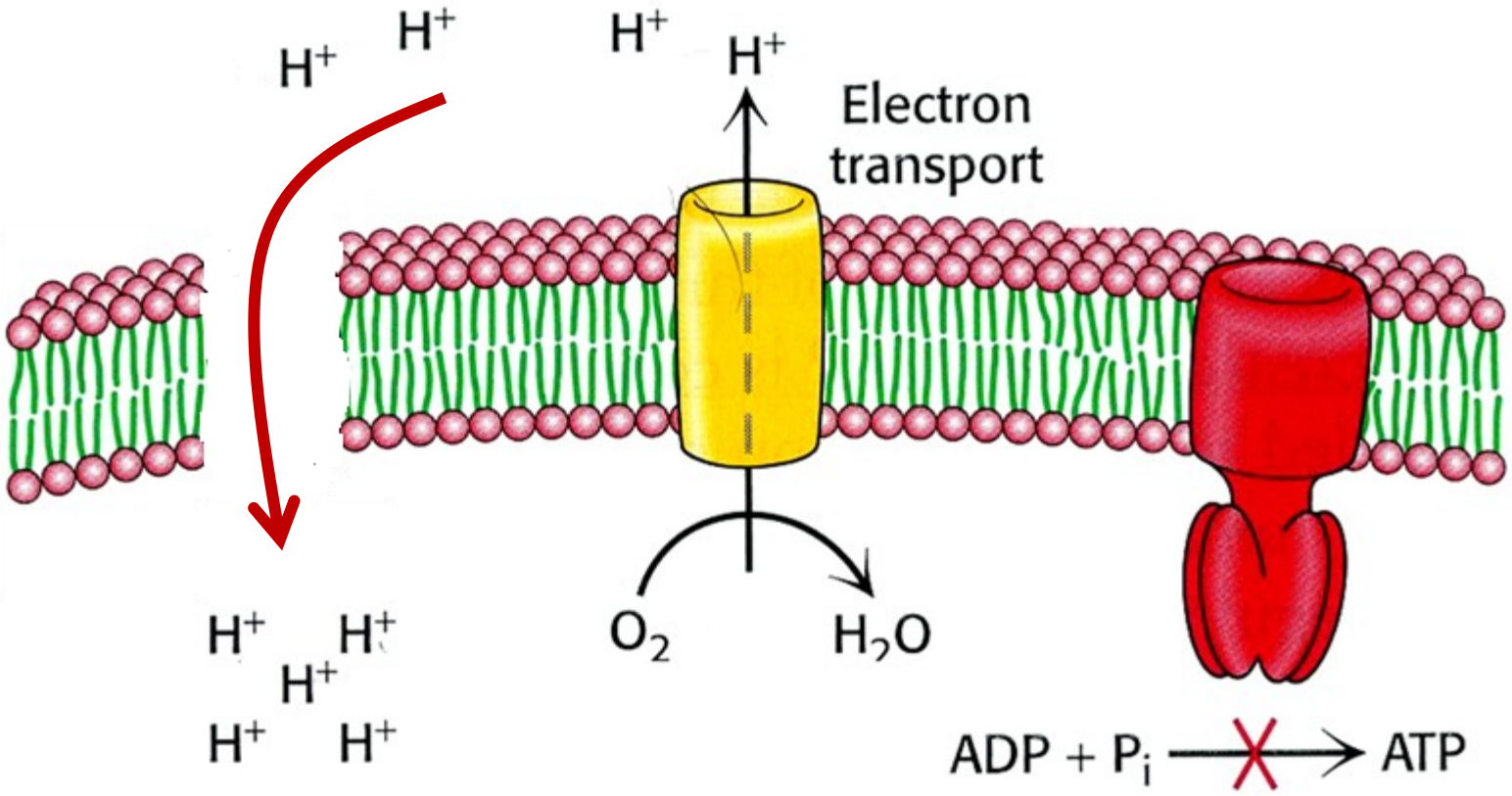
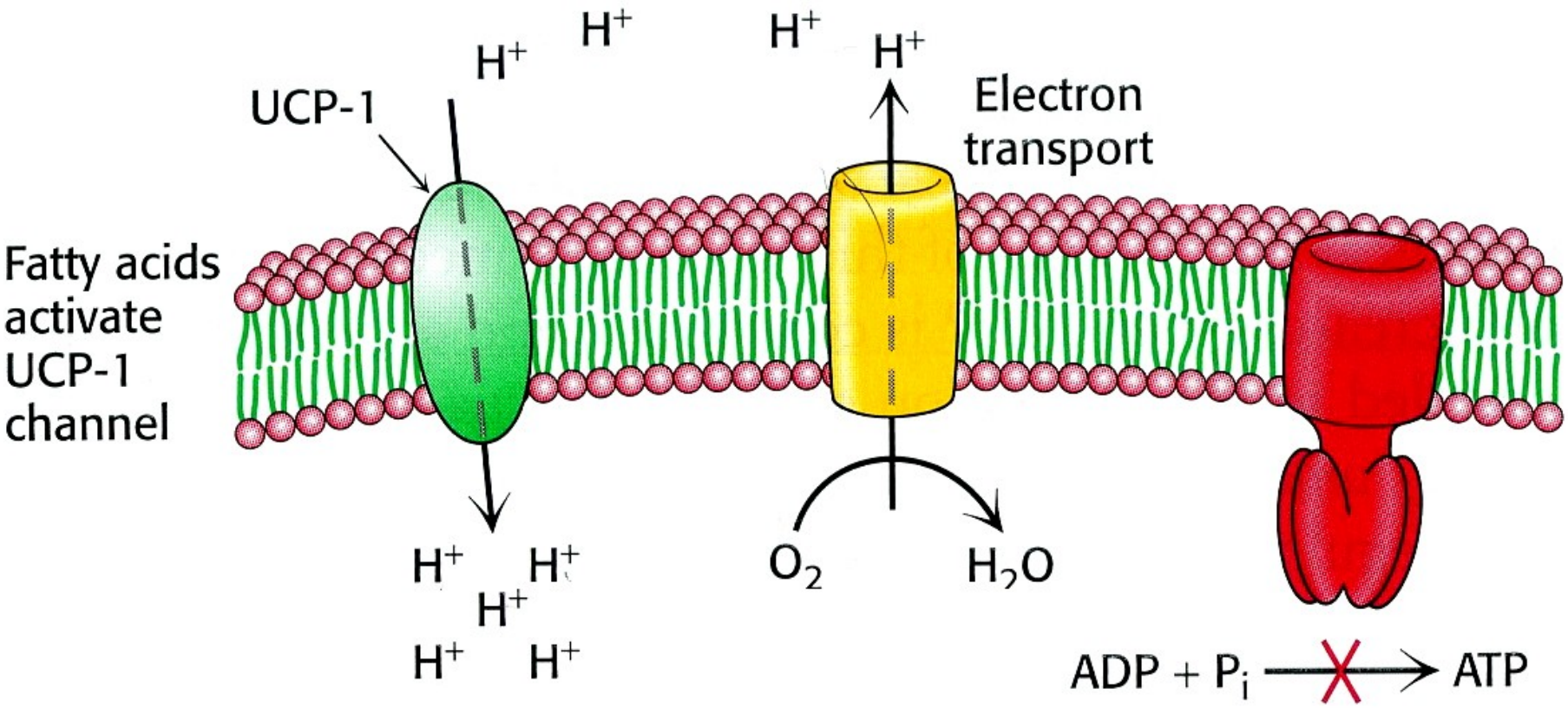
Découplage


H+
H+
H+
H+
Electron transport
H+
H+
H+
H+
H+
O2
H2O
ADP + Pi
ATP


H+
H+
H+
H+
Electron
transport
H+
H+
H+
H+
H+
O2
H2O
ADP + Pi
ATP


H+
H+
H+
H+
H+
Electron
transport
H+
H+
H+
H+
H+
O2
H2O
ADP + Pi
ATP

UCP-1 : Uncoupling protein-1



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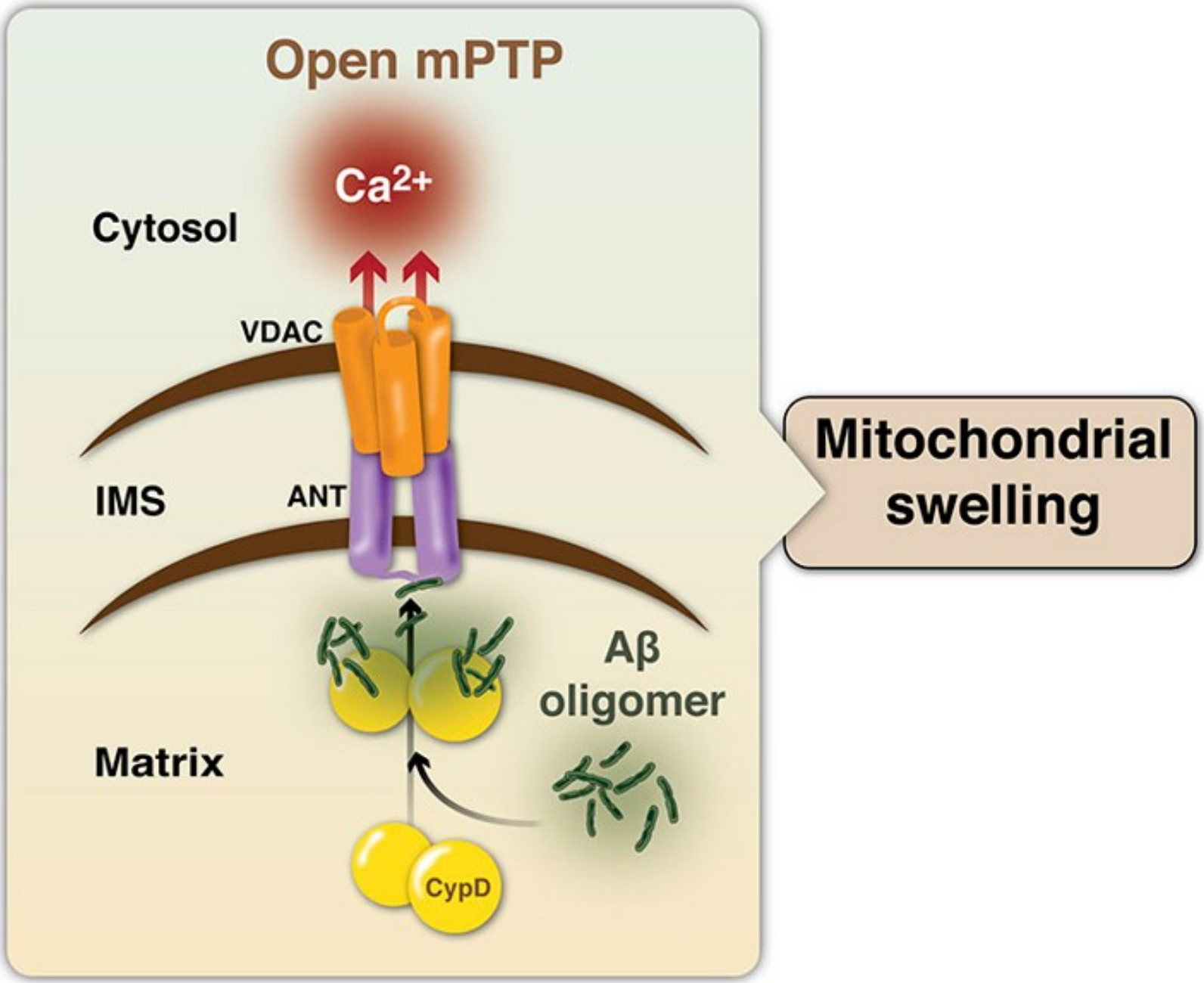
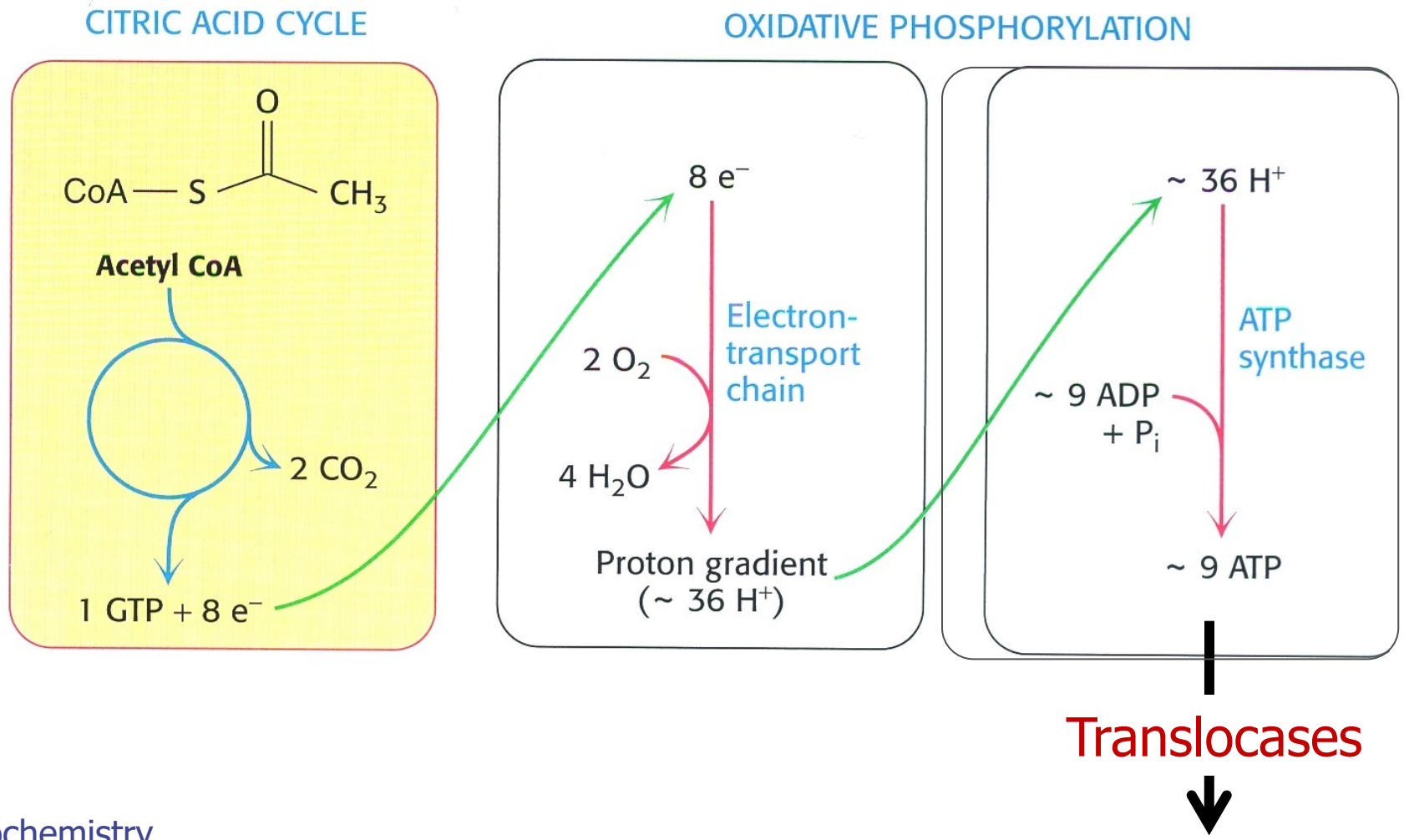
Fuite mitochondriale



mPTP : mitochondrial Permeability Transition Pore

Anomalie mitochondriale de la manipulation du Ca^{2+}

La respiration cellulaire



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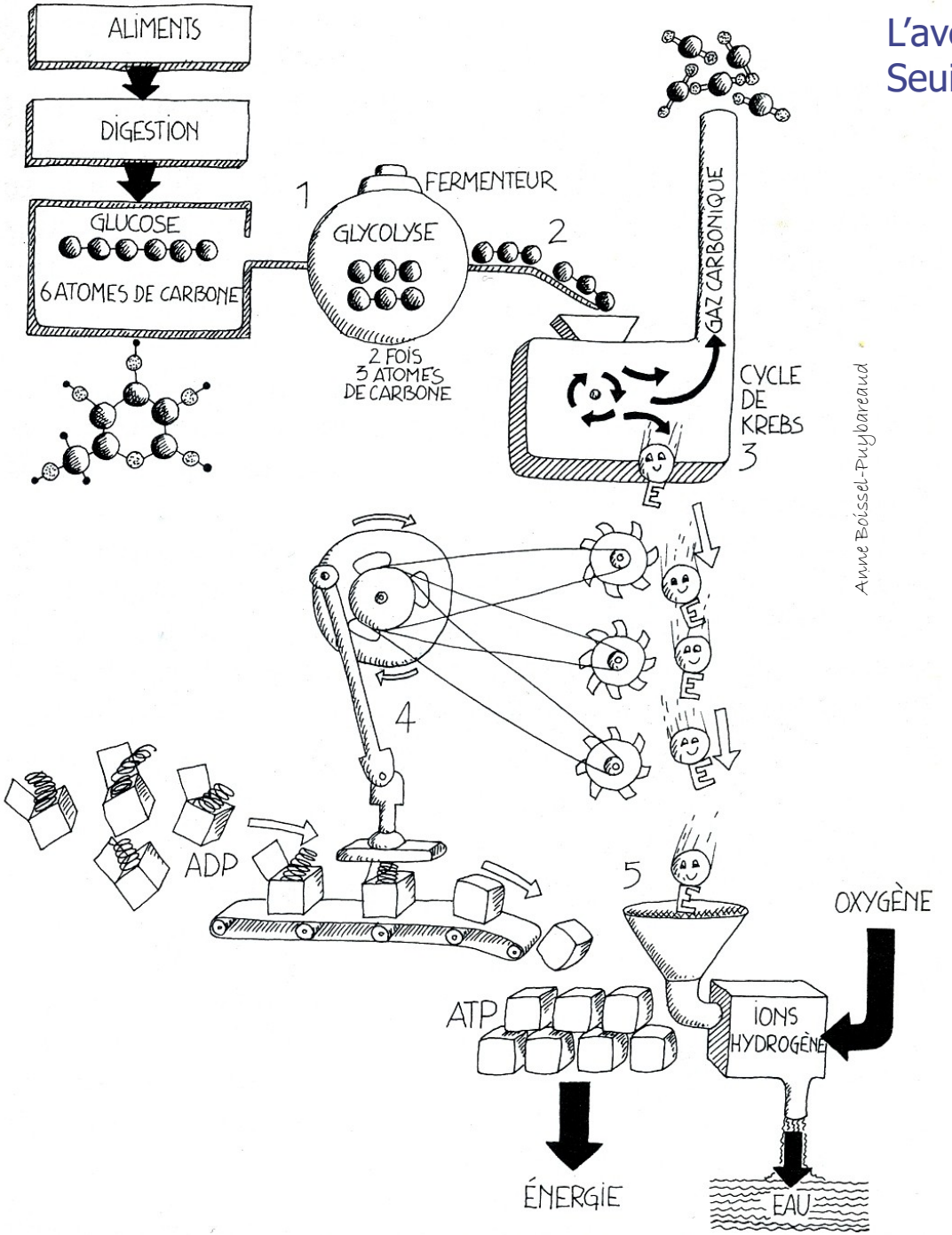
L'aventure du vivant. Joël de Rosnay
Seuil, 1988. « Points Sciences »



La mitochondrie : centrale énergétique de la cellule

Equivalents réducteurs

- Electrons
- Atome d'hydrogène (H) = 1proton (H^+) + 1 électron
- Ion Hydrure (H^-) = 1 proton (H^+) + 2 électrons