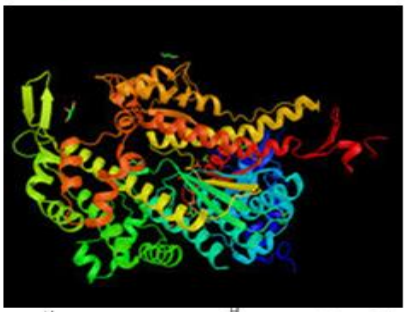
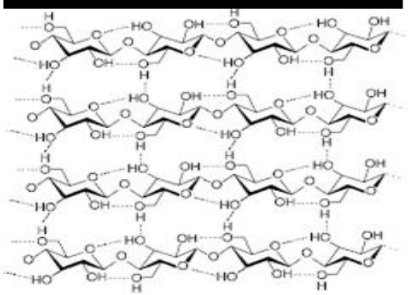


UNIVERSIDADE ESTADUAL DE RORAIMA

CURSO DE MEDICINA

Disciplina: Bioquímica

MÓDULO 2: Catabolismo

AULA 9

CADEIRA TRANSPORTADORA DE ELÉTRONS, FOSFORILAÇÃO OXIDATIVA E TERMOGÊNESE

Prof. Higo Nasser S. Moreira

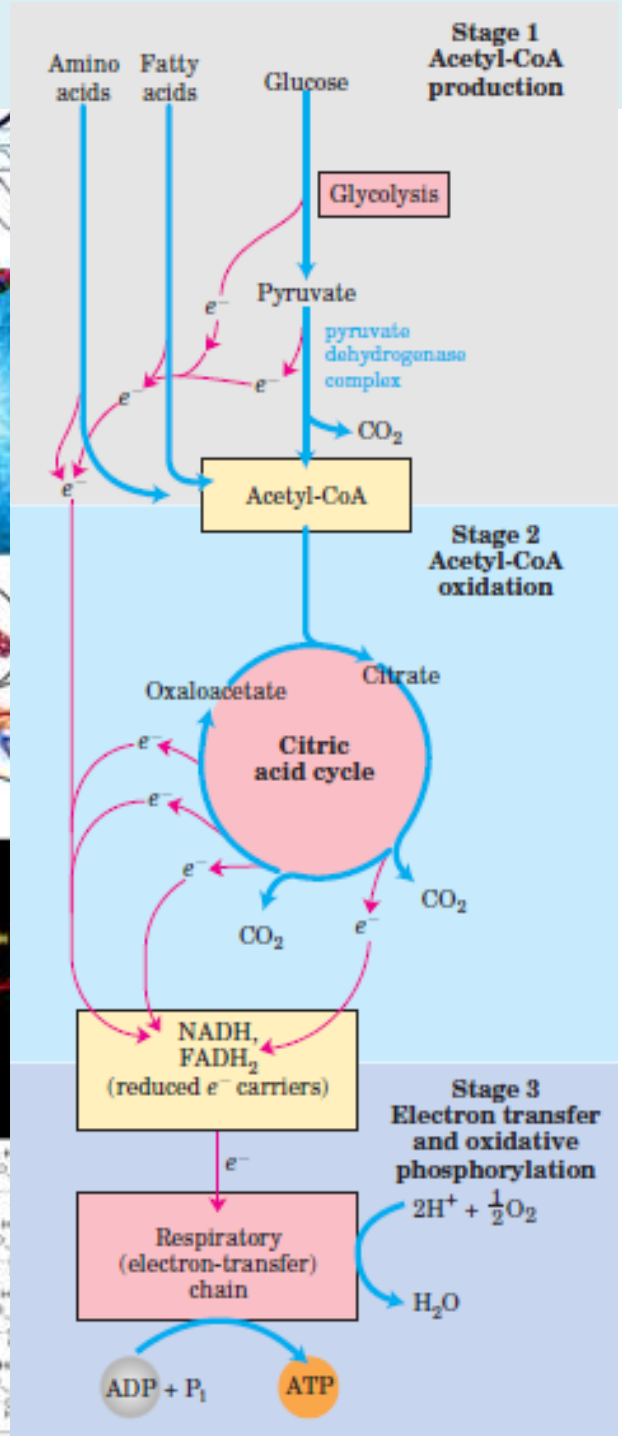
***Doctor Scientiae* em Bioquímica Aplicada**

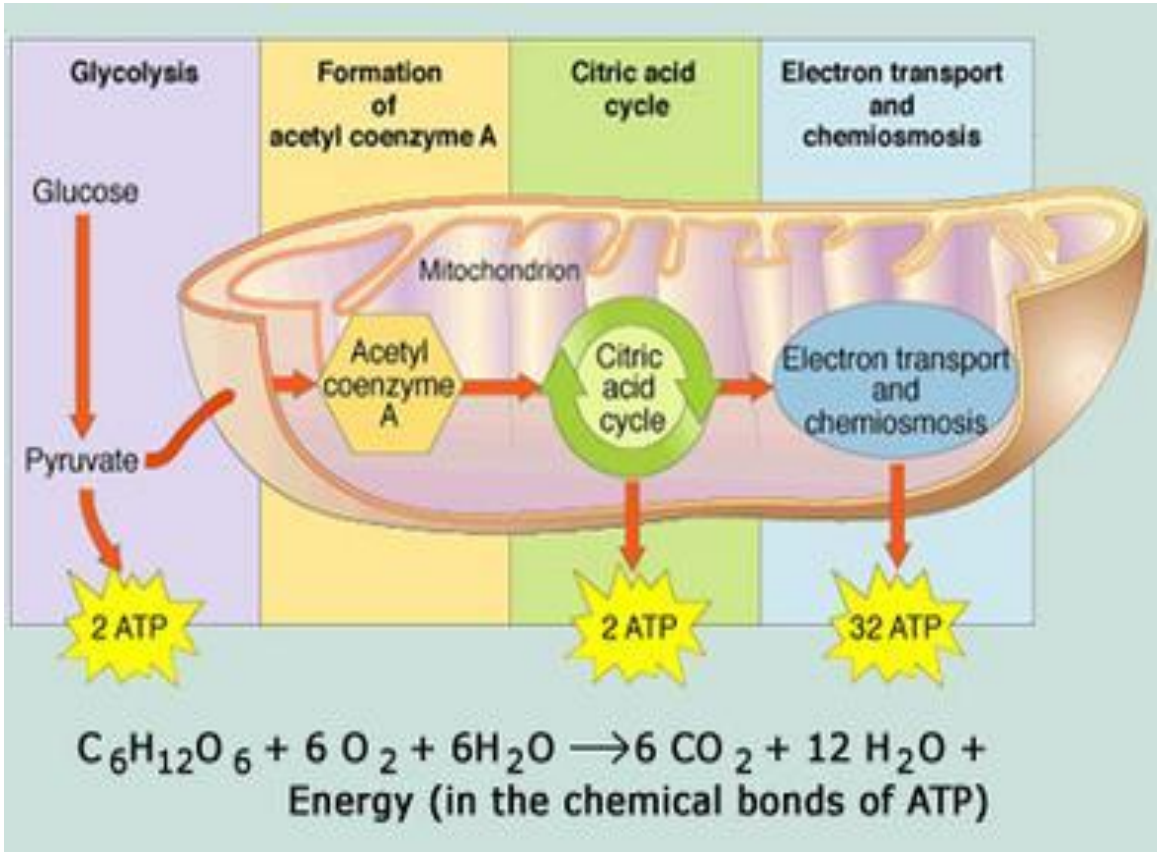
Universidade Federal de Viçosa – Brasil

Docente do Curso de Medicina da Universidade Estadual de Roraima

Boa Vista – Roraima

ETAPAS DA RESPIRAÇÃO CELULAR





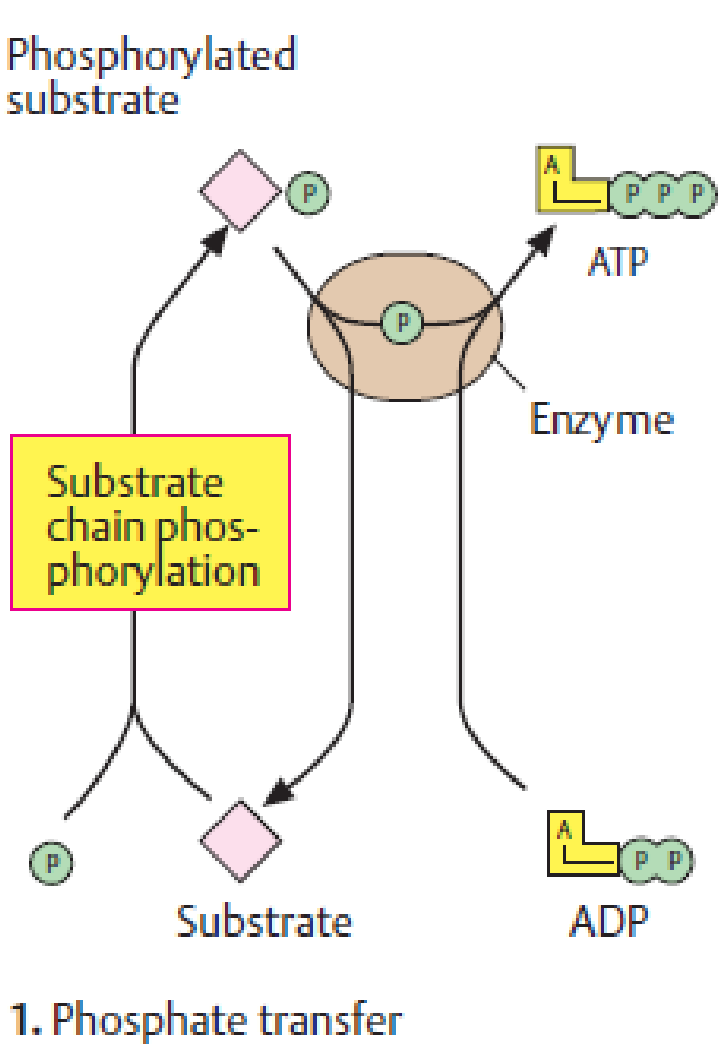
1. GLICÓLISE

2. DESCARBOXILAÇÃO OXIDATIVA

3. CICLO DO ÁCIDO CÍTRICO

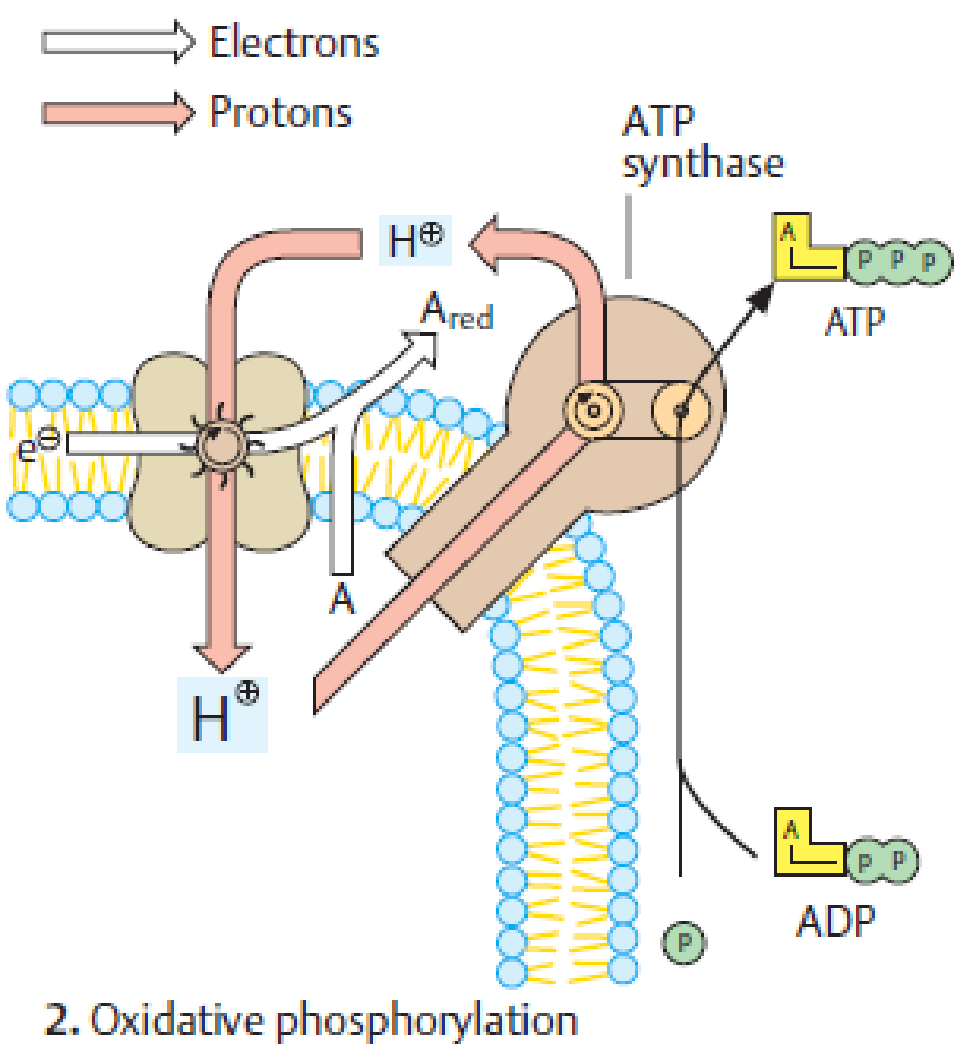
4. CADEIA TRANSPORTADORA DE ELÉTRONS

FOSFORILAÇÃO À NIVEL DE SUBSTRATO



1. Phosphate transfer

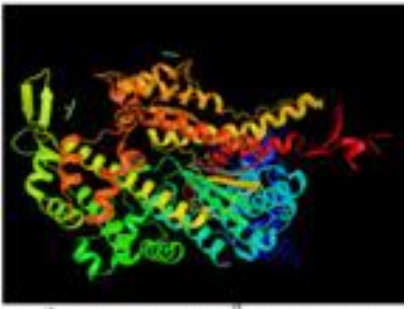
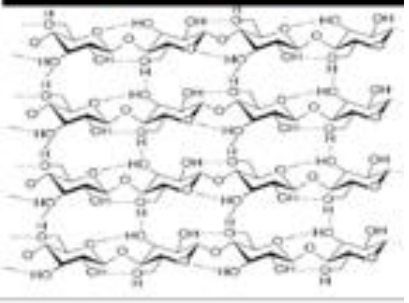
FOSFORILAÇÃO OXIDATIVA



2. Oxidative phosphorylation

CADEIA TRANSPORTADORA DE ELÉTRONS (CTE) ou CADEIA RESPIRATÓRIA



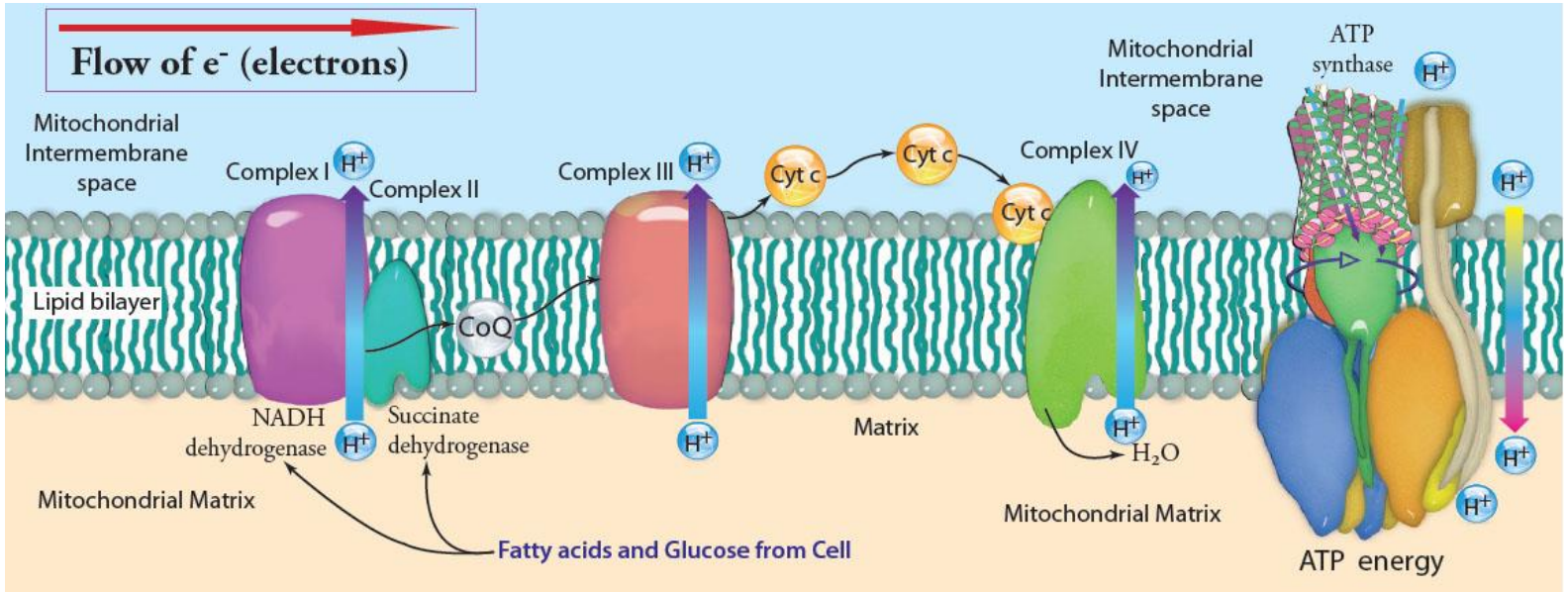
Quatro complexos de proteínas que são integrados na membrana mitocondrial interna

1. **COMPLEXO I (complexo NADH Desidrogenase)**
2. **COMPLEXO III (complexo citocromo b-c1)**
3. **COMPLEXO IV (complexo de citocromo oxidase)**
4. **COMPLEX II ou succinato desidrogenase, que pertence ao ciclo do ácido cítrico**

Duas (2) moléculas transportadoras móveis:

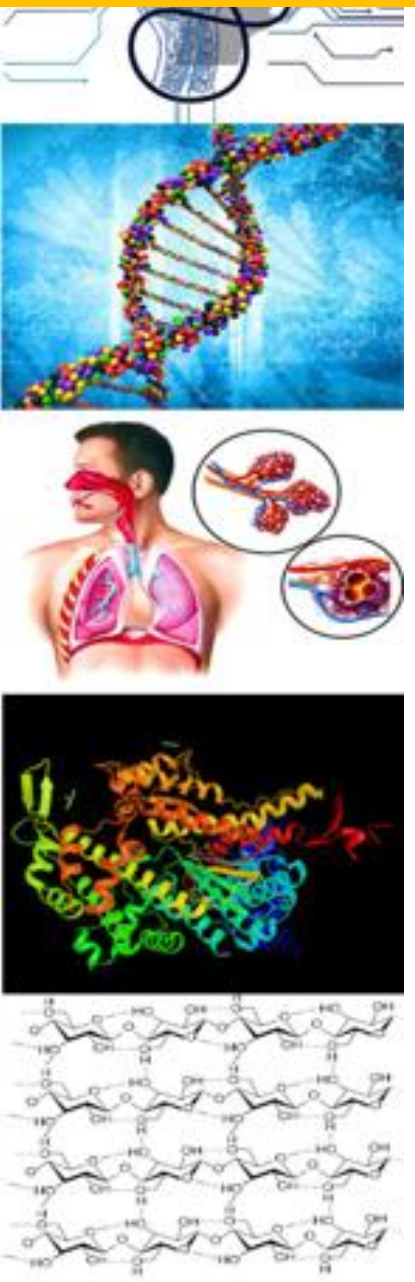
1. **Ubiquinona (ou Coenzima Q)**
2. **Citocromo C**

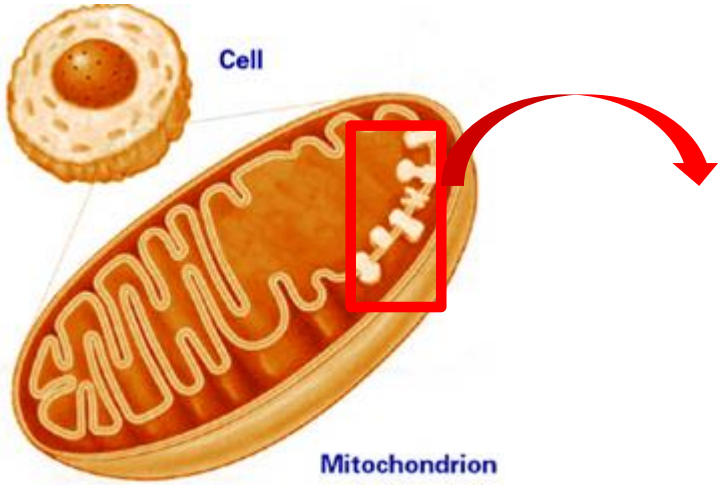
ATP sintase ou COMPLEXO V:



CADEIA TRANSPORTADORA DE ELÉTRONS (CTE)

Os complexos da cadeia transportadora são complexos multienzimáticos





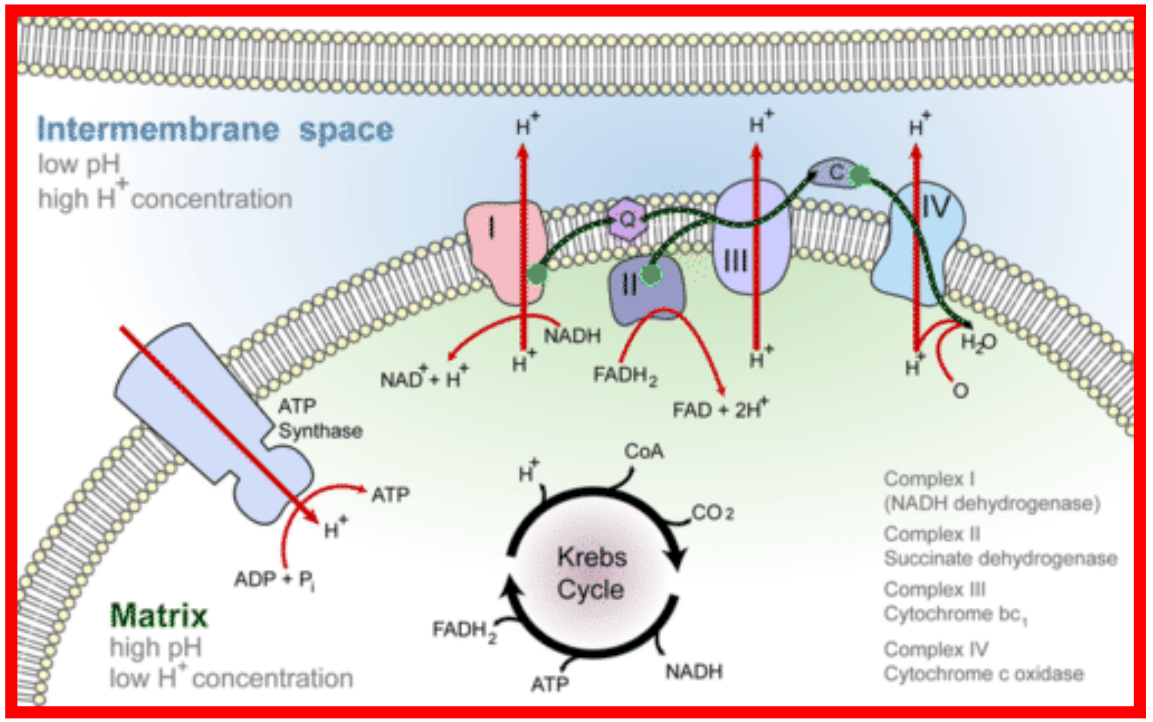
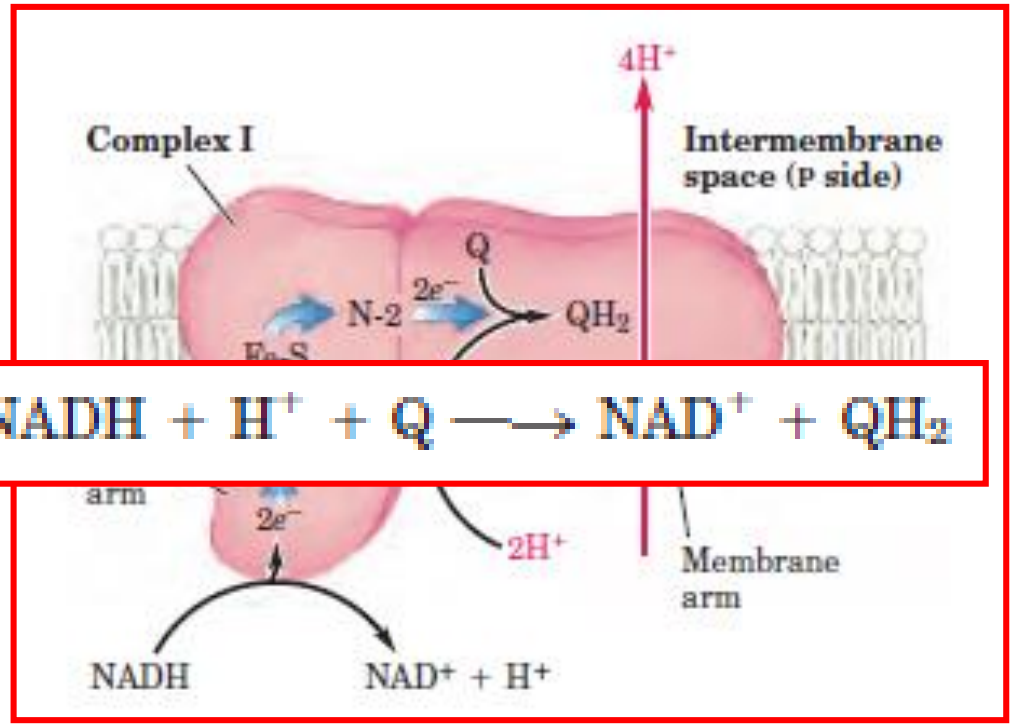


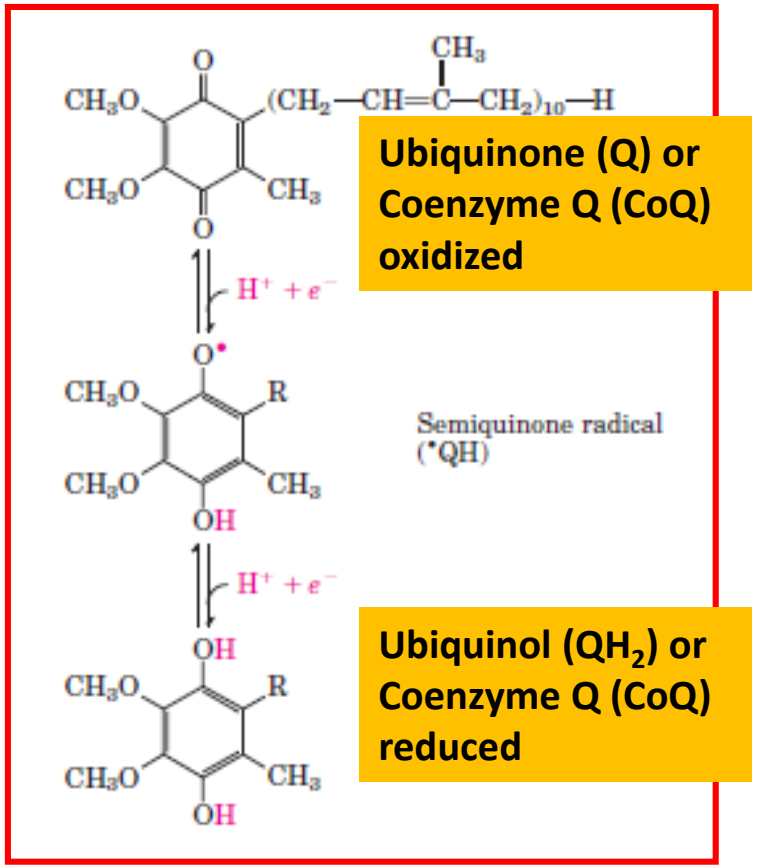
TABLE 19–3 The Protein Components of the Mitochondrial Electron-Transfer Chain

Enzyme complex/protein	*Mass (kDa)*	*Number of subunits**	*Prosthetic group(s)*
I NADH dehydrogenase	850	43 (14)	FMN, Fe-S
II Succinate dehydrogenase	140	4	FAD, Fe-S
III Ubiquinone cytochrome *c* oxidoreductase	250	11	Hemes, Fe-S
Cytochrome $c^{\dagger}$	13	1	Heme
IV Cytochrome oxidase	160	13 (3–4)	Hemes; Cu_A, Cu_B

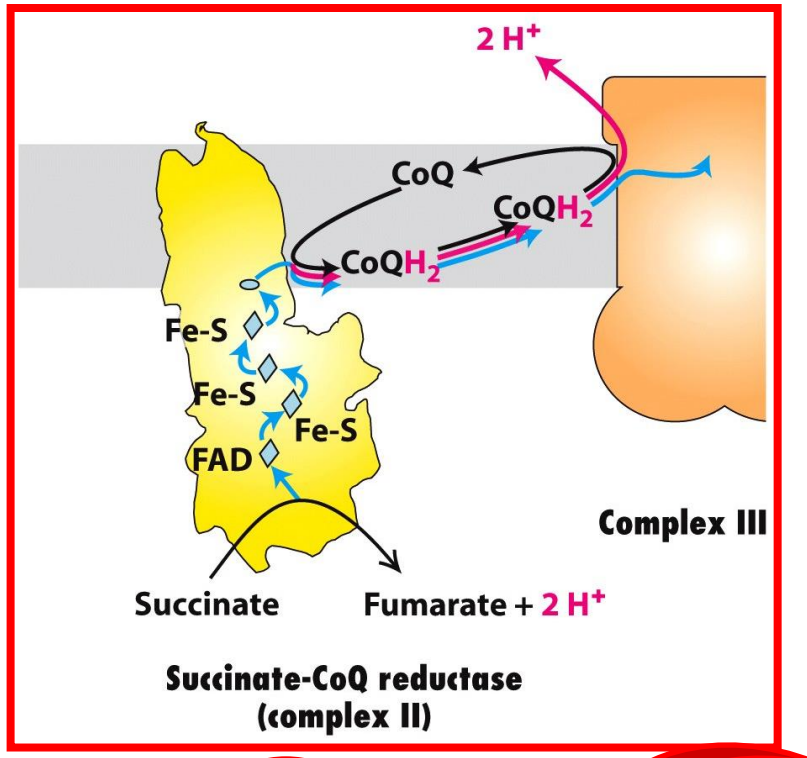
- ✓ **Complexo enzimático formado por 42 cadeias polipeptídicas diferentes.**
- ✓ **Redução da Ubiquinona móvel (CoQ) para Ubiquinol (CoQH2)**
- ✓ **Bombeamento de 4 prótons (íons H^+) da matriz mitocondrial para o espaço intermembrana.**

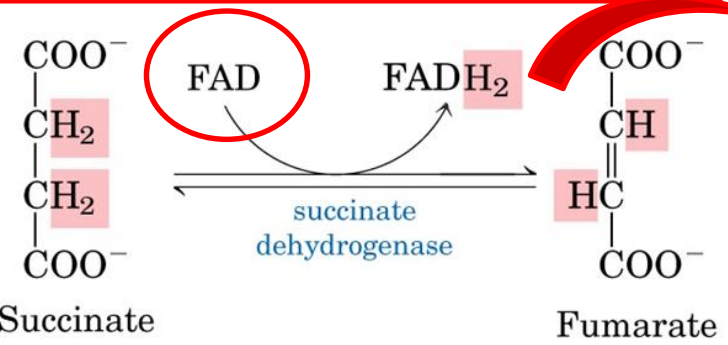


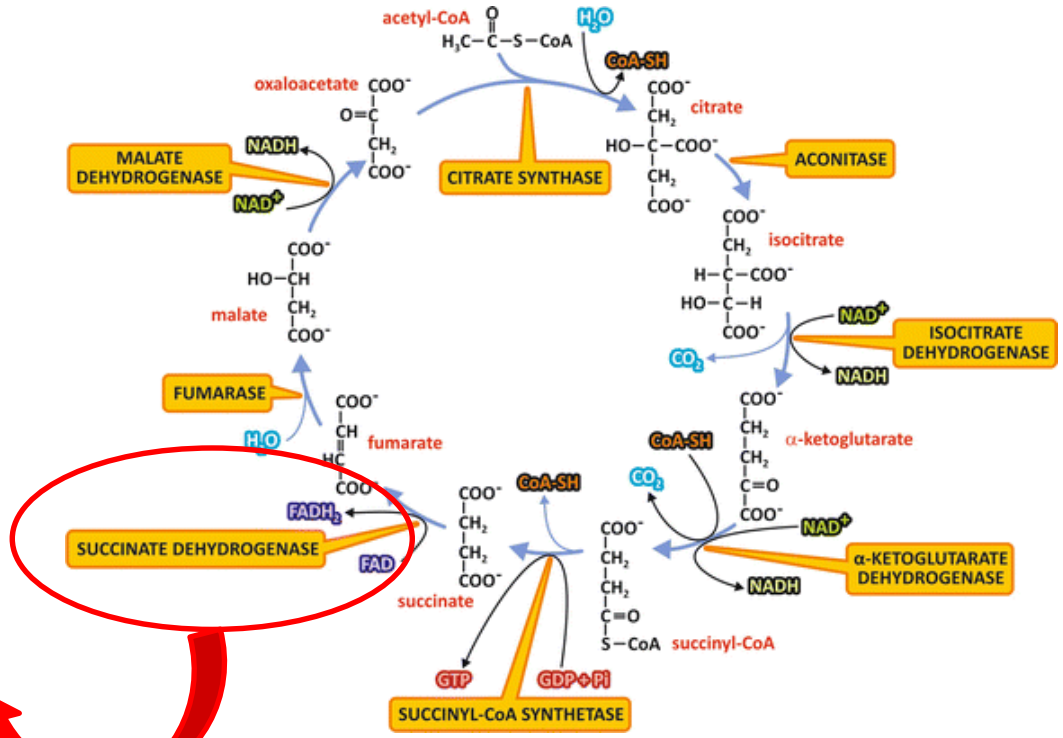
$NADH + H^+ + CoQ \rightarrow NAD^+ + CoQH_2$



O COMPLEXO II ou SUCCINATO DESIDROGENASE é uma das enzimas do Ciclo de Krebs

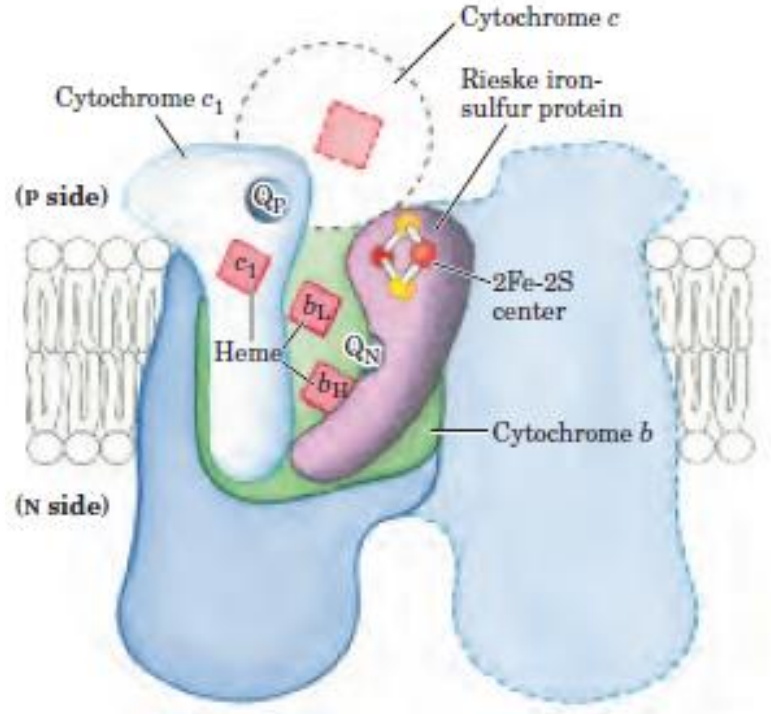


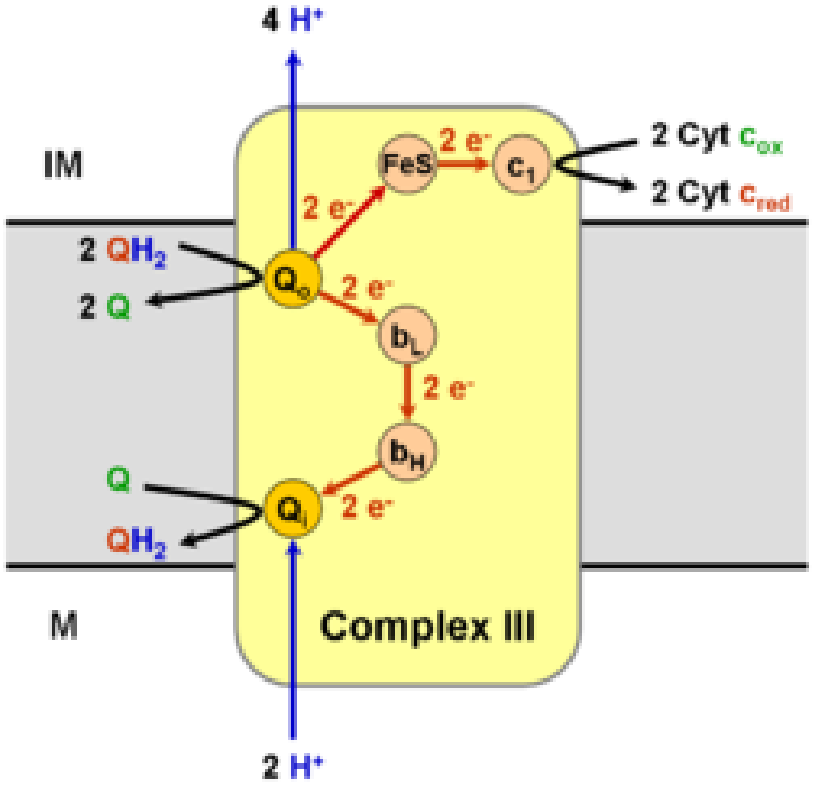




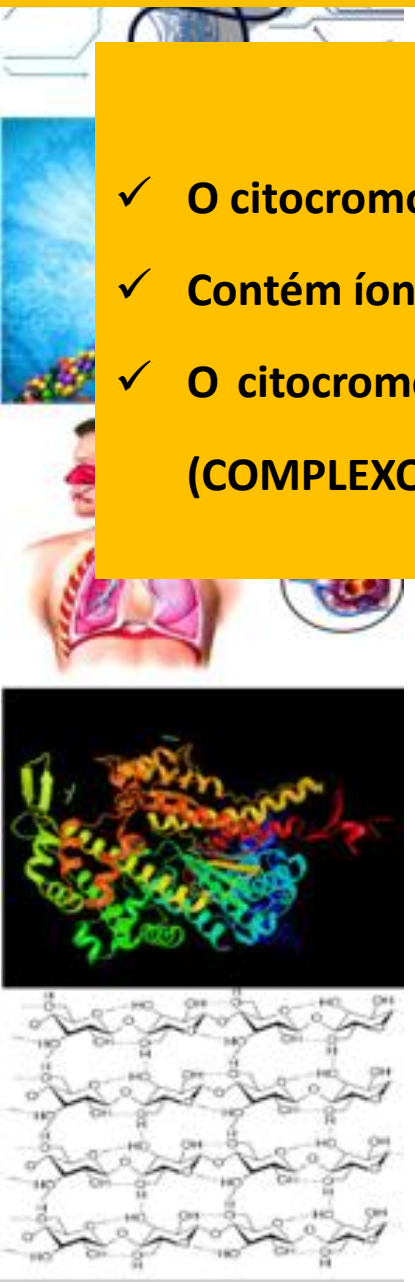
$FADH_2$ + CoQ → FAD + $CoQH_2$

- ✓ **Oxidação de UBIQUINOL (CoQH2) em UBIQUINONA (CoQ)**
- ✓ **Redução de 2 moléculas Citocromo C1 por molécula de Ubiquinol.**
- ✓ **Bombeamento de 4 prótons ($4H^+$)**



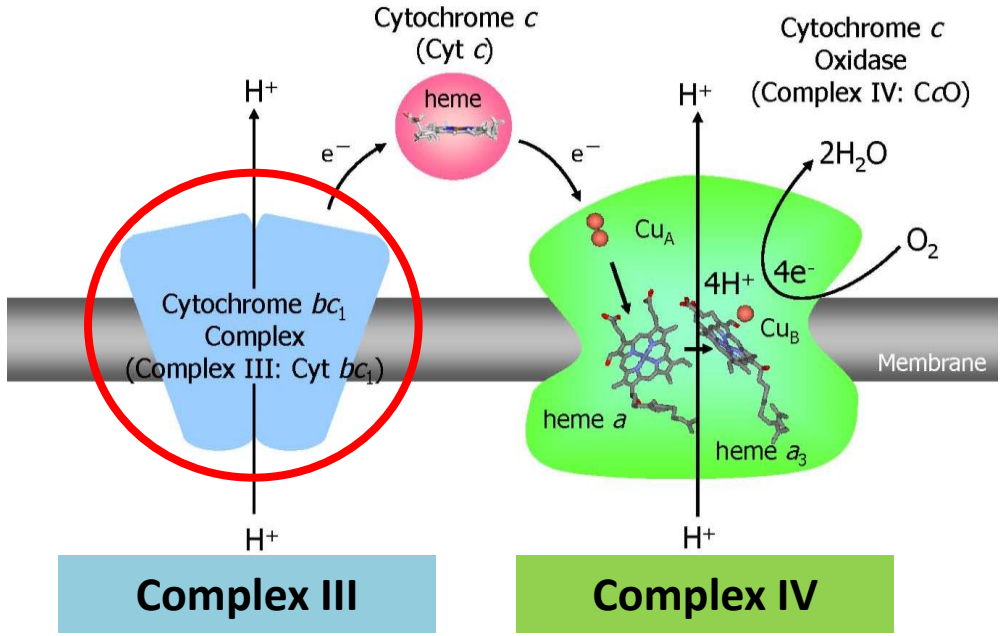


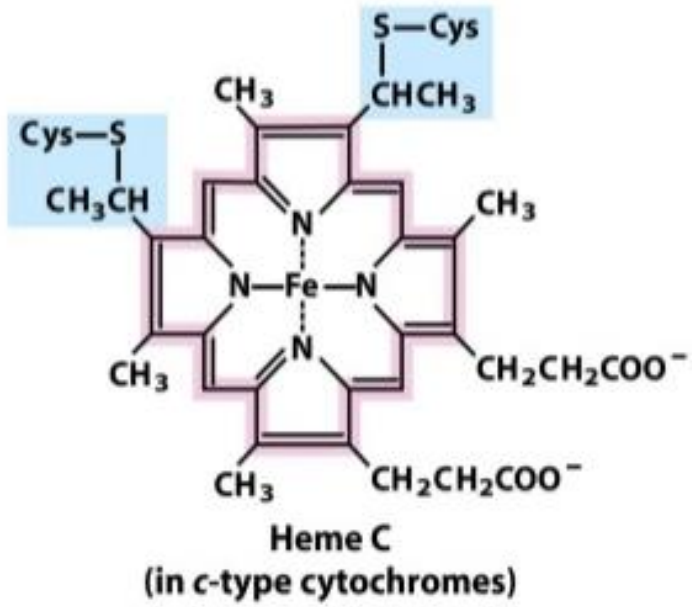
$CoQH_2$ + 2 Citocrome C_1 (Oxidado) + $2H^+$ → CoQ + Citocromo C_1 (Reduzido) + $4H^+$



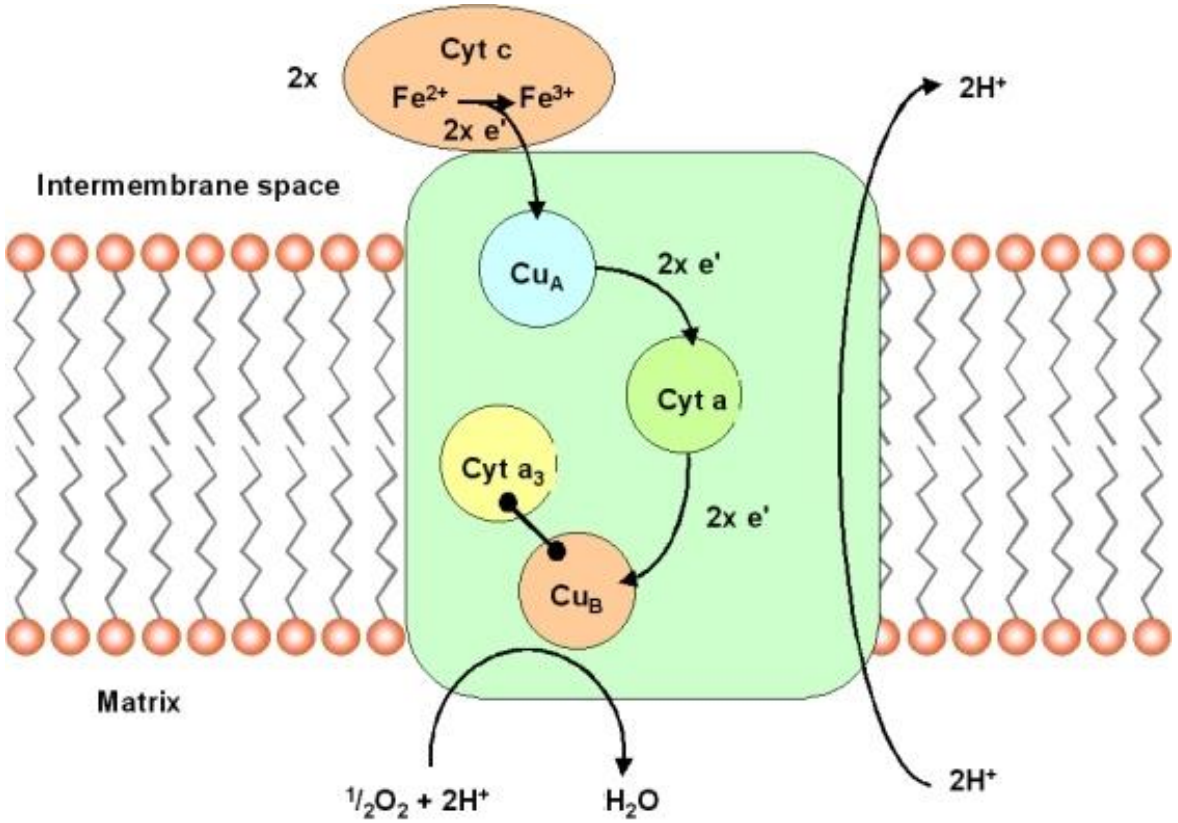
CITOCROMO C (Segundo transportador móvel de elétrons)

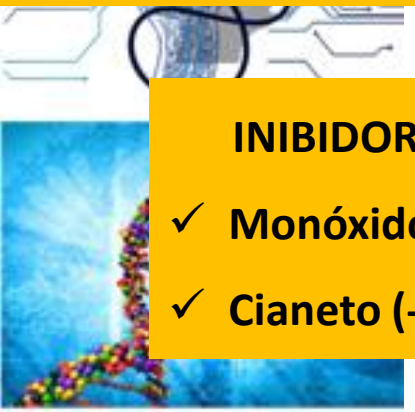
- ✓ **O citocromo C é uma proteína solúvel contendo o grupo prostético HEME;**
- ✓ **Contém íons $Fe3^+$ (oxidado) ou férrico, $Fe2^+$ (reduzido);**
- ✓ **O citocromo c carrega um único elétron do complexo citocromo bc1 (COMPLEXO III) para a CITOCROMO OXIDASE (COMPLEXO IV)**

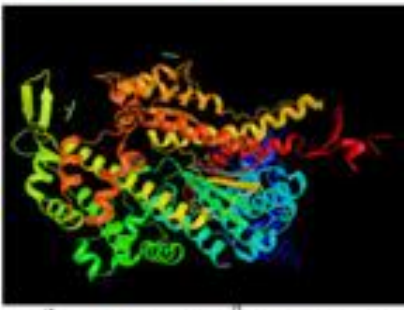


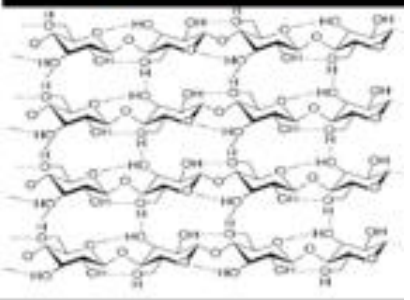


- ✓ A <u>CITOCROMO C OXIDASE</u> transporta os elétrons do CITOCROMO C (reduzido) para o O_2, reduzindo-o a H_2O.
- ✓ Bombeamento de 2 H^+ (prótons) para o espaço intermembrana.







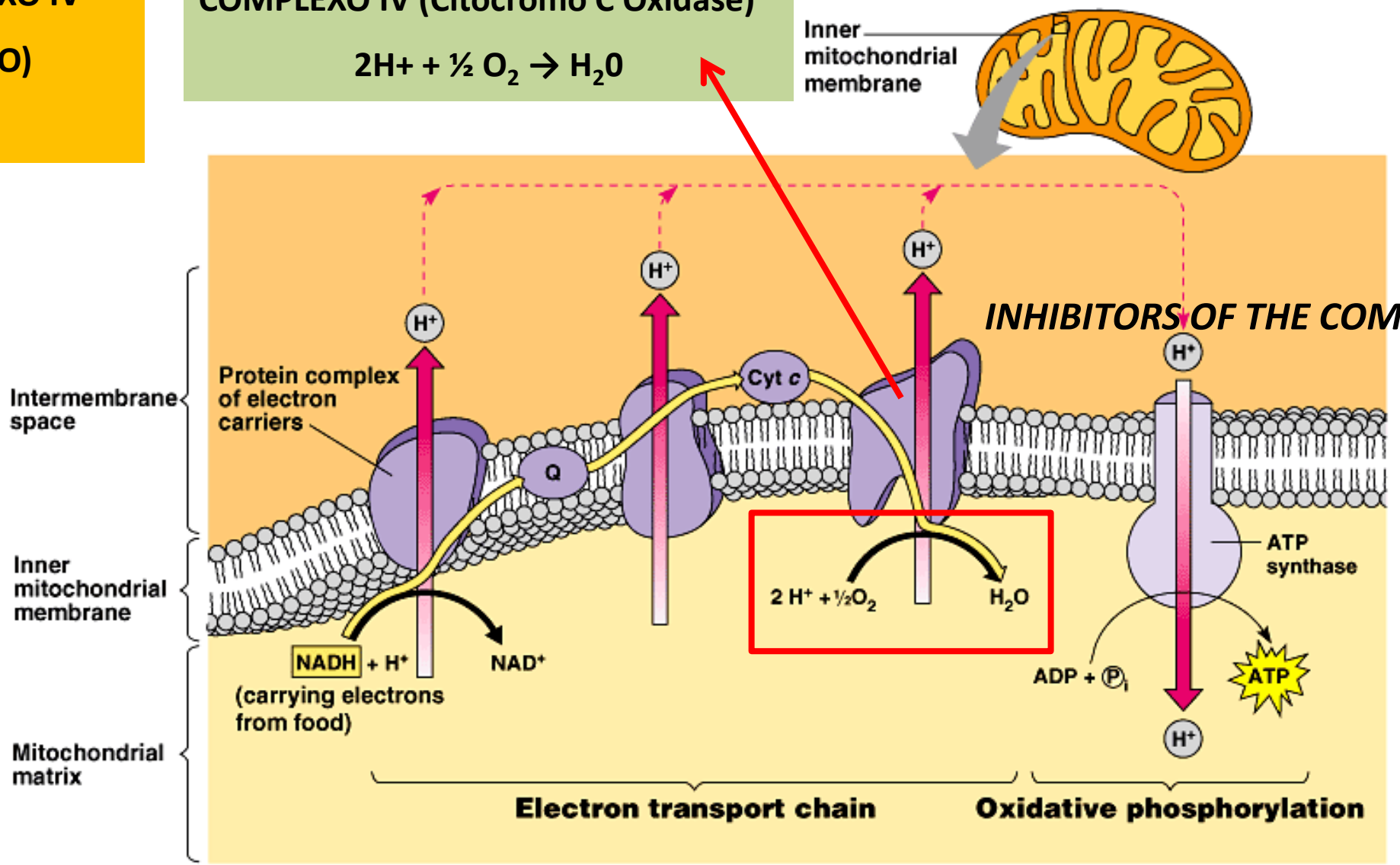


INIBIDORES DO COMPLEXO IV

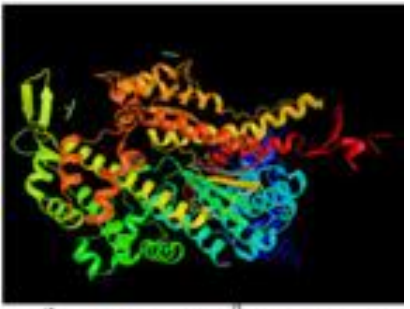
- ✓ **Monóxido de carbono (CO)**
- ✓ **Cianeto (-CN)**

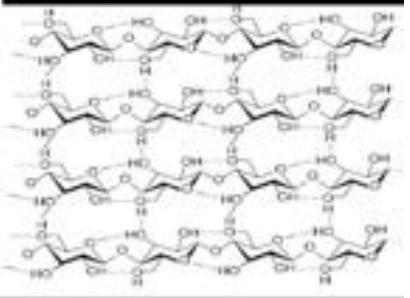
COMPLEXO IV (Citocromo C Oxidase)

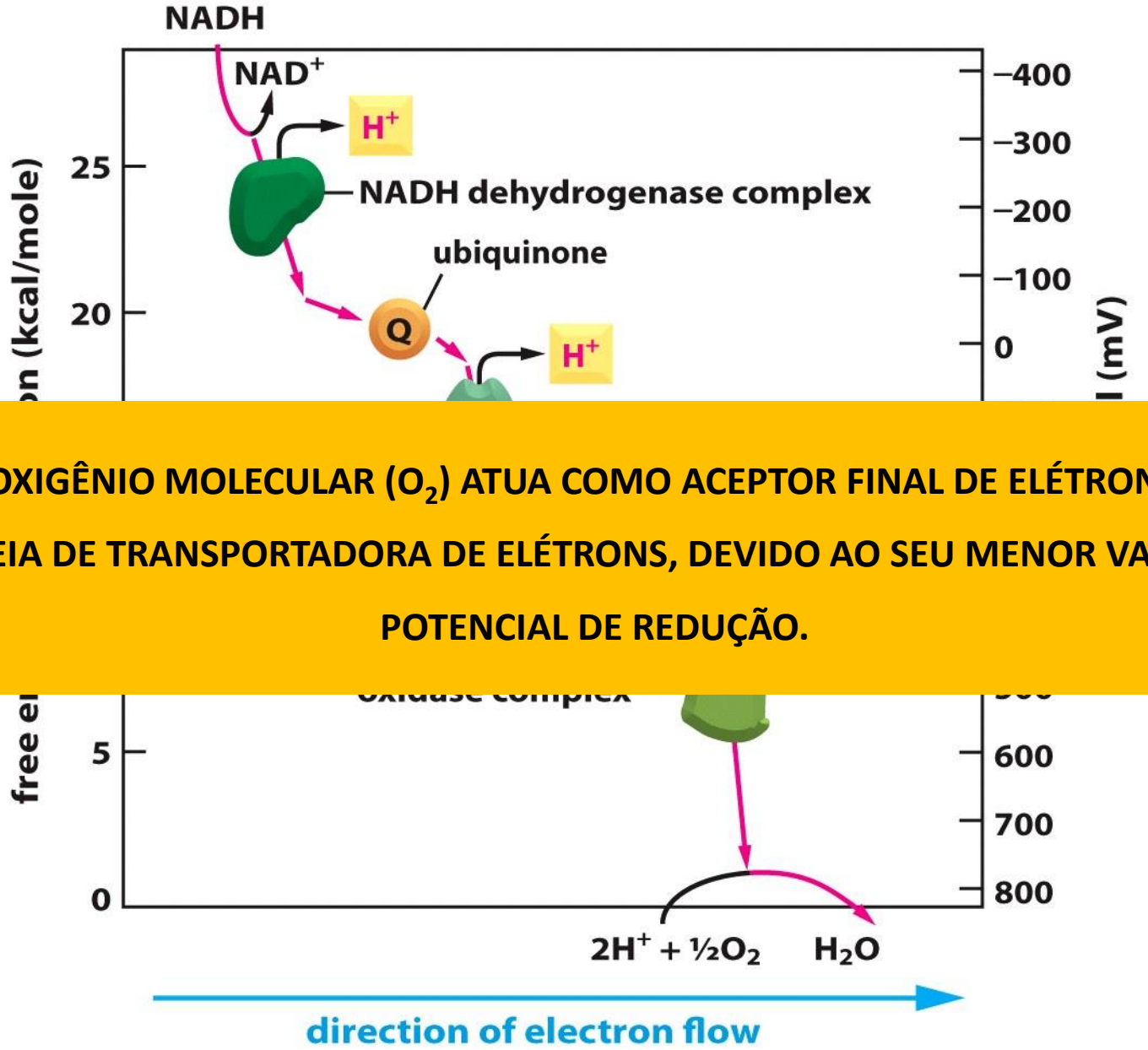
$2H+ + ½\ O_2 \rightarrow H_20$



POR QUE O O_2 É O ACEPTOR FINAL DE ELÉTRONS?

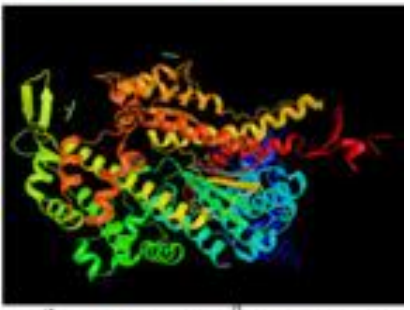
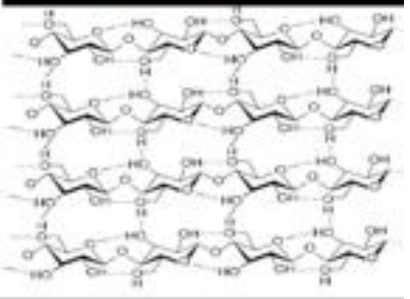




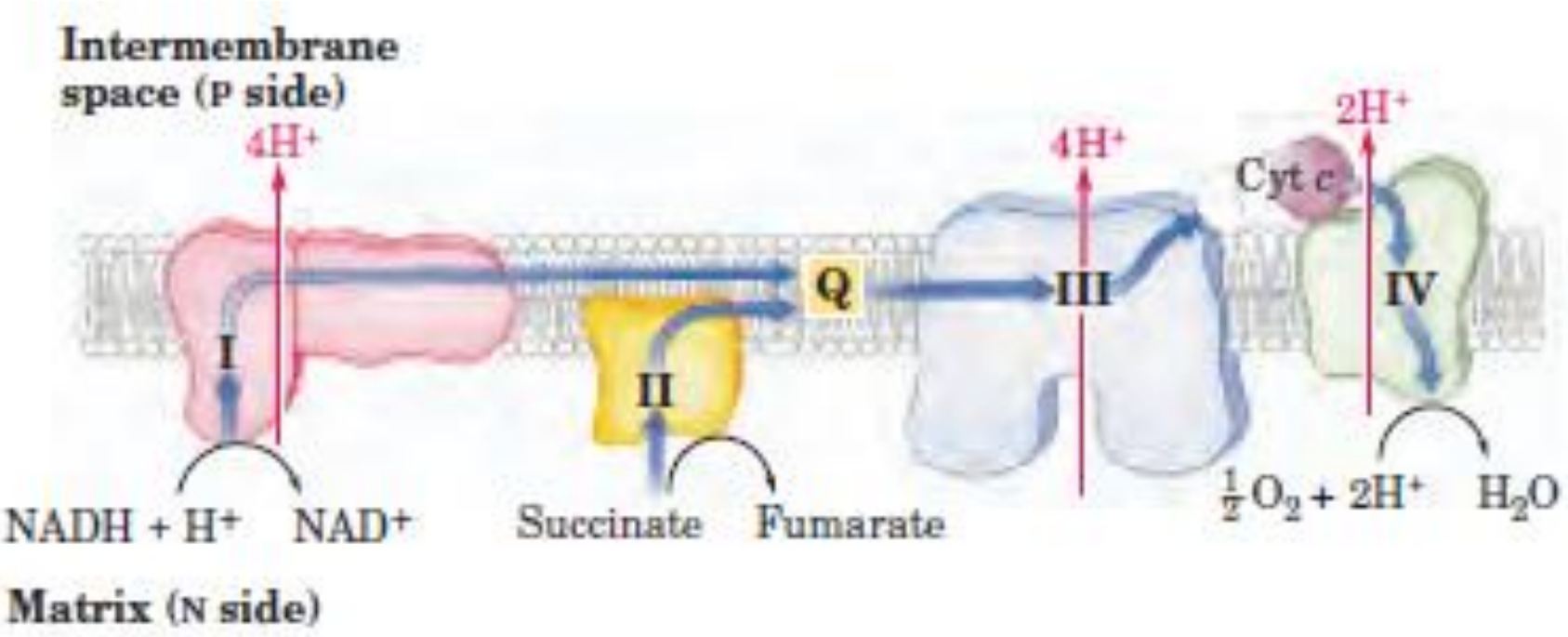


O OXIGÊNIO MOLECULAR (O_2) ATUA COMO ACEPTOR FINAL DE ELÉTRONS NA CADEIA DE TRANSPORTADORA DE ELÉTRONS, DEVIDO AO SEU MENOR VALOR DE POTENCIAL DE REDUÇÃO.



- ✓ **Oxidação de NADH e $FADH_2$ em NAD^+ e FAD.**
- ✓ **Bombeamento de prótons pelos complexos I, III e IV.**

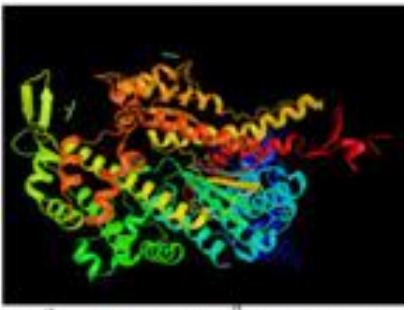
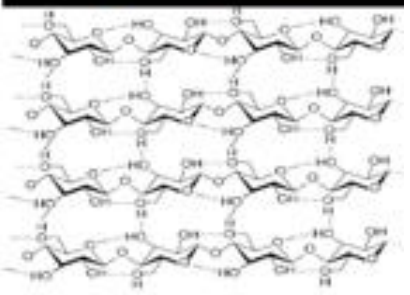


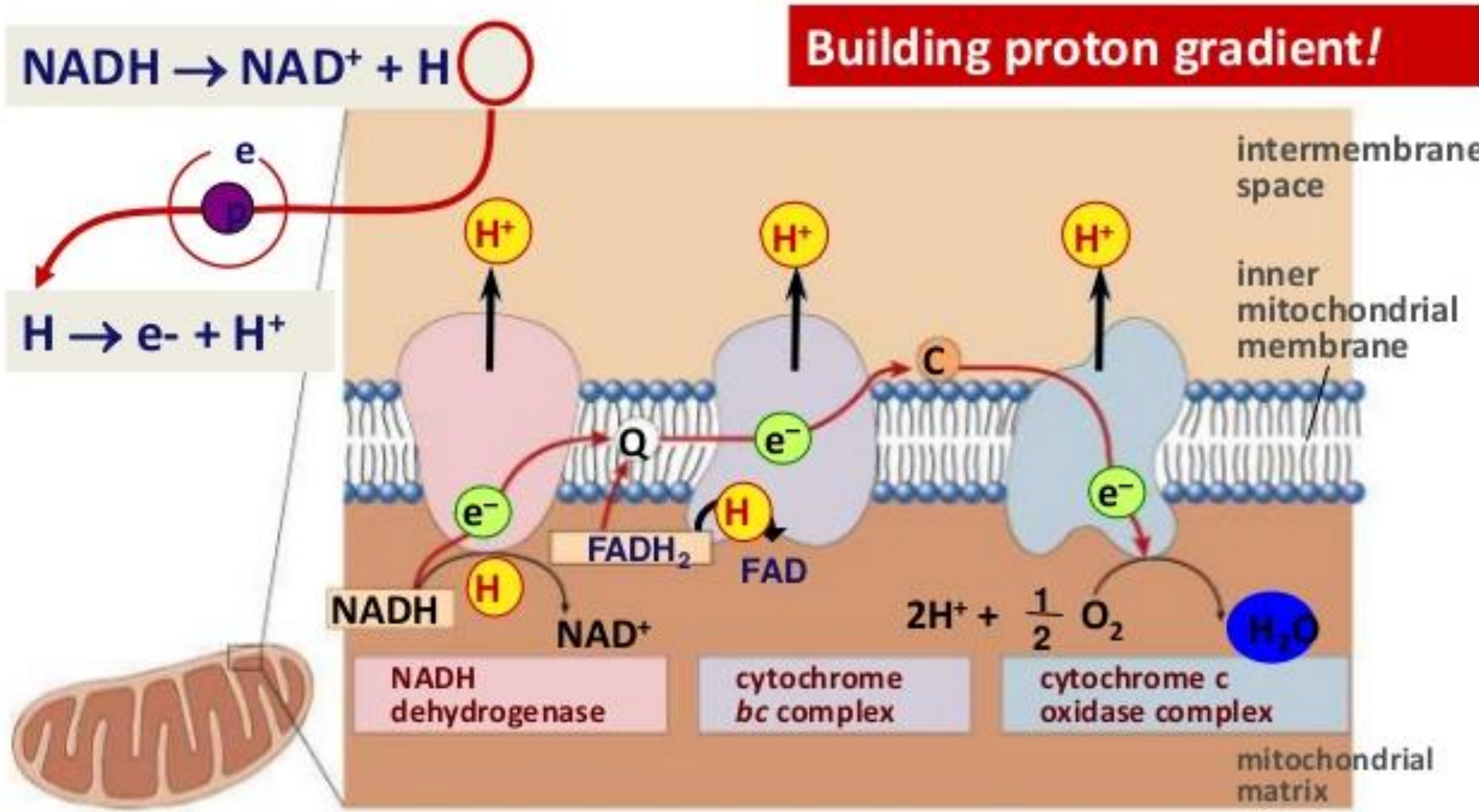
1 NADH = 10 H^+ = 3 ATPs

1 $FADH_2$ = 6H^+ = 2 ATPs

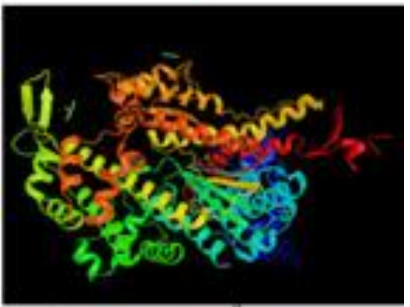
Regeneração de NAD^+ (complexo I) e FAD (complexo II)

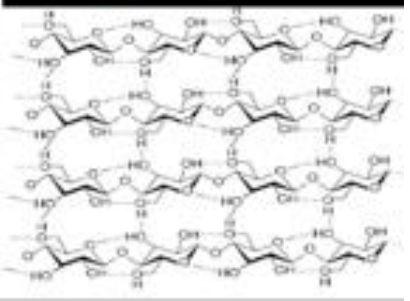



NADH → NAD⁺ + H
e
H → e- + H⁺
Building proton gradient!
intermembrane space
inner mitochondrial membrane
H⁺
H⁺
H⁺
C
Q
e⁻
e⁻
e⁻
H
H
FADH₂
FAD
NADH
NAD⁺
2H⁺ + ½ O₂
H₂O
NADH dehydrogenase
cytochrome bc complex
cytochrome c oxidase complex
mitochondrial matrix

CADEIA TRANSPORTADORA DE ELÉTRONS (CTE)
Teoria quimiosmótica de Mitchel e Gradiente Eletroquímico





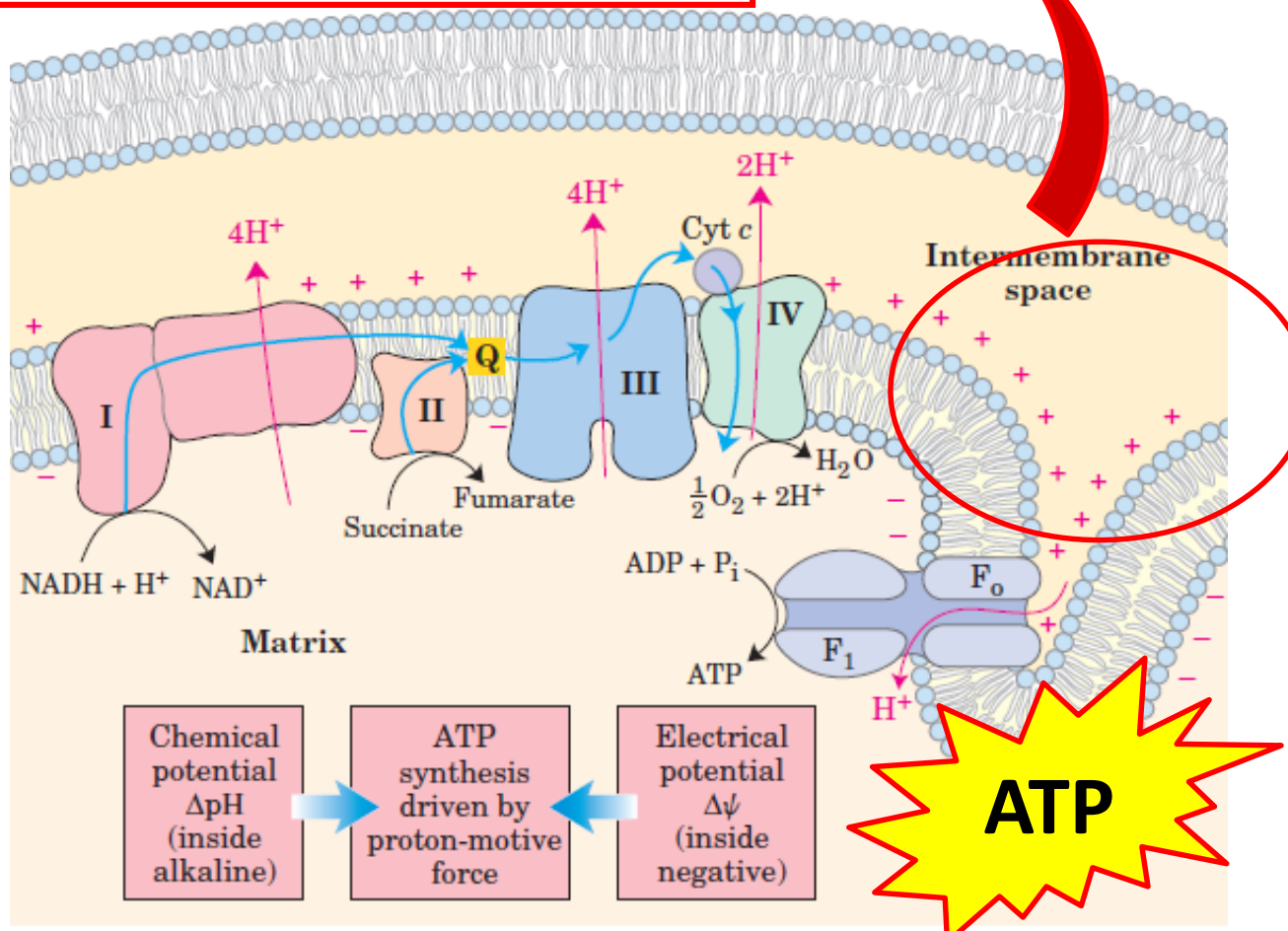
1 NADH = 10 H^+ = 3 ATPs

1 $FADH_2$ = 6H^+ = 2 ATPs

Gradiente **ELETROQUÍMICO**

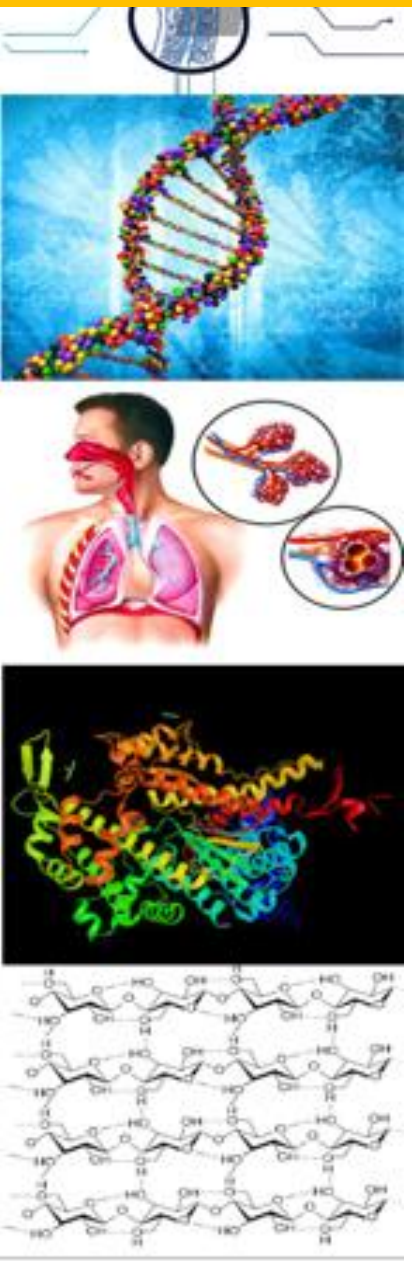
Gradiente elétrico: diferença de cargas +

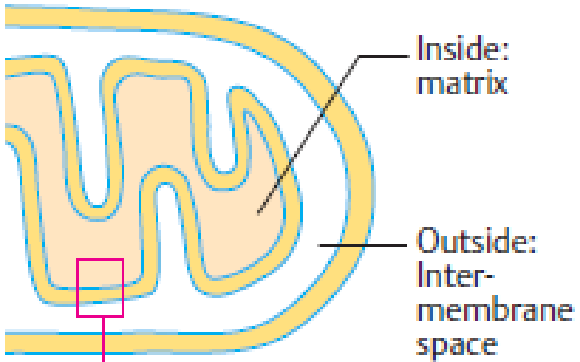
Gradiente químico: diferença de [H^+]

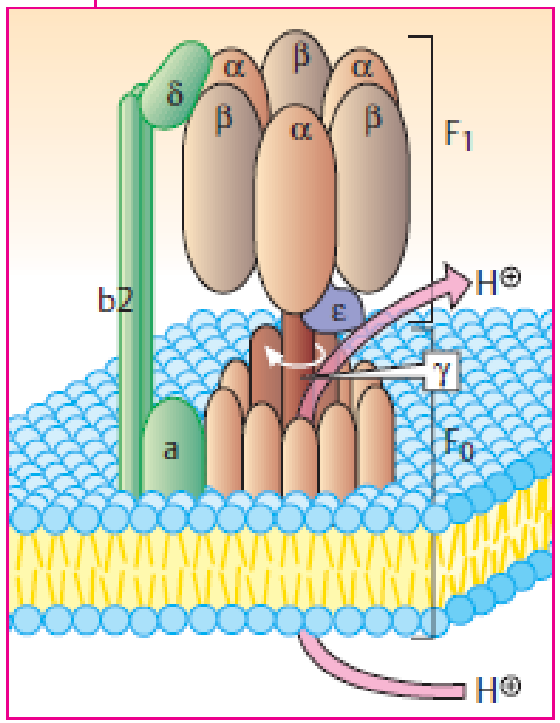


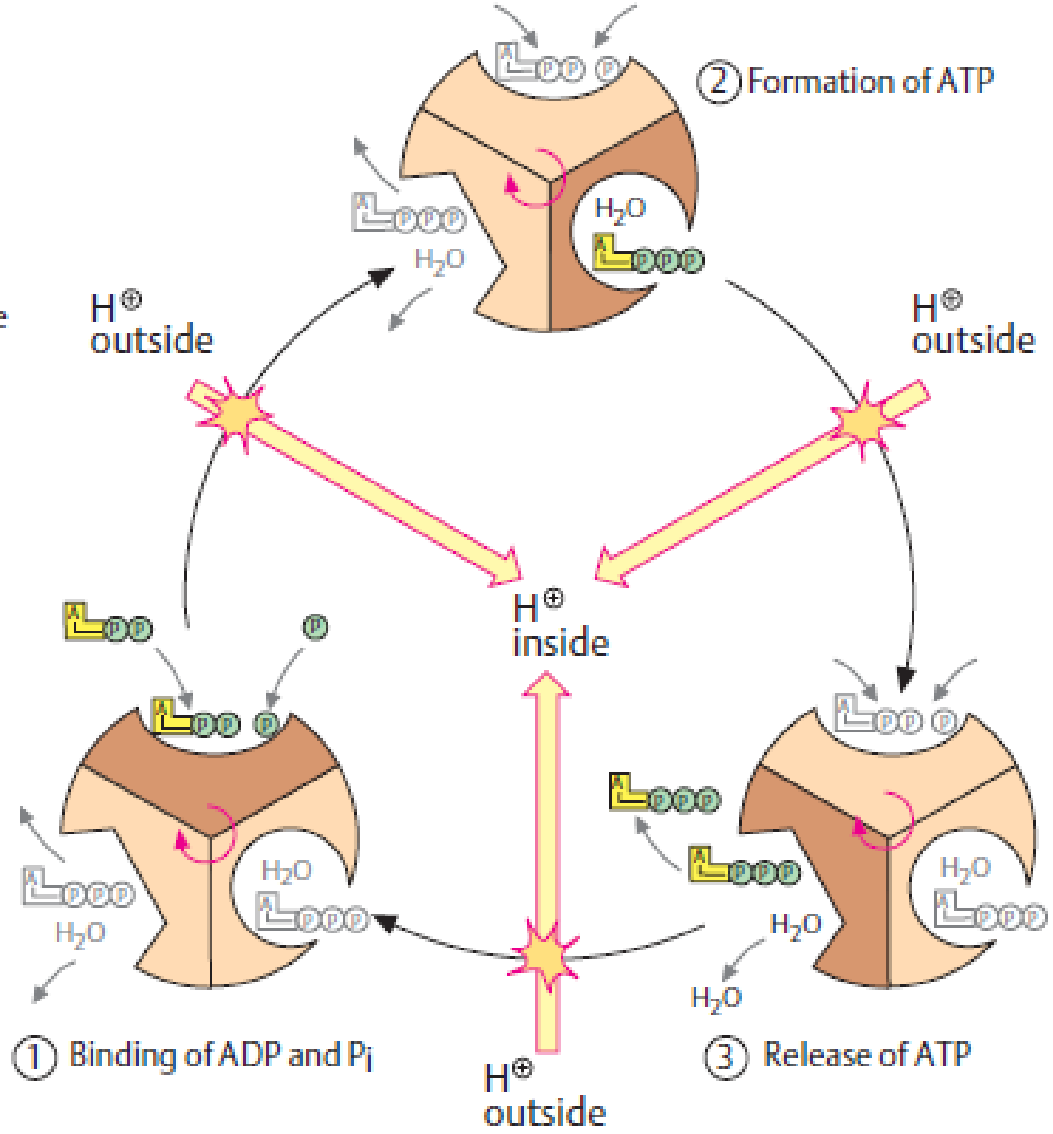
ATP SINTASE

A força eletromotriz do fluxo de prótons é usada para realizar trabalho químico para a síntese de ATP a partir de ADP e Pi

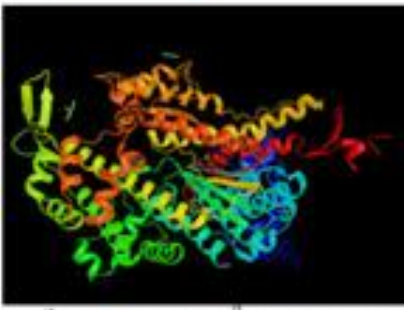
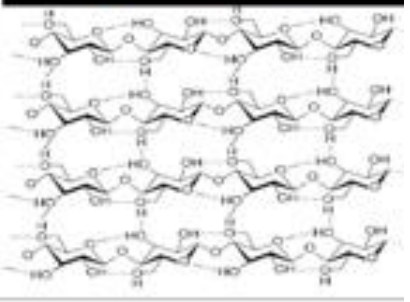








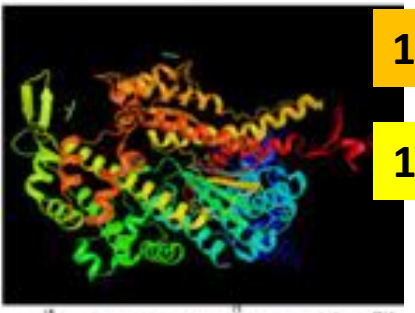
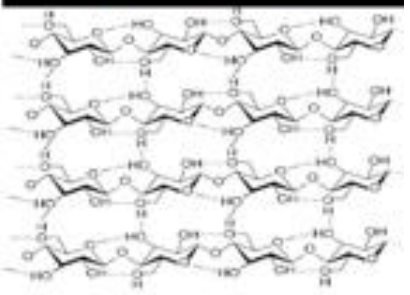


TESTE 1 - O EQUILÍBRIO FINAL DA RESPIRAÇÃO CELULAR

1- Determine o número total de moléculas de ATP produzidas pela oxidação completa de 1 mol de glicose na respiração celular em CO_2 e H_2O



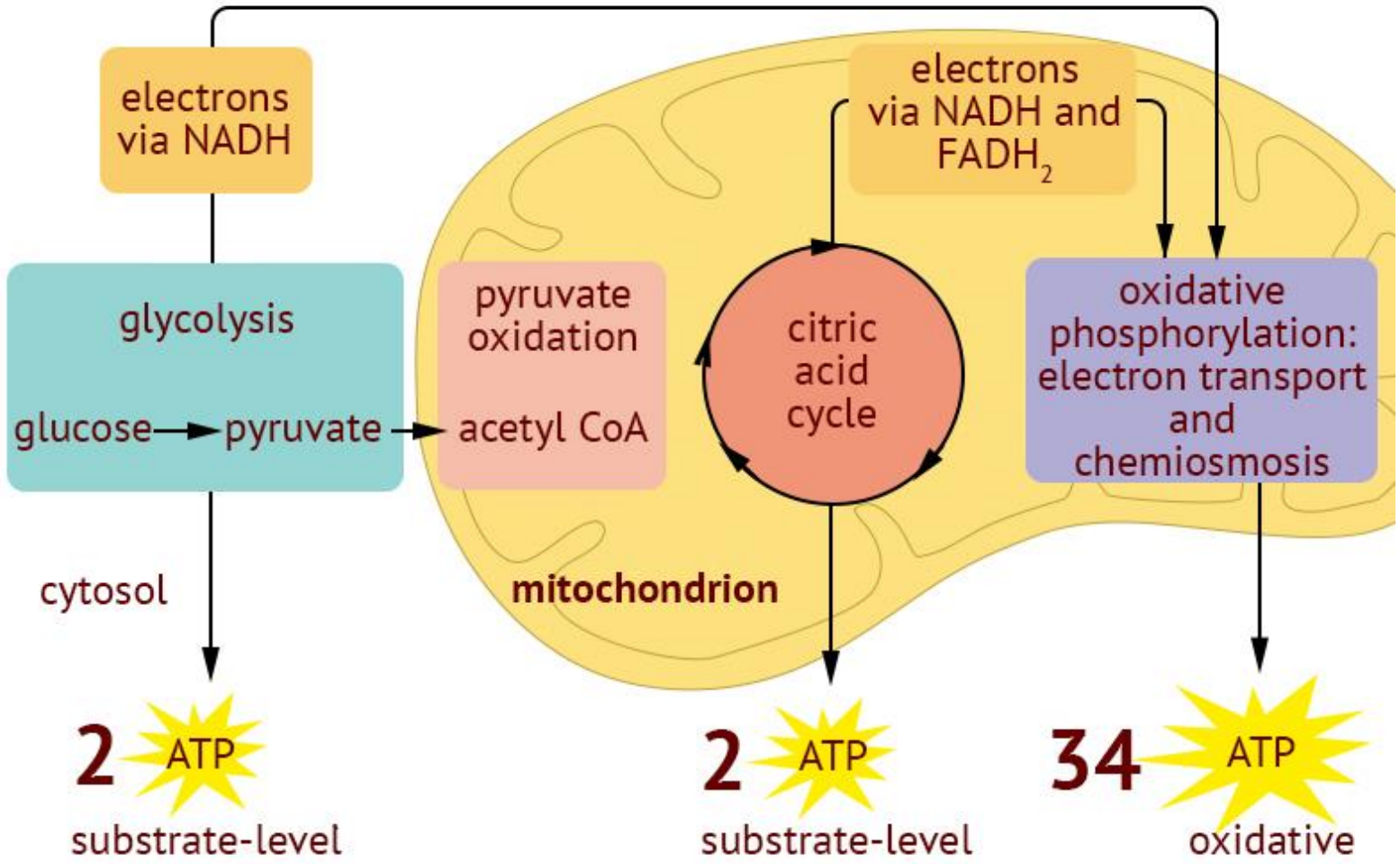




O BALANÇO FINAL DA RESPIRAÇÃO CELULAR

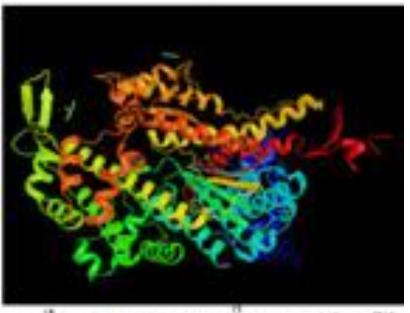
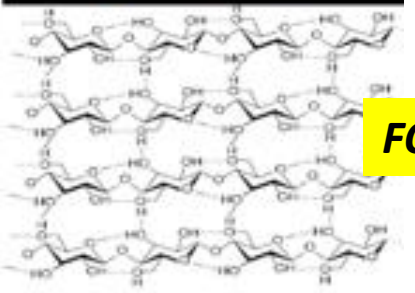
- ✓ **A formação de ATP pela <u>CADEIA TRANSPORTADORA DE ELÉTRONS/FOSFORILAÇÃO OXIDATIVA</u> é muito mais eficiente do que <u>a FOSFORILAÇÃO EM NÍVEL DE SUBSTRATO</u>**

1 NADH: 3 ATPs

1 $FADH_2$: 2 ATPs

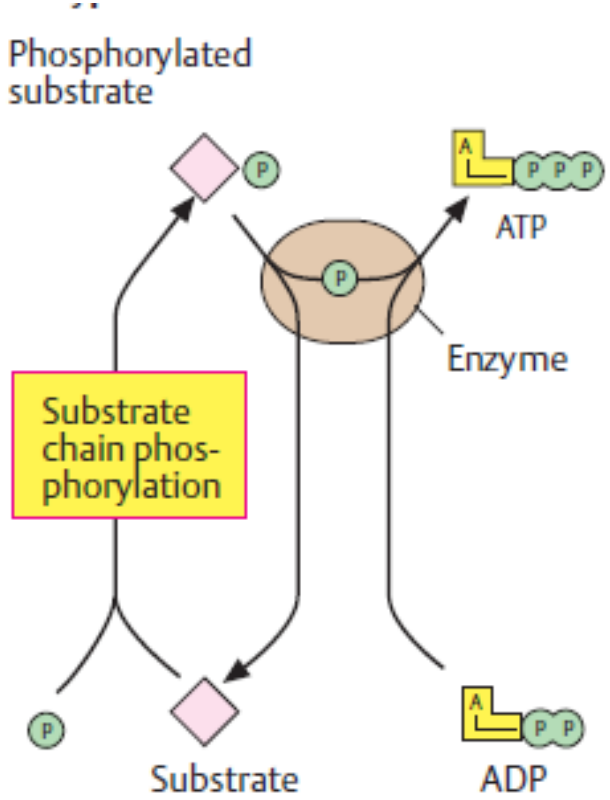




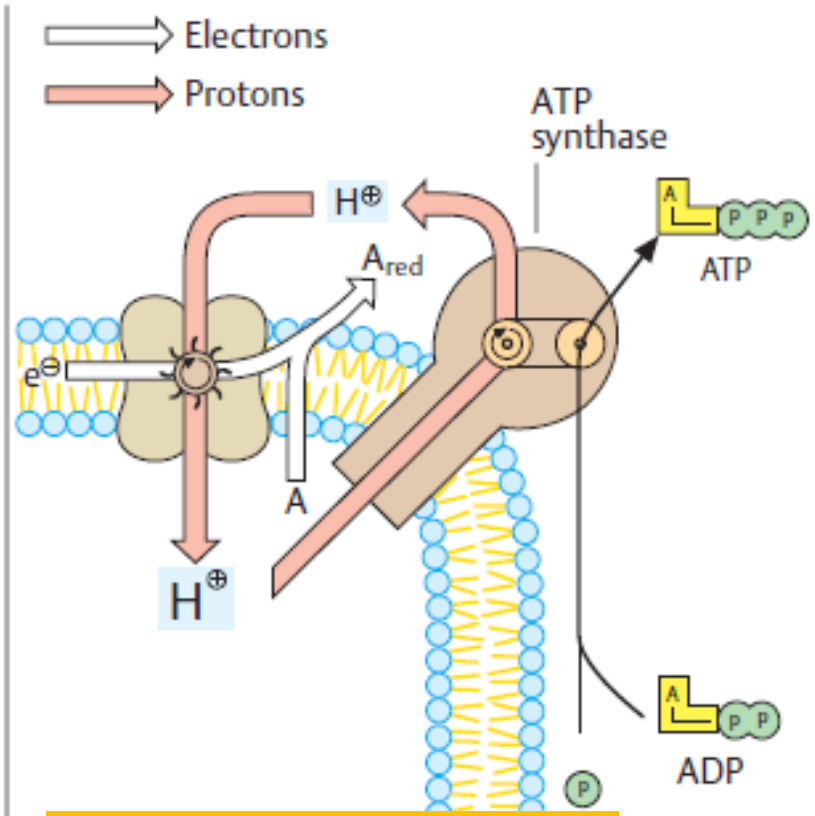




TESTE 2 – FOSFORILAÇÃO À NÍVEL DE SUBSTRATO VS RESPIRAÇÃO CELULAR

2- Considerando os dois principais processos de obtenção de ATP, qual é o de maior eficiência? Explique sua resposta com base no número de moléculas de ATP obtidas em cada caso.



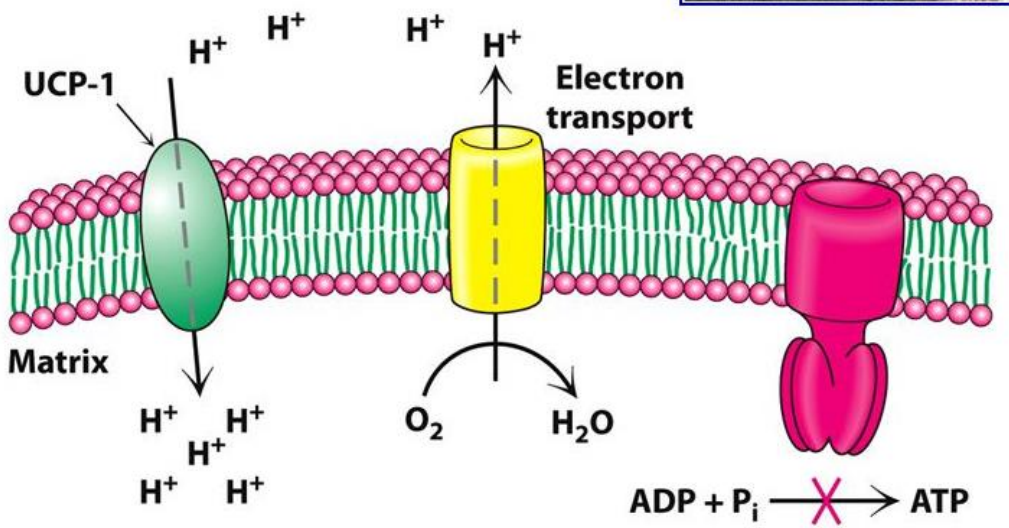
FOSFORILAÇÃO À NÍVEL DE SUBSTRATO

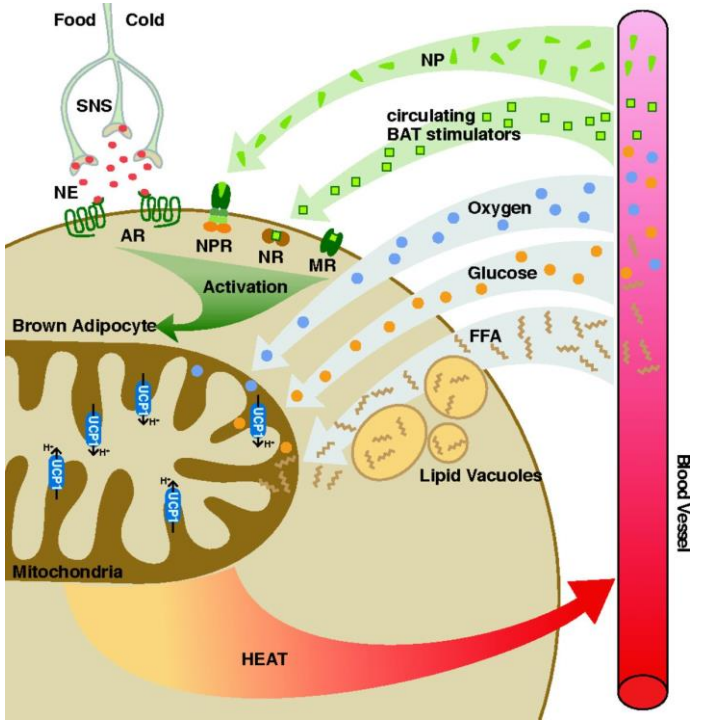


FOSFORILAÇÃO OXIDATIVA

GERAÇÃO DE CALOR POR DESACOPLAMENTO DA CADEIA DE TRANSPORTE DE ELÉTRONS

- ✓ **TERMOGENINA ou PROTEÍNA DE DESACOPLAMENTO 1 (UCP-1);**
- ✓ **O fluxo de prótons através de UCP-1 produz calor**
- ✓ **Contribui para a manutenção do calor corporal**
- ✓ **Abundante em tecido adiposo marrom**
- ✓ **UCP-1 "rouba" o potencial eletroquímico da síntese de ATP**





Urso hibernando