

# Electron Transport and Oxidative Phosphorylation

CHEM 420 – Principles of Biochemistry  
Instructor – Anthony S. Serianni

Chapter 22: Voet/Voet, *Biochemistry*, 2011  
Fall 2015

November 30

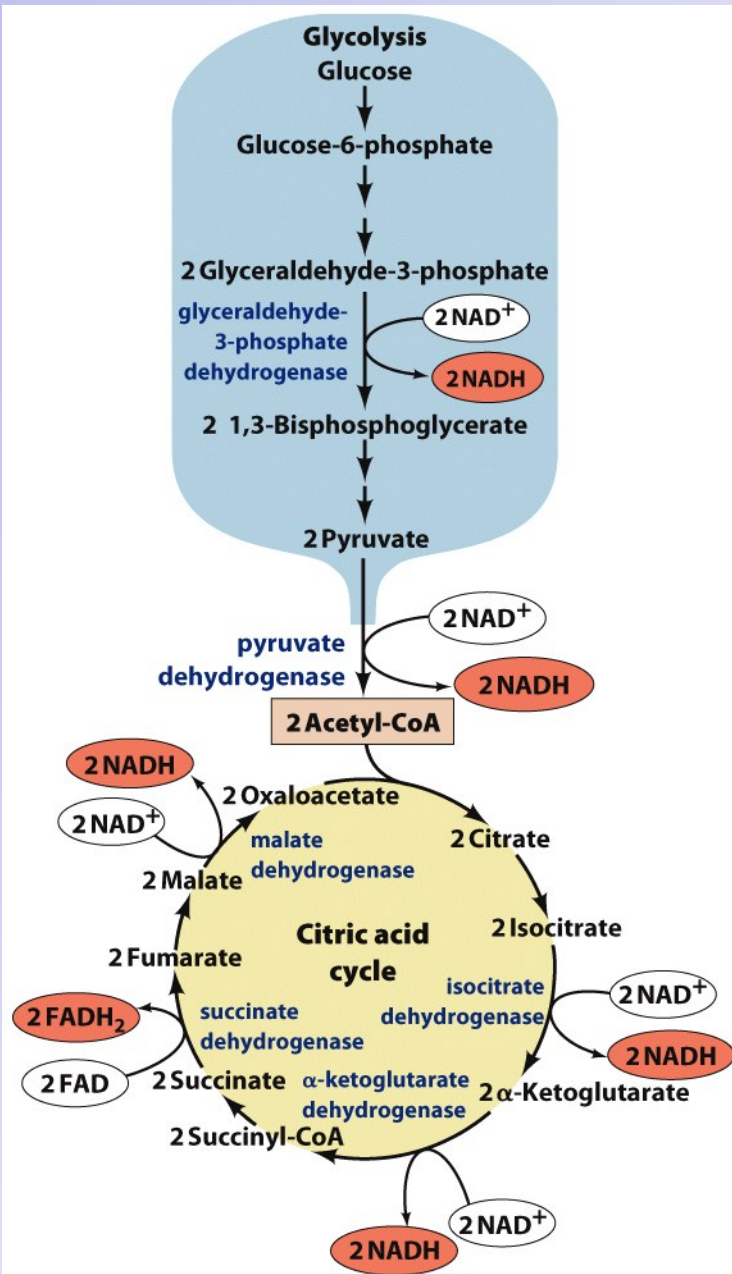
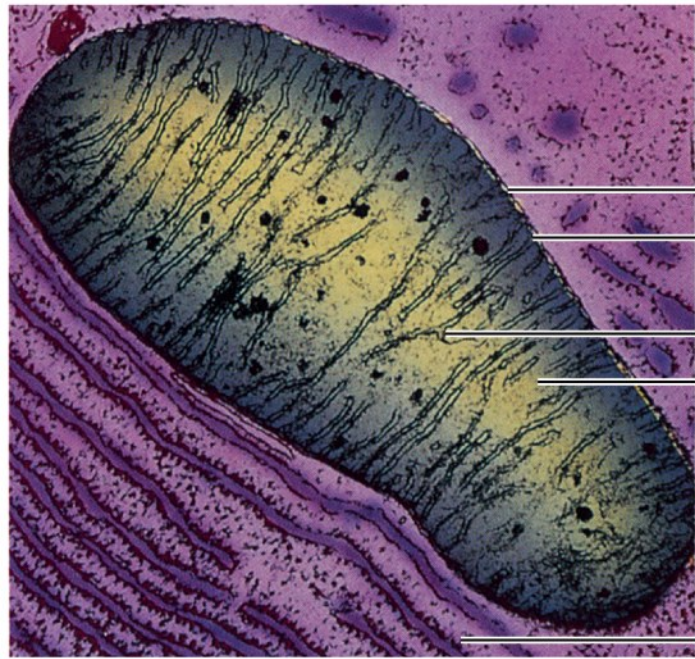


Figure 22-1  
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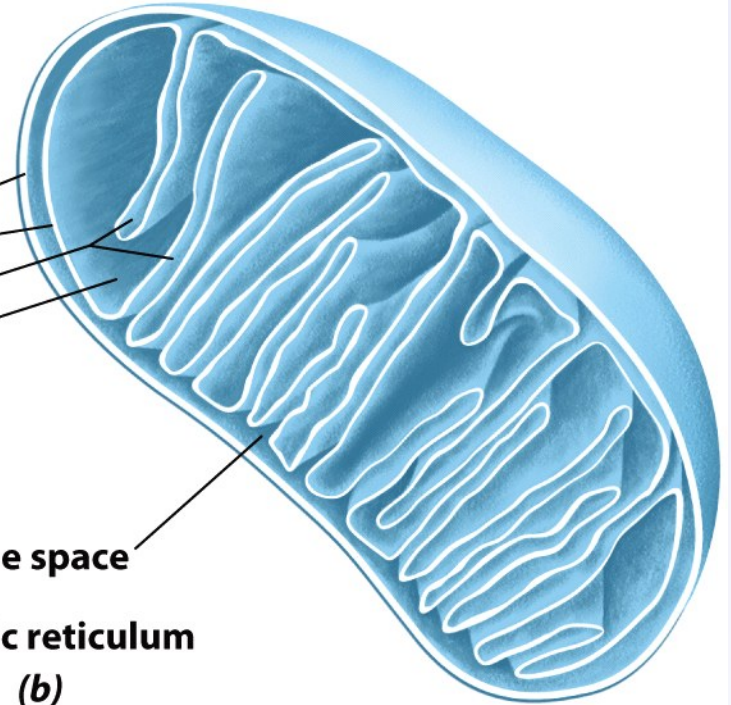


**(a)**

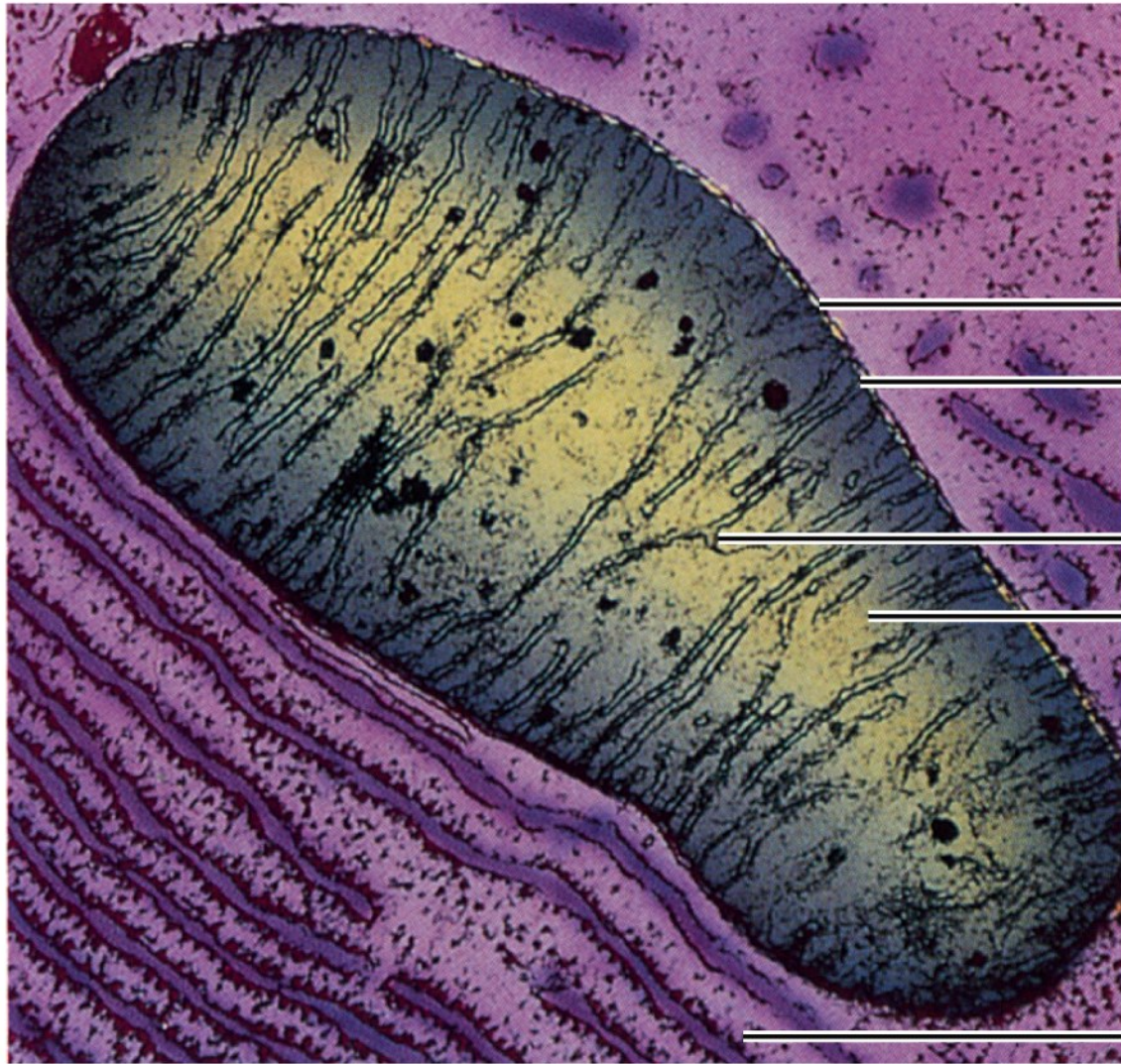
**Figure 22-2**

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**Outer membrane**  
**Inner membrane**  
**Cristae**  
**Matrix**  
**Intermembrane space**  
**Rough endoplasmic reticulum**



**(b)**



**Outer membrane**

**Inner membrane**

**Cristae**

**Matrix**

**Rough endoplasmic  
reticulum**

Figure 22-2a  
K.R. Porter/Photo Researchers, Inc.

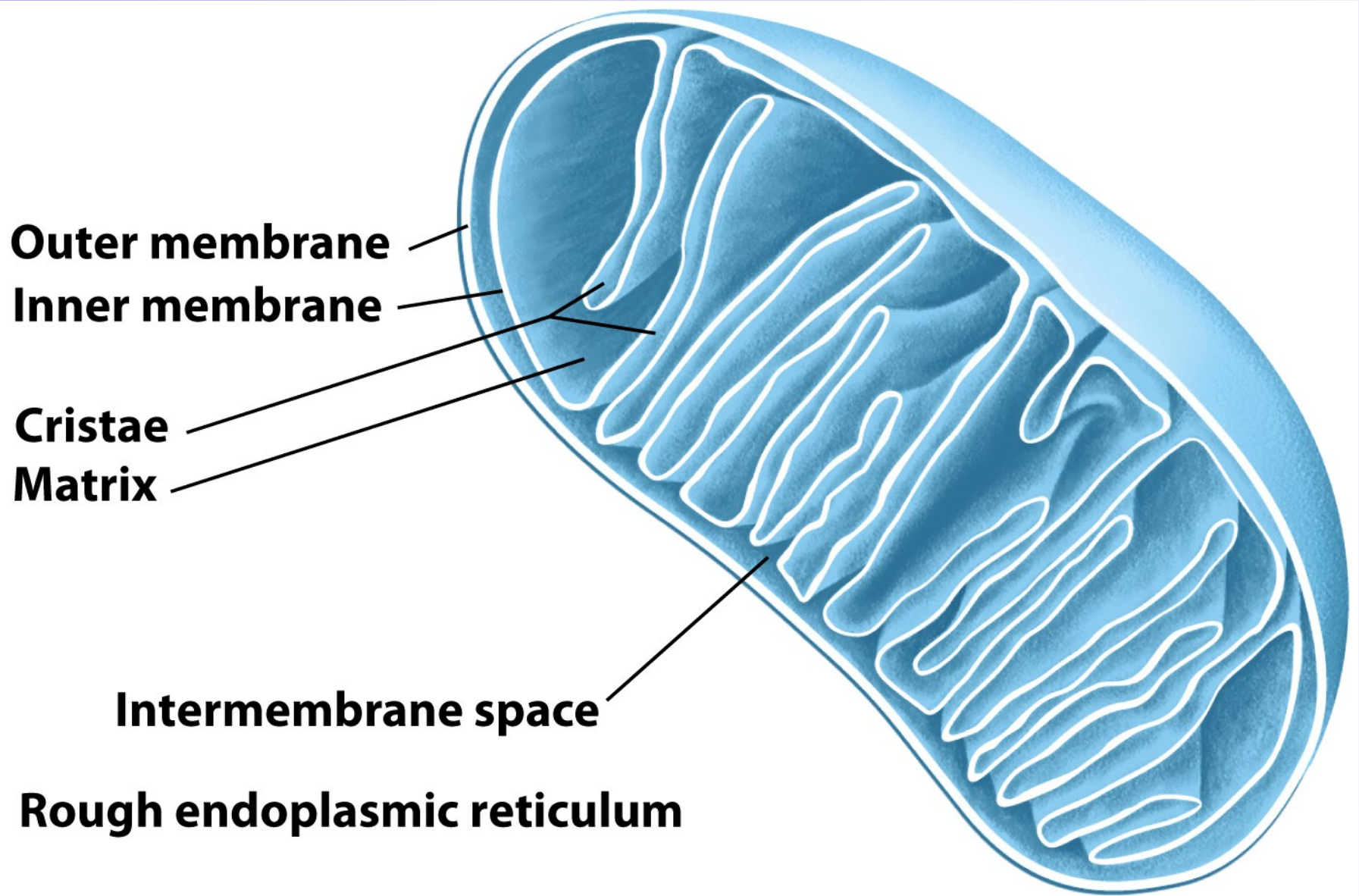


Figure 22-2b  
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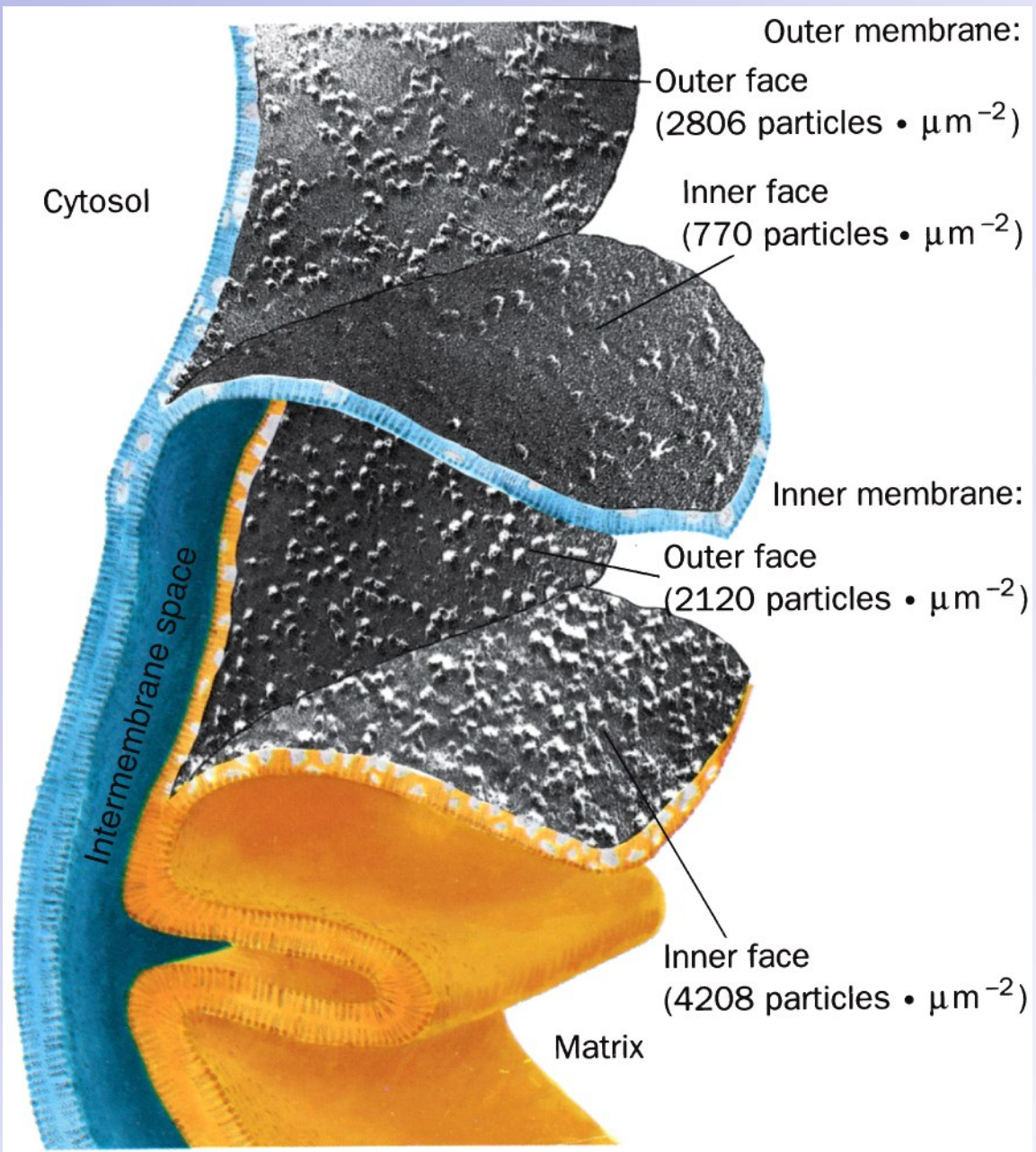


Figure 22-3  
Courtesy of Lester Packer, University of California at Berkeley

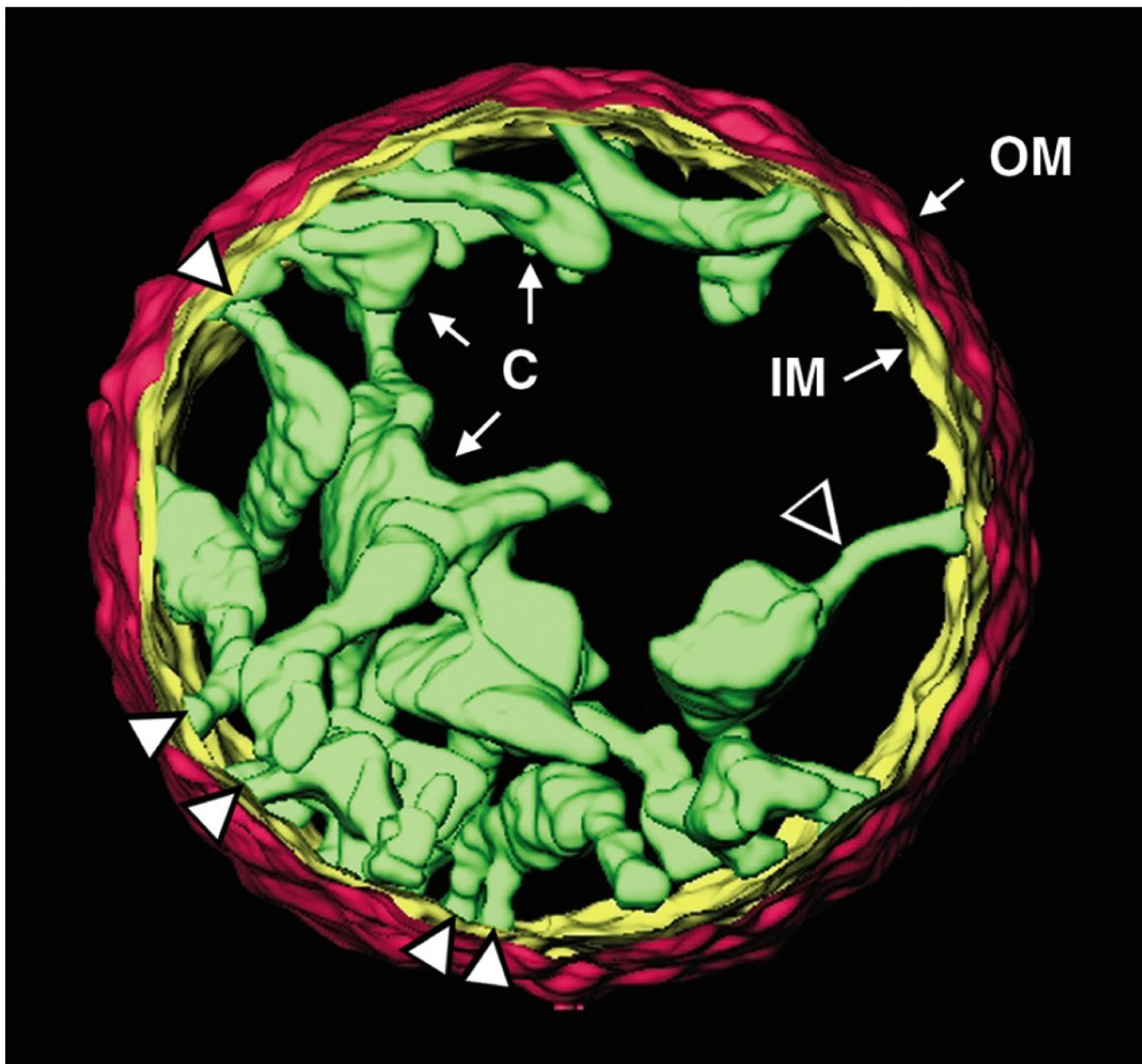


Figure 22-4  
Courtesy of Carmen Mannella, Wadsworth Center, Albany, New York

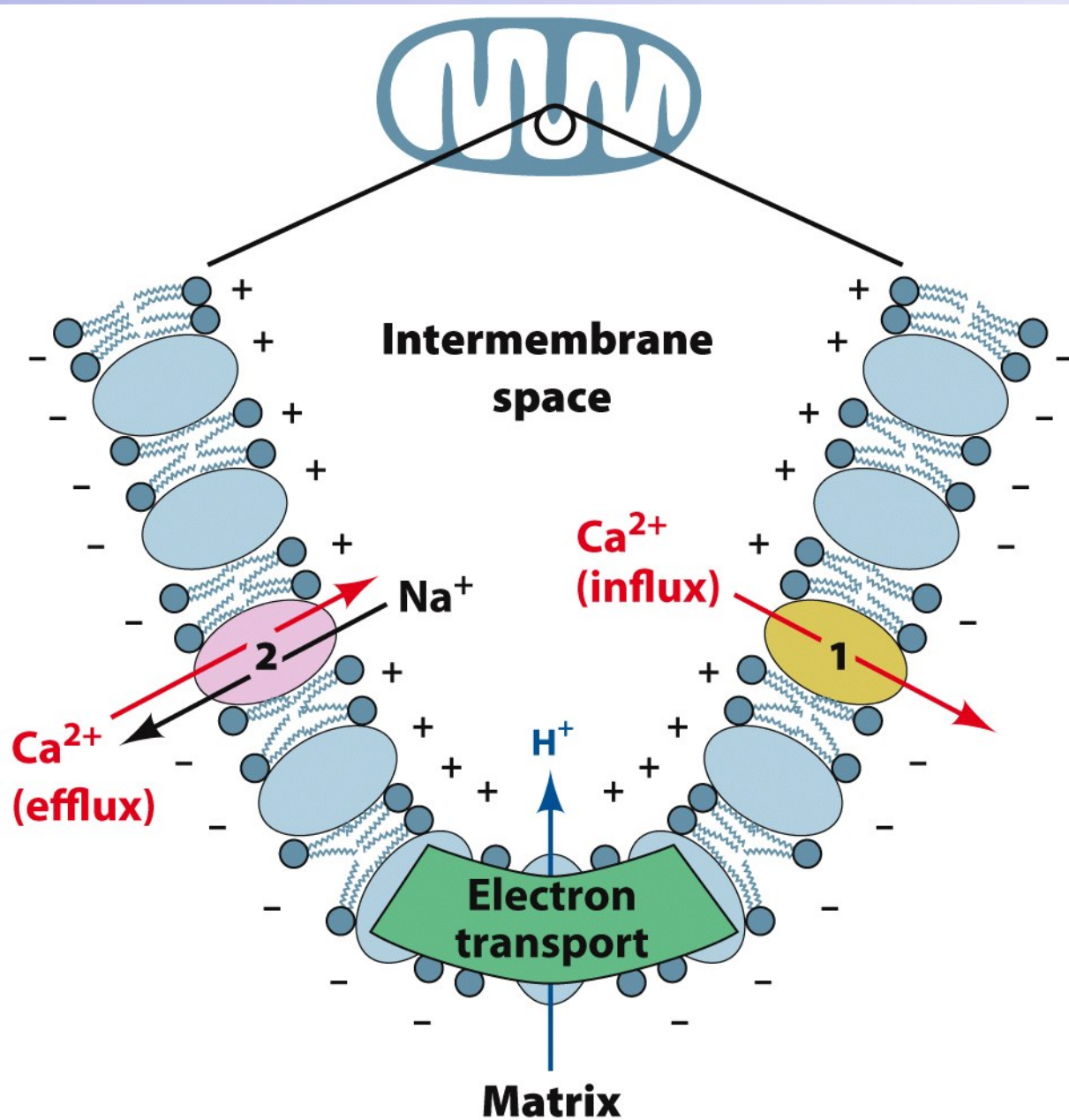


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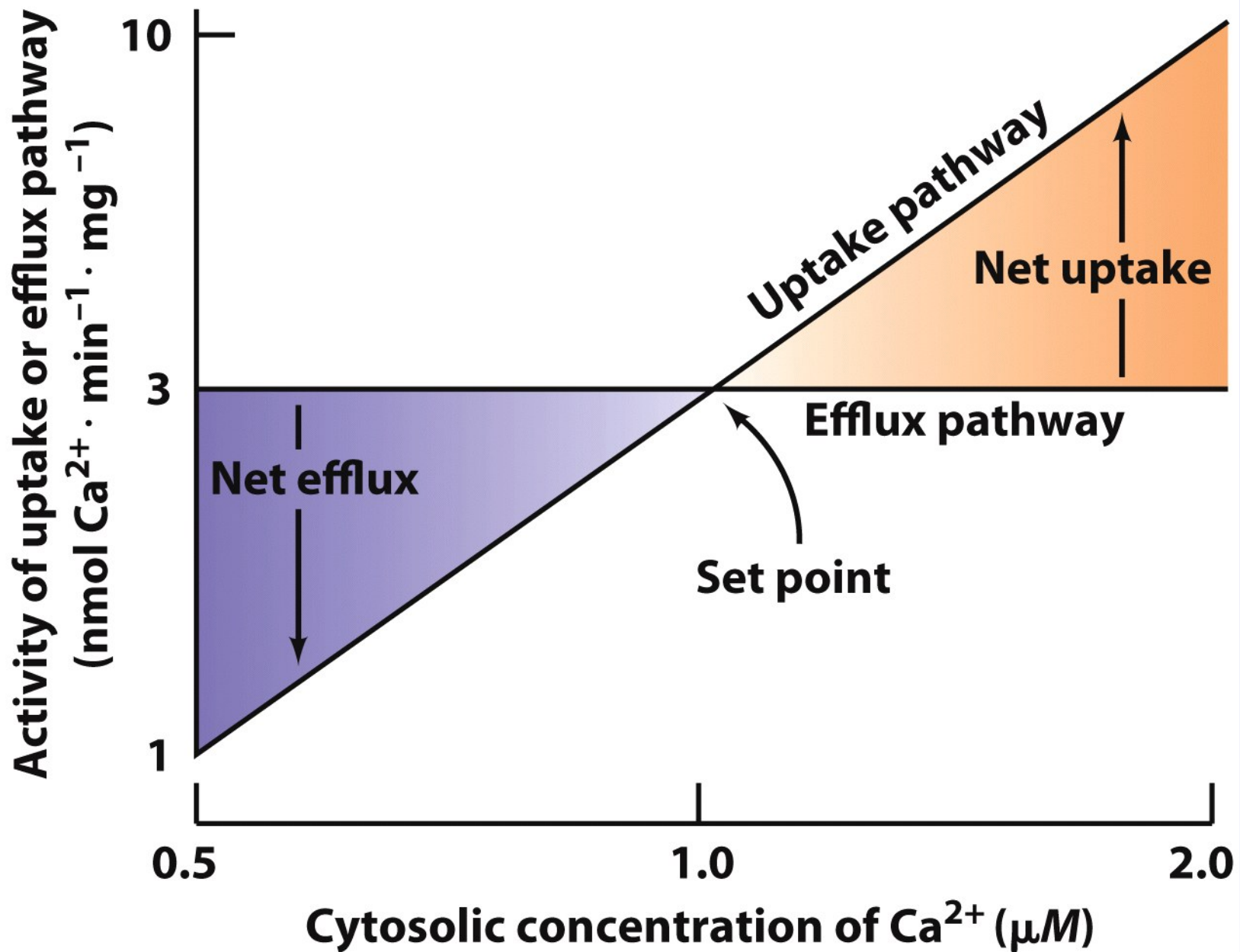


Figure 22-6  
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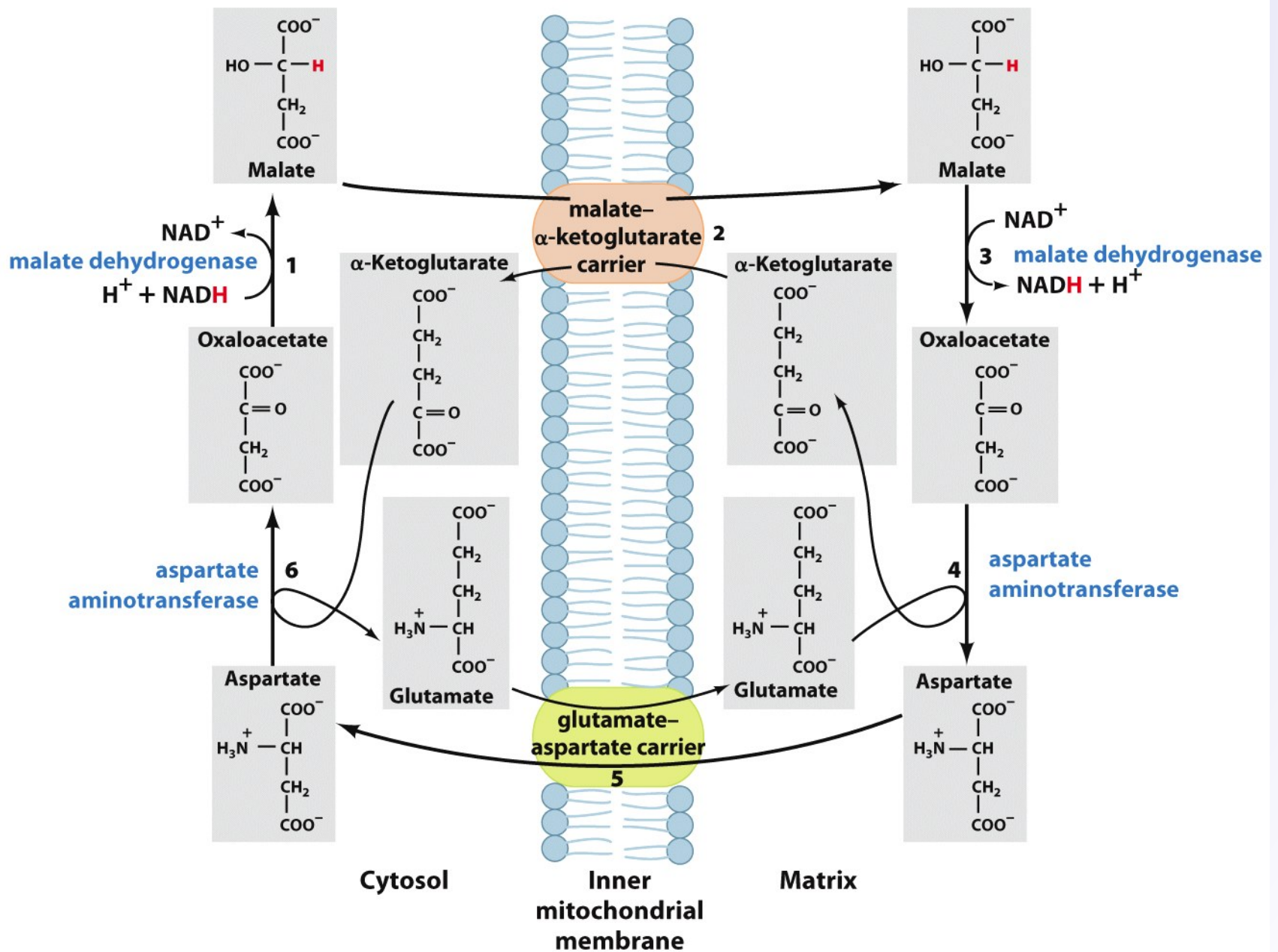


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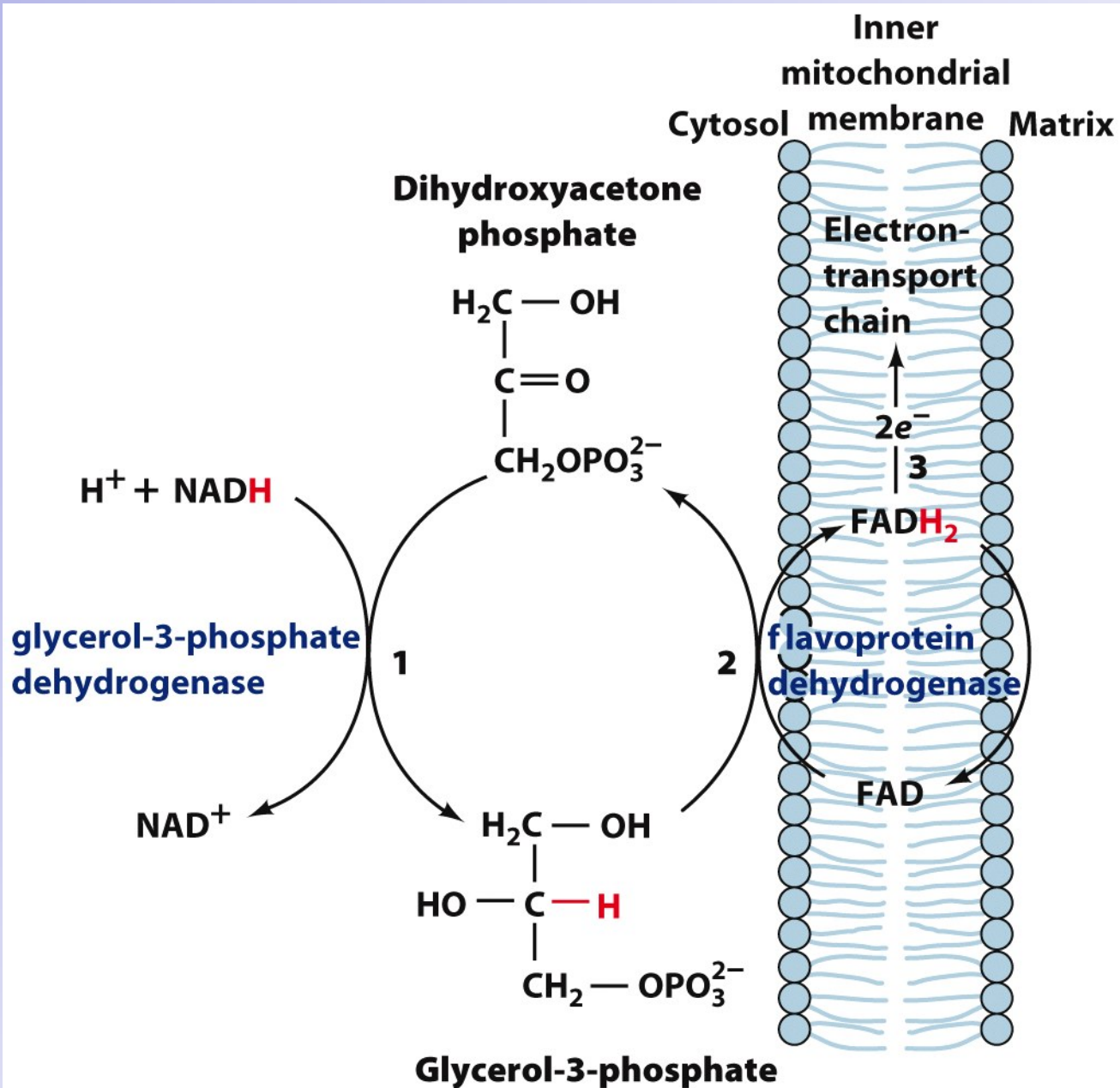


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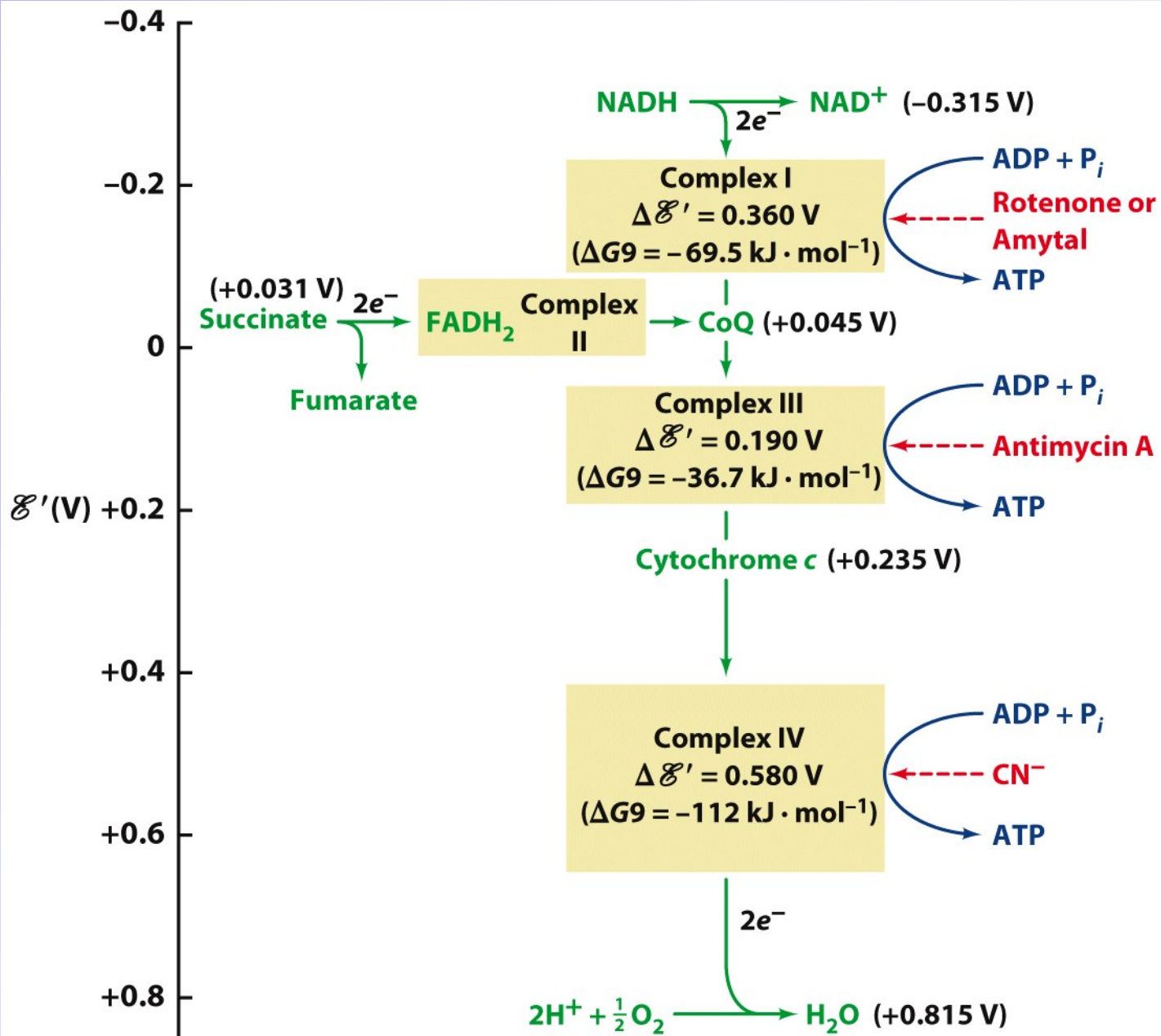


Figure 22-9  
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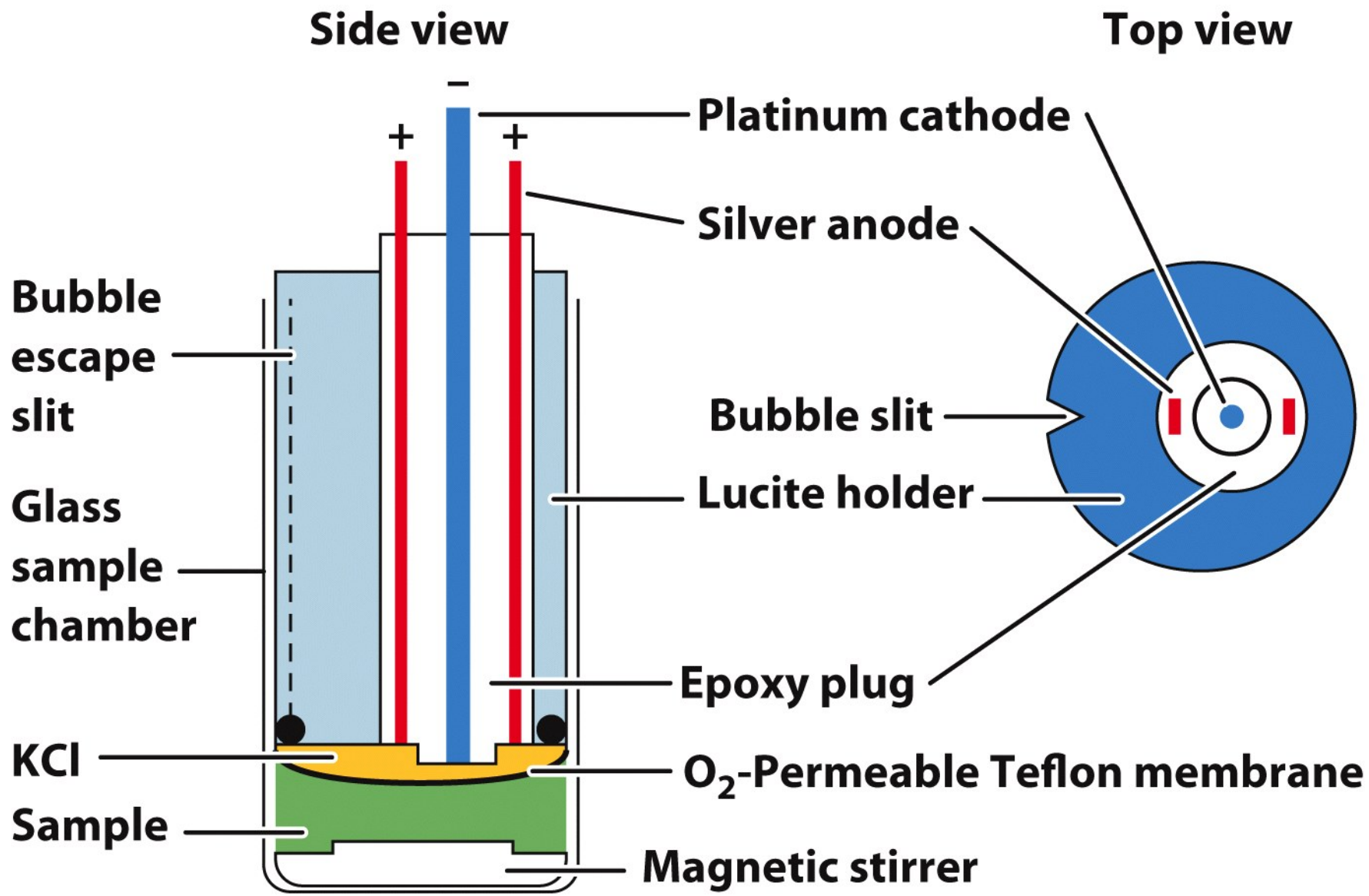
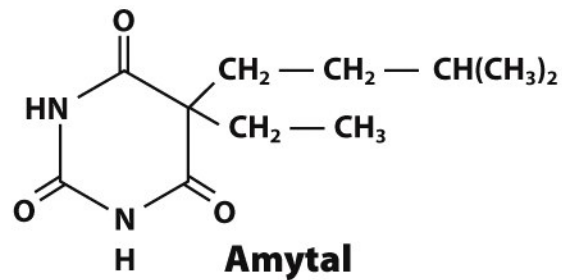
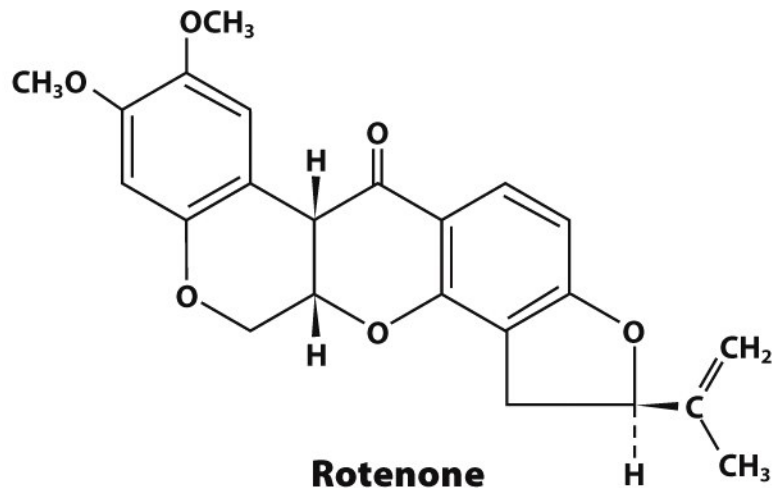
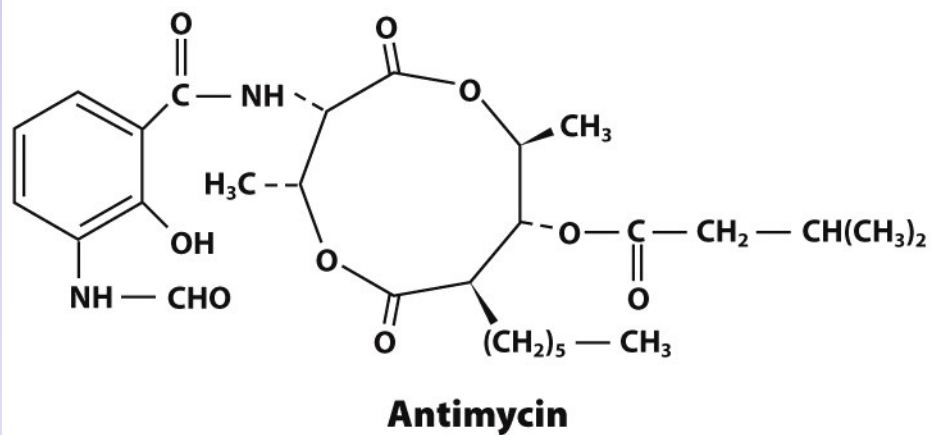


Figure 22-10

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**Cyanide**



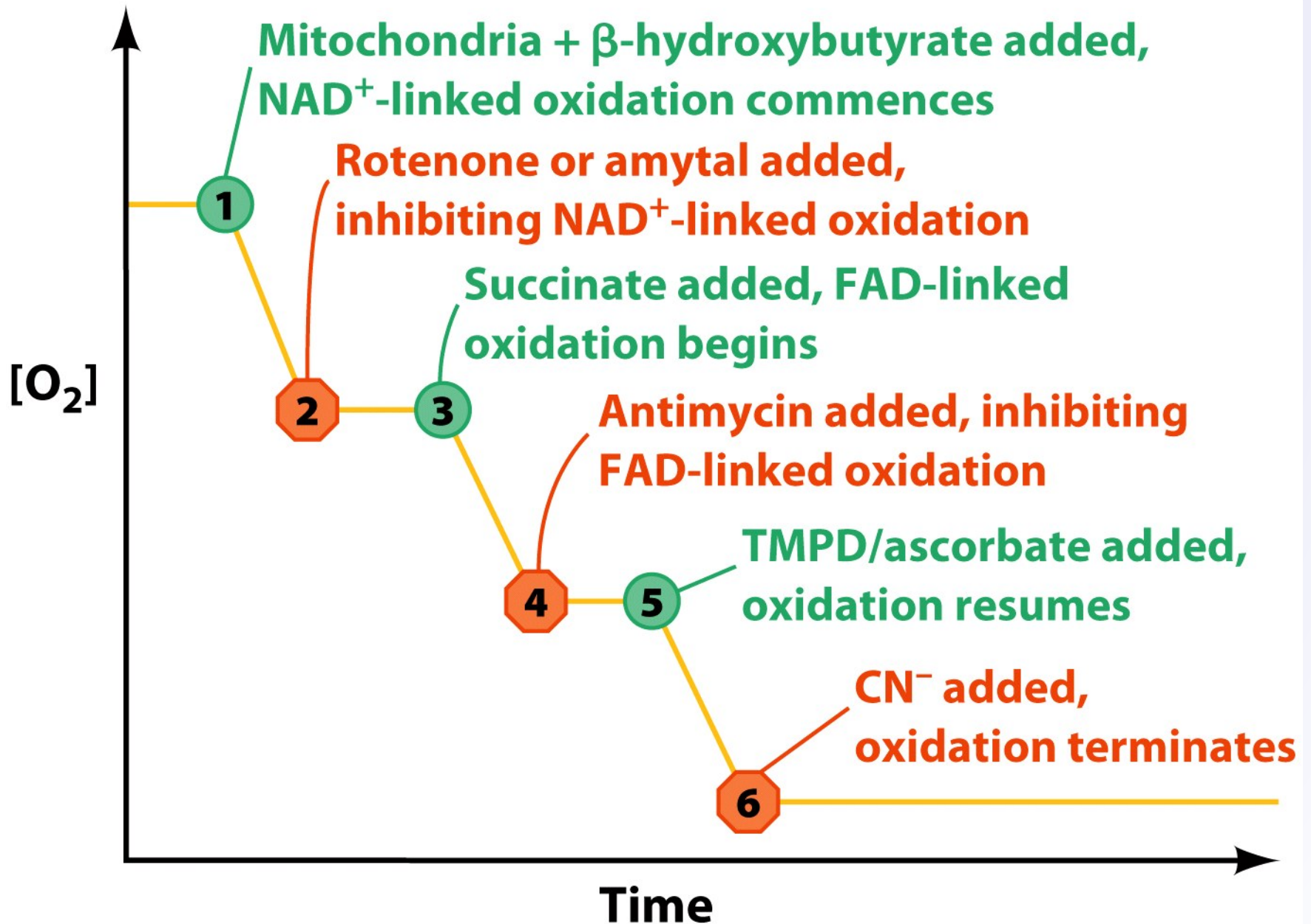
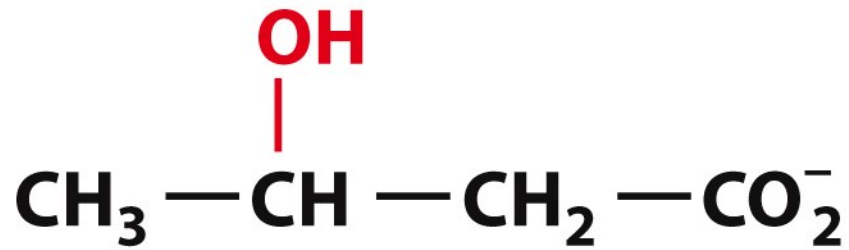
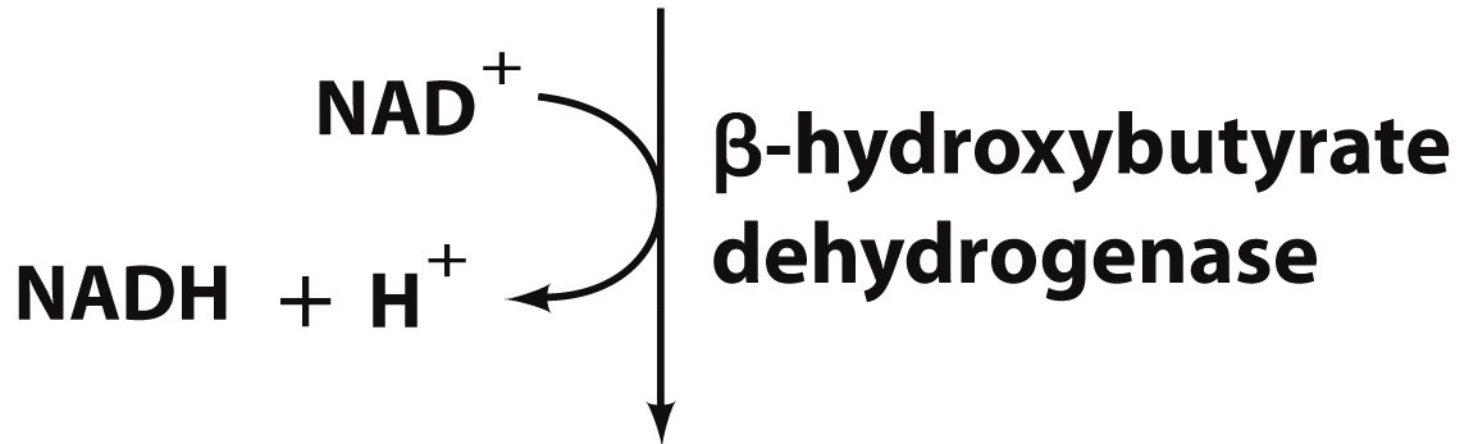


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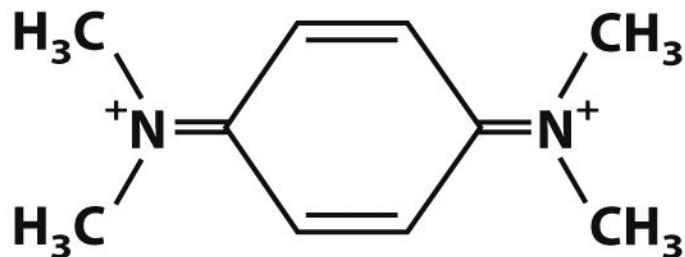


**$\beta$ -Hydroxybutyrate**



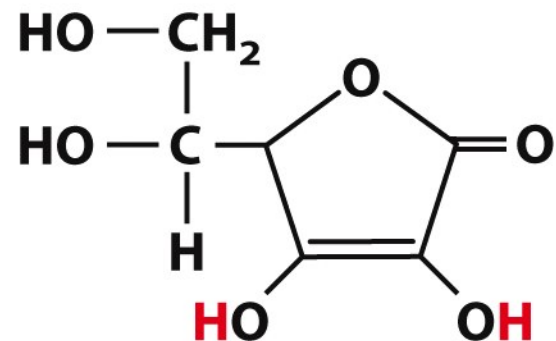
**Acetoacetate**



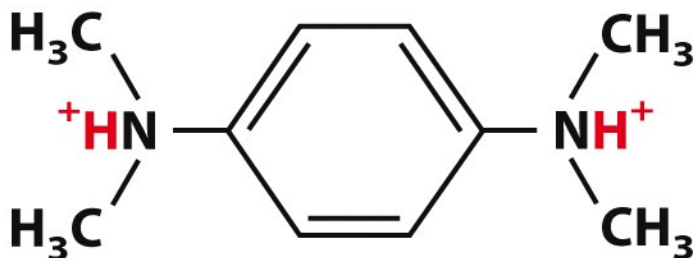


**Tetramethyl-*p*-phenylenediamine  
(TMPD), oxidized form**

+

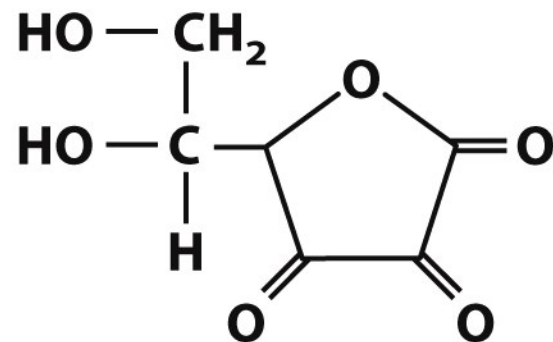


**Ascorbic acid**



**TMPD, reduced form**

+



**Dehydroascorbic acid**

**Table 22-1 Reduction Potentials of Electron-Transport Chain Components in Resting Mitochondria**

Component	$\mathcal{E}'(V)$
NADH	-0.315
<b>Complex I (NADH:CoQ oxidoreductase; ~900 kD, 45 subunits):</b>	
FMN	-0.380
[2Fe-2S]N1a	-0.370
[2Fe-2S]N1b	-0.250
[4Fe-4S]N3, 4, 5, 6a, 6b, 7	-0.250
[4Fe-4S]N2	-0.150
Succinate	0.031
<b>Complex II (succinate-CoQ oxidoreductase; ~140 kD, 4 subunits):</b>	
FAD	-0.040
[2Fe-2S]	-0.030
[4Fe-4S]	-0.245
[3Fe-4S]	-0.060
Heme $b_{560}$	-0.080
Coenzyme Q	0.045
<b>Complex III (CoQ-cytochrome c oxidoreductase; ~450 kD, 9-11 subunits):</b>	
Heme $b_H$ ( $b_{562}$ )	0.030
Heme $b_L$ ( $b_{566}$ )	-0.030
[2Fe-2S]	0.280
Heme $c_1$	0.215
Cytochrome c	0.235
<b>Complex IV (cytochrome c oxidase; ~410 kD, 8-13 subunits):</b>	
Heme $a$	0.210
Cu <sub>A</sub>	0.245
Cu <sub>B</sub>	0.340
Heme $a_3$	0.385
O <sub>2</sub>	0.815

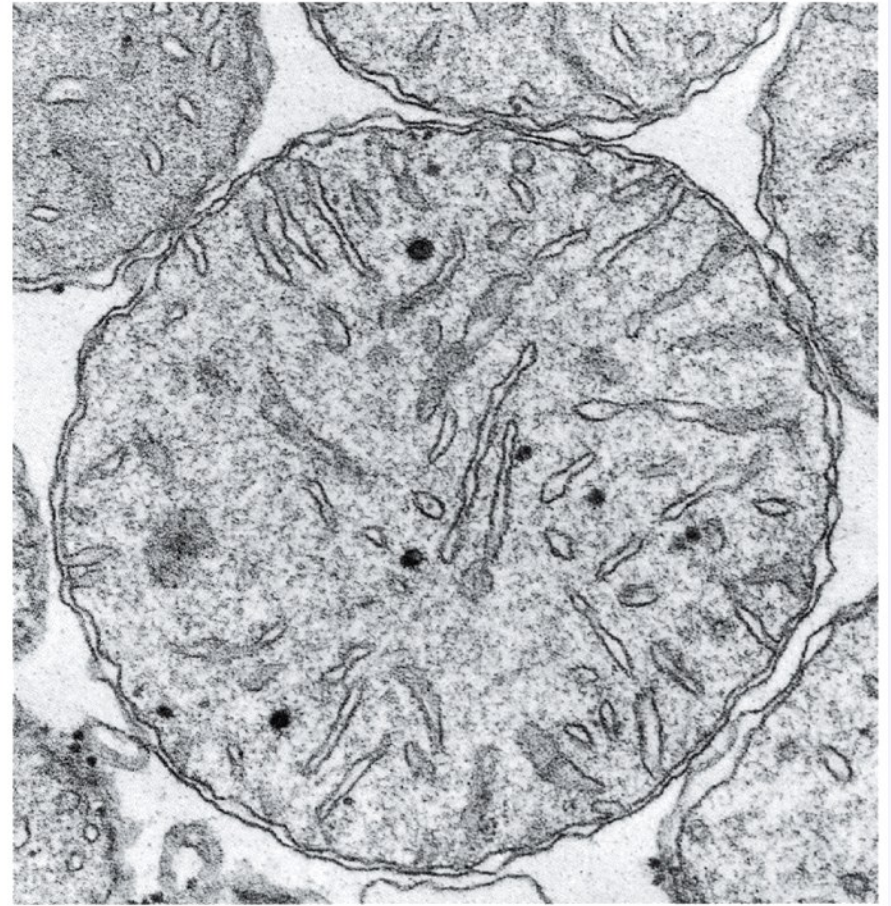
Source: Mainly Wilson, D.F., Erecinska, M., and Dutton, P.L., *Annu. Rev. Biophys. Bioeng.* 3, 205 and 208 (1974); and Wilson, D.F., in Bittar, E.E. (Ed.), *Membrane Structure and Function*, Vol. 1, p. 160, Wiley (1980).

Table 22-1

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**(a)**



**(b)**

Figure 22-12  
Courtesy of Charles Hackenbrock, University of North Carolina Medical School

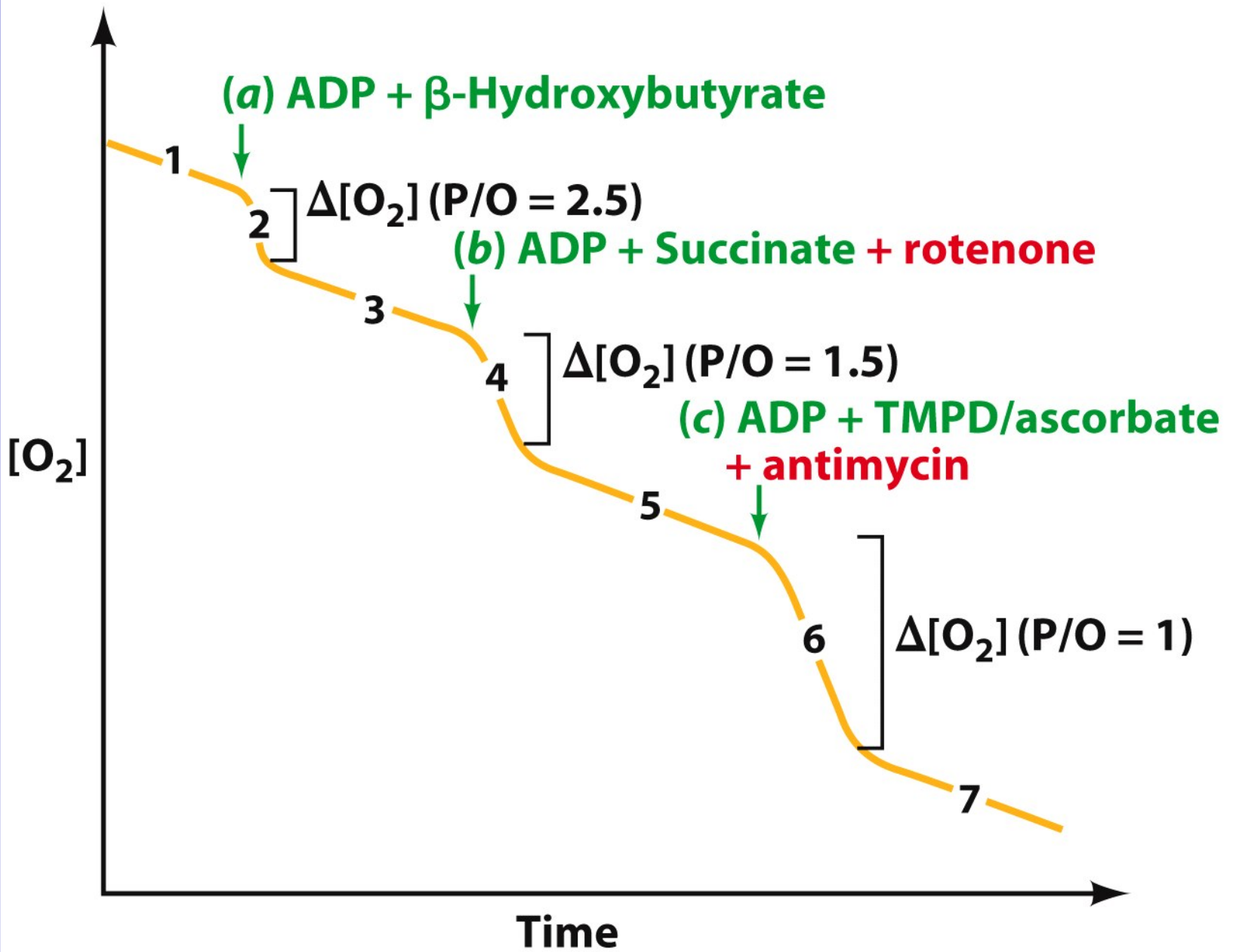


Figure 22-13  
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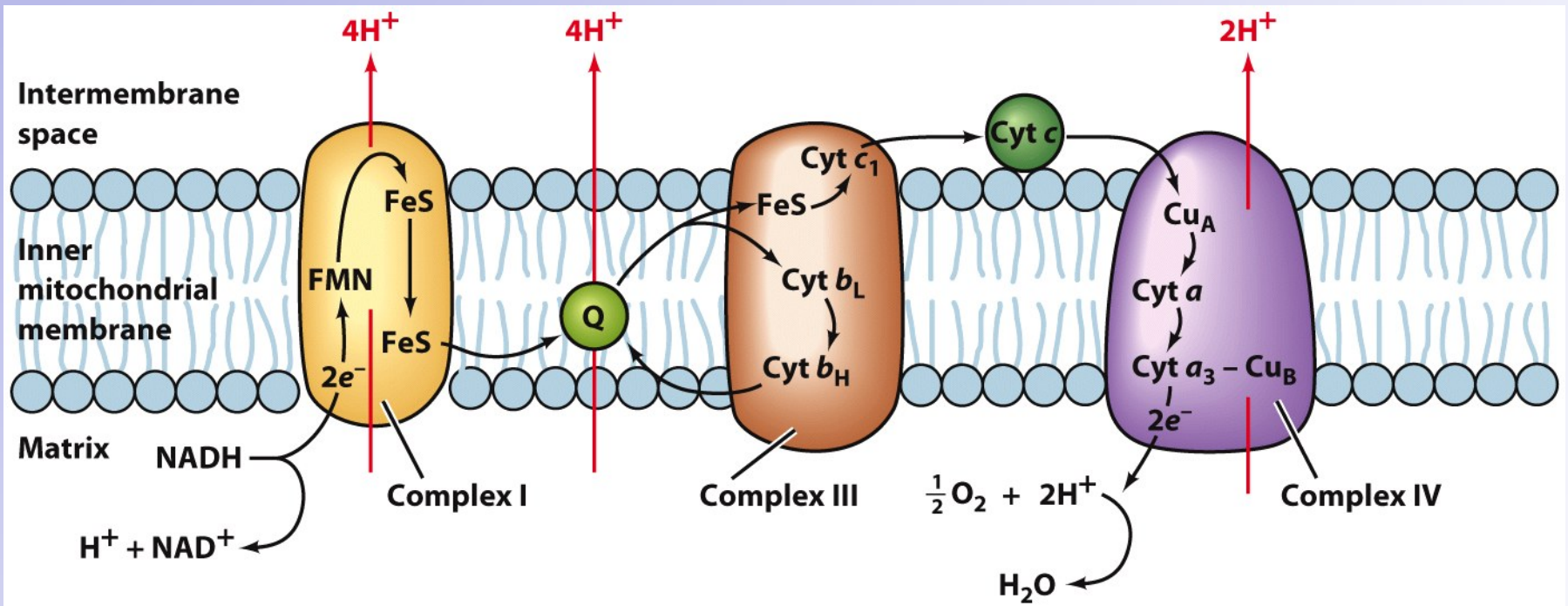
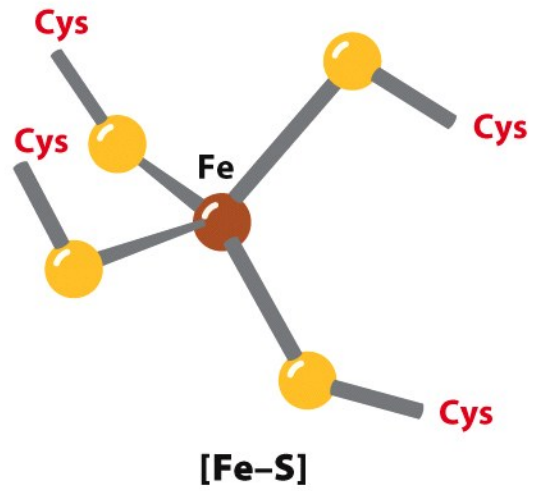
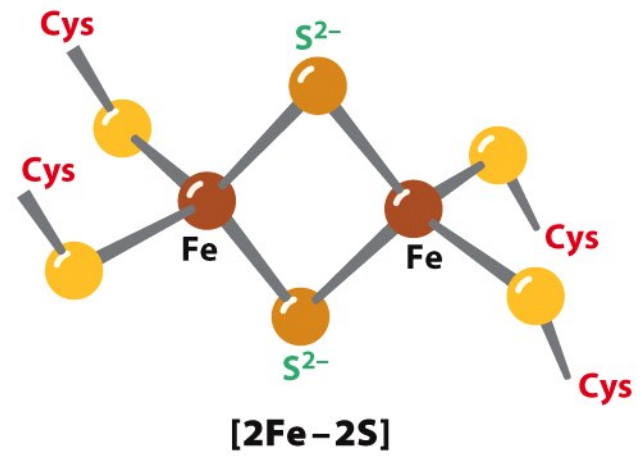


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(a)



(b)



(c)

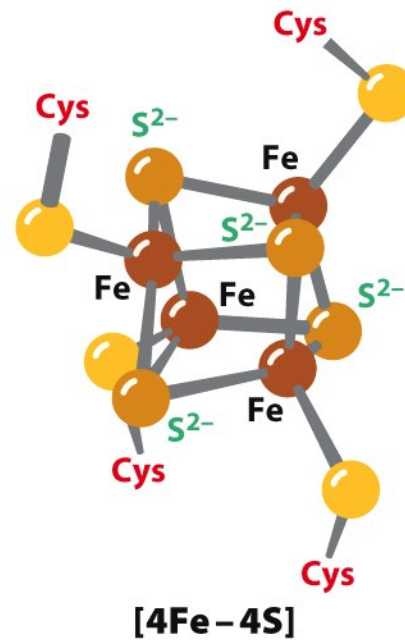


Figure 22-15

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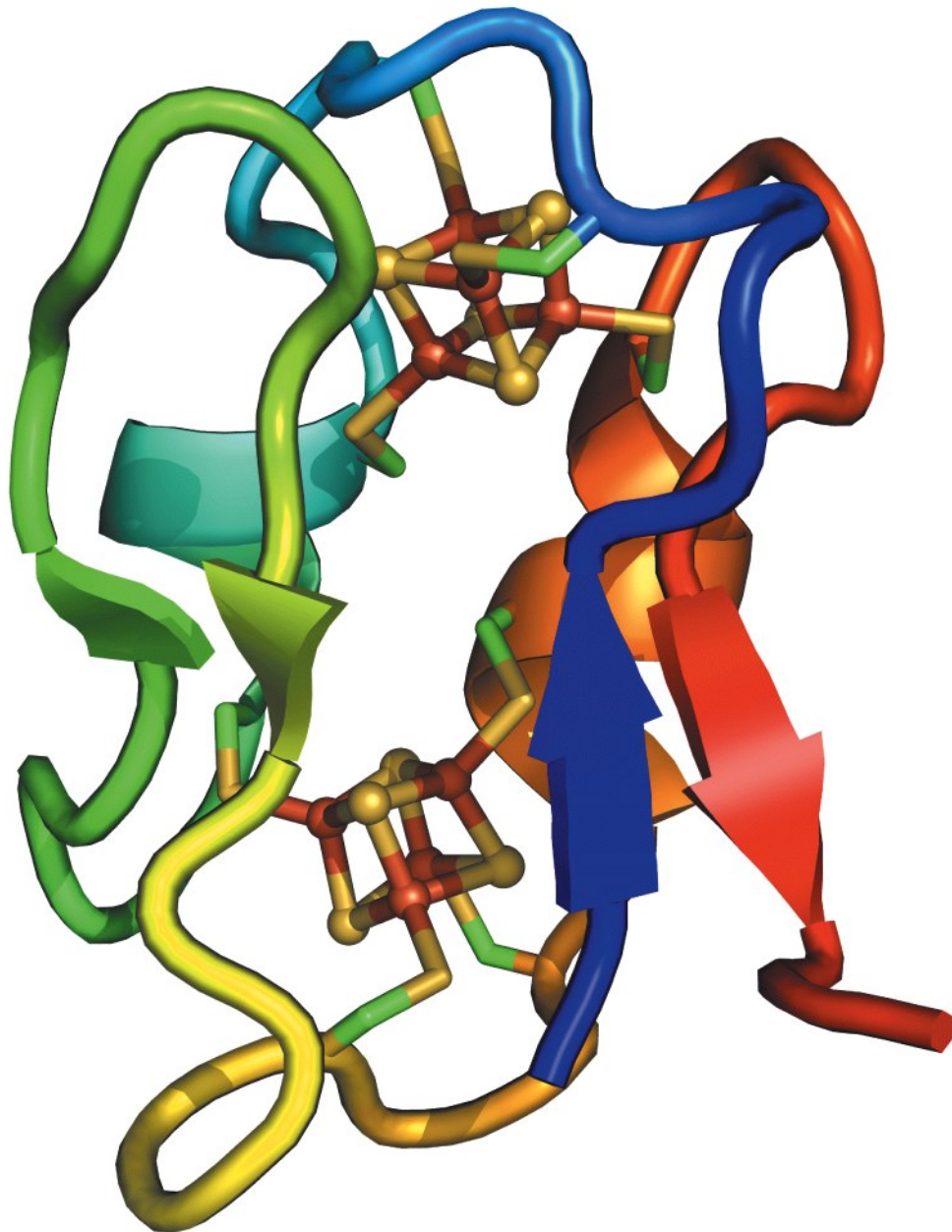
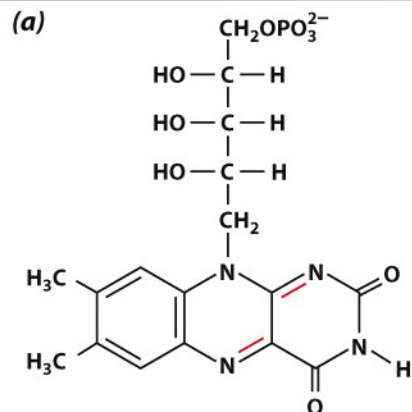
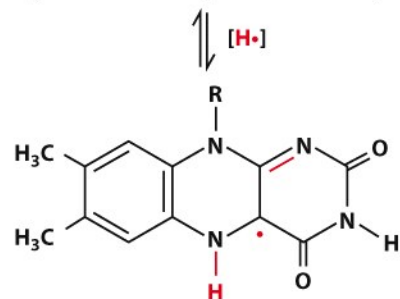


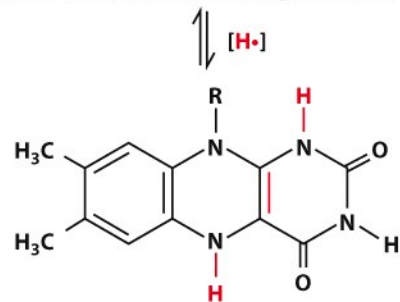
Figure 22-16  
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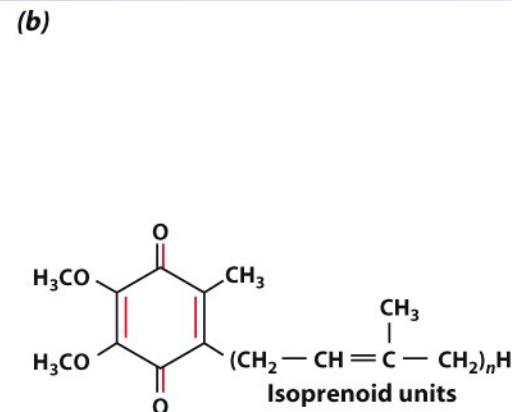
**Flavin mononucleotide (FMN)**  
(oxidized or quinone form)



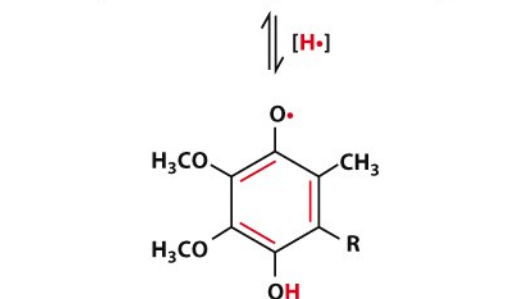
**FMNH• (radical or semiquinone form)**



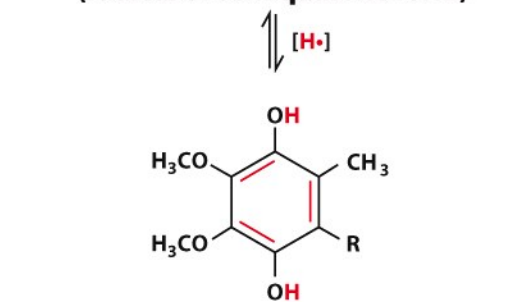
**FMNH<sub>2</sub> (reduced or hydroquinone form)**



**Coenzyme Q (CoQ) or ubiquinone**  
(oxidized or quinone form)



**Coenzyme QH• or ubisemiquinone**  
(radical or semiquinone form)



**Coenzyme QH<sub>2</sub> or ubiquinol**  
(reduced or hydroquinone form)

Figure 22-17



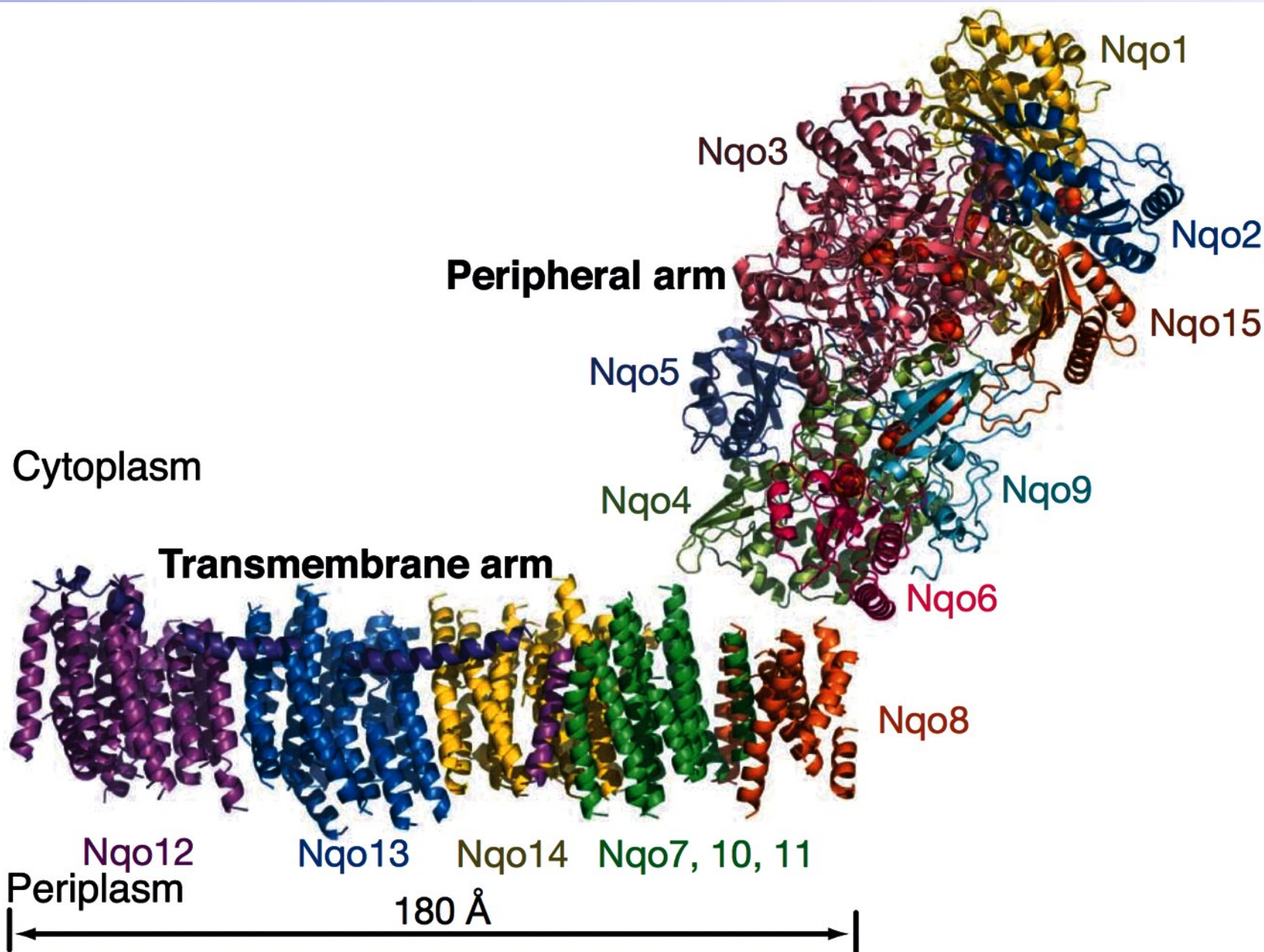


Figure 22-18

Courtesy of Leonid Sazanov, Medical Research Council, Cambridge, U.K. PDBid 3M9S.

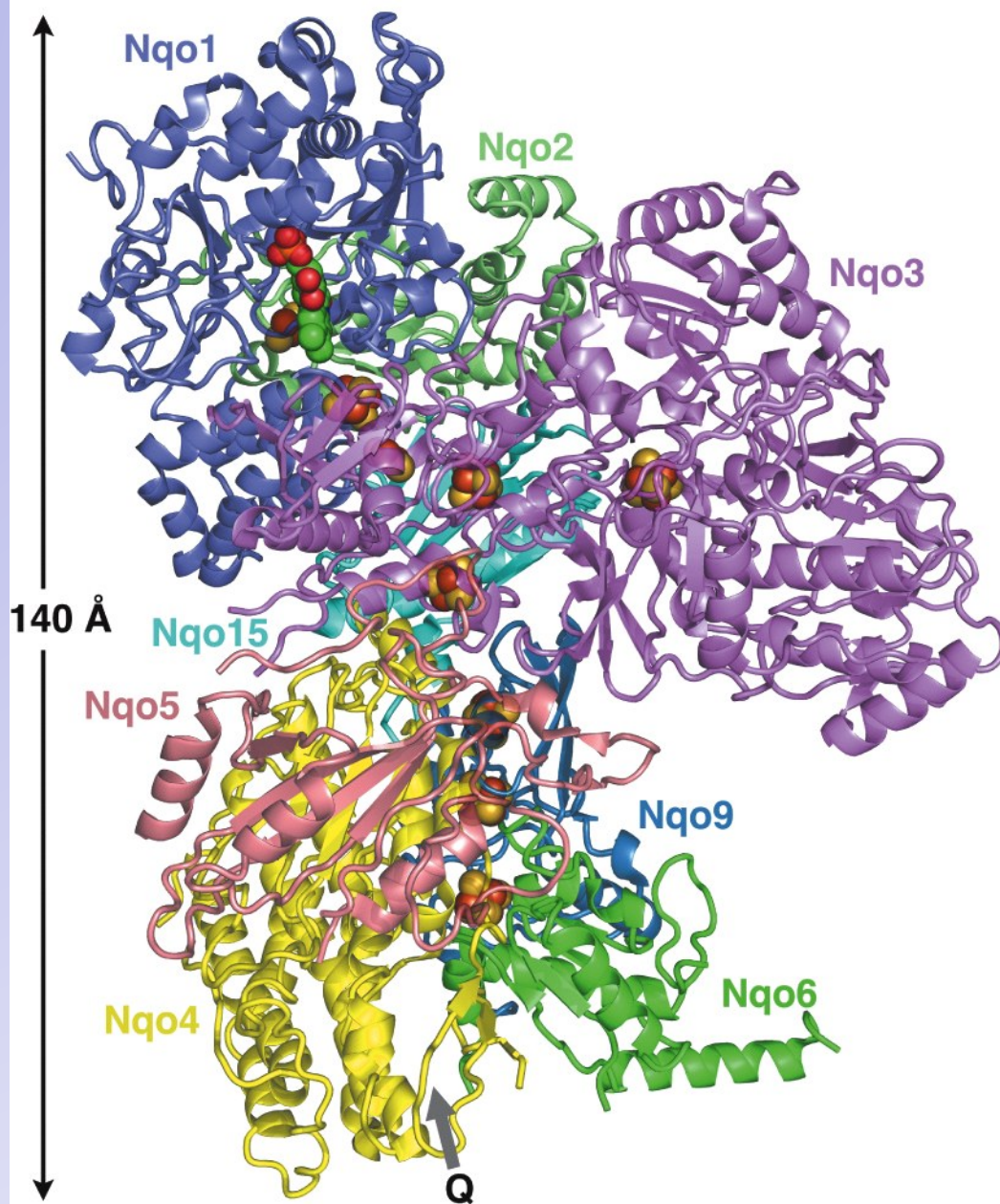


Figure 22-19a  
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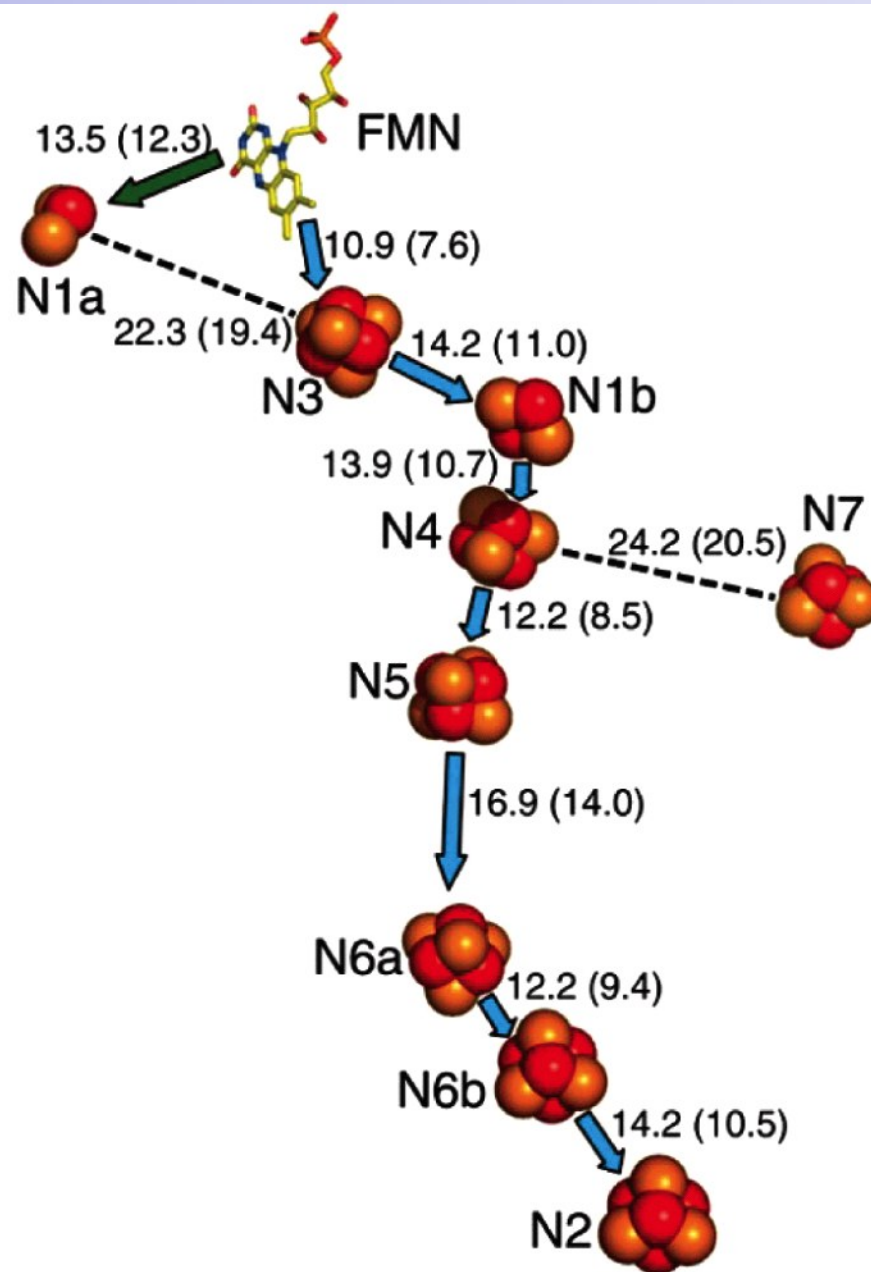


Figure 22-19b

Courtesy of Leonid Sazanov, Medical Research Council, Cambridge, U.K. PDBid 2FUG.

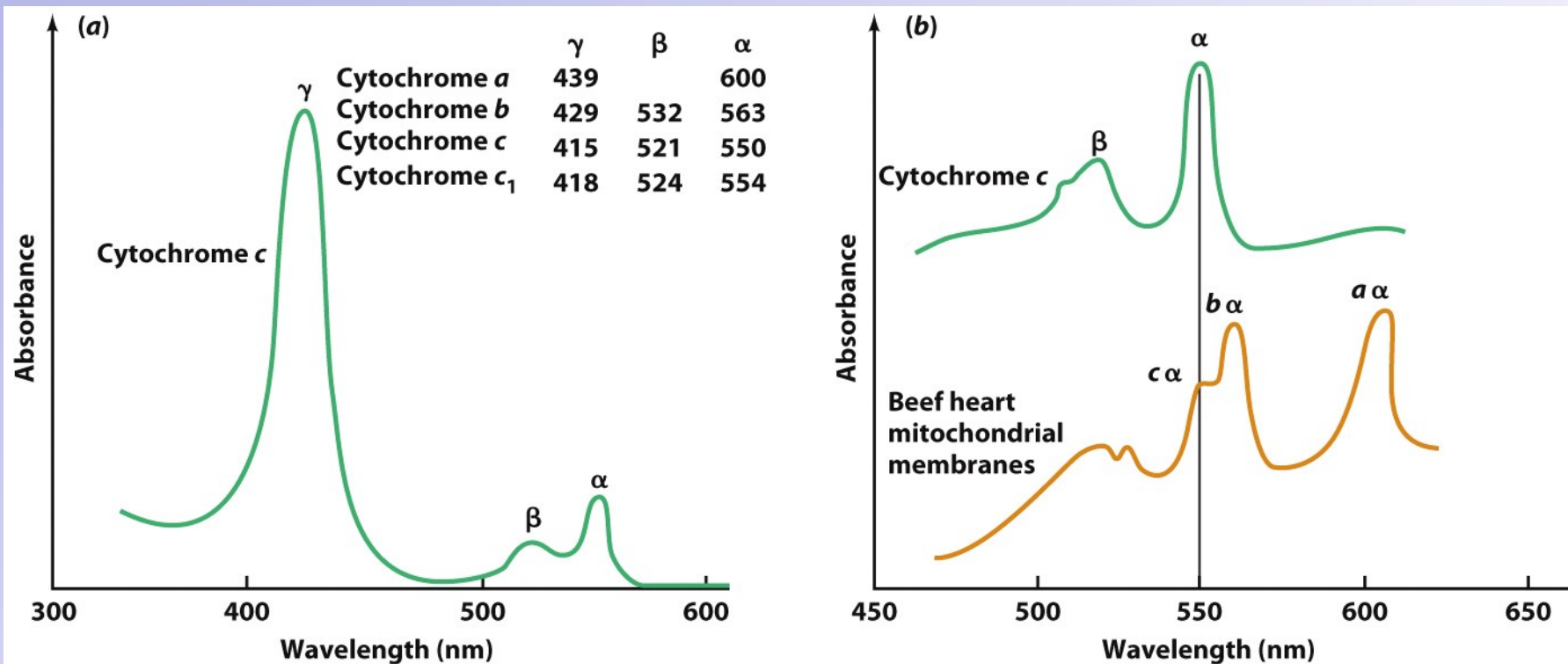


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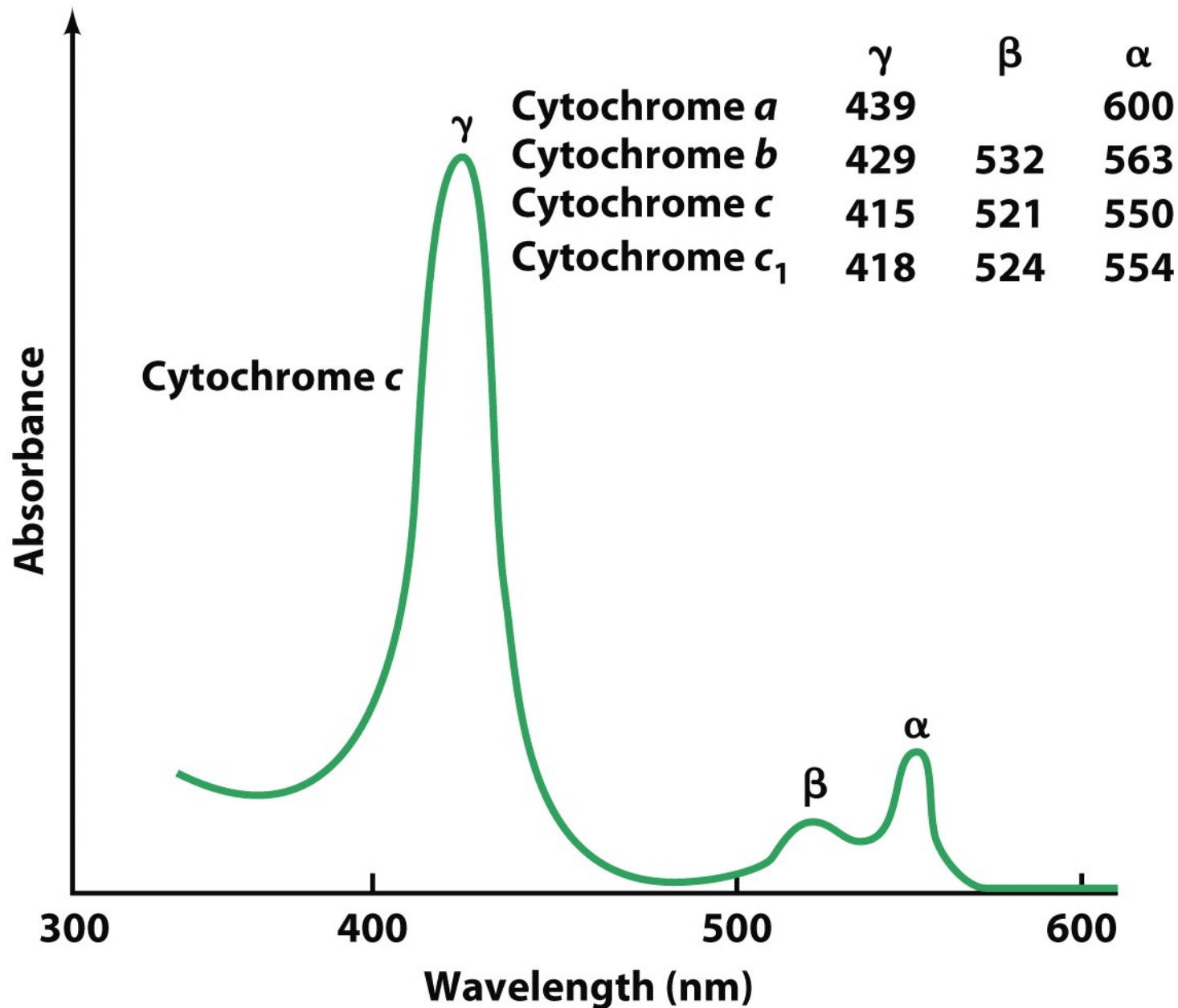


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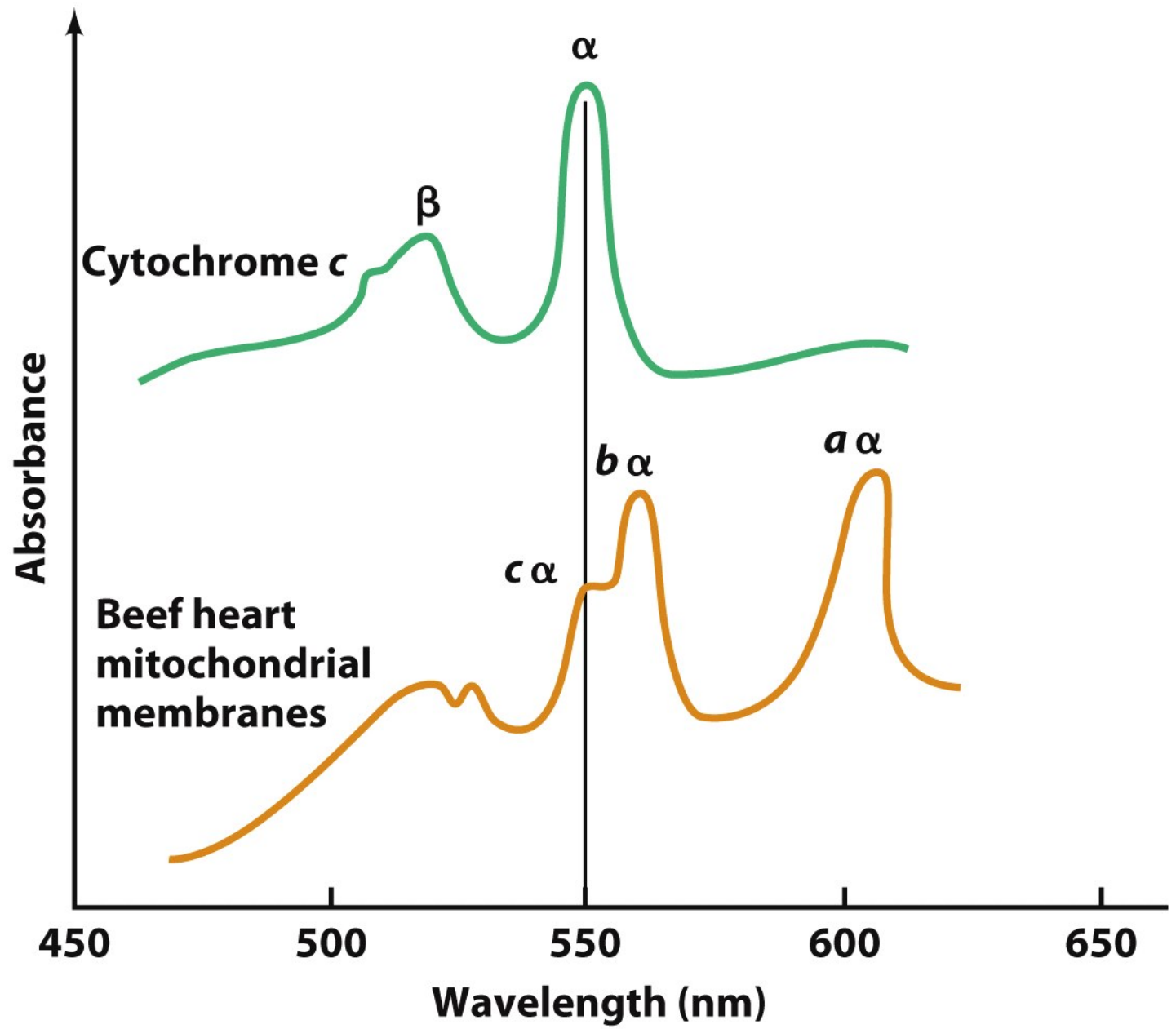


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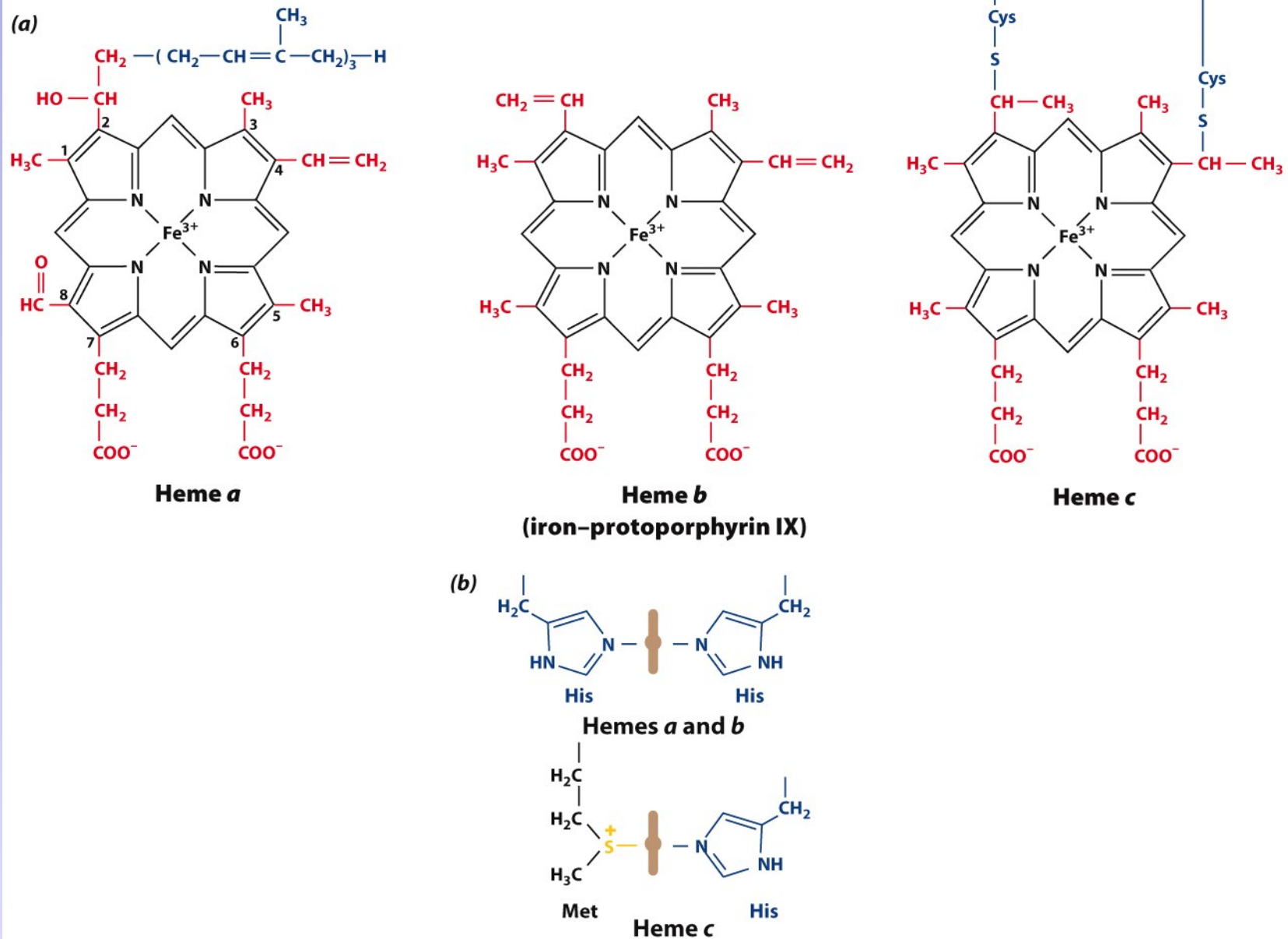


Figure 22-21

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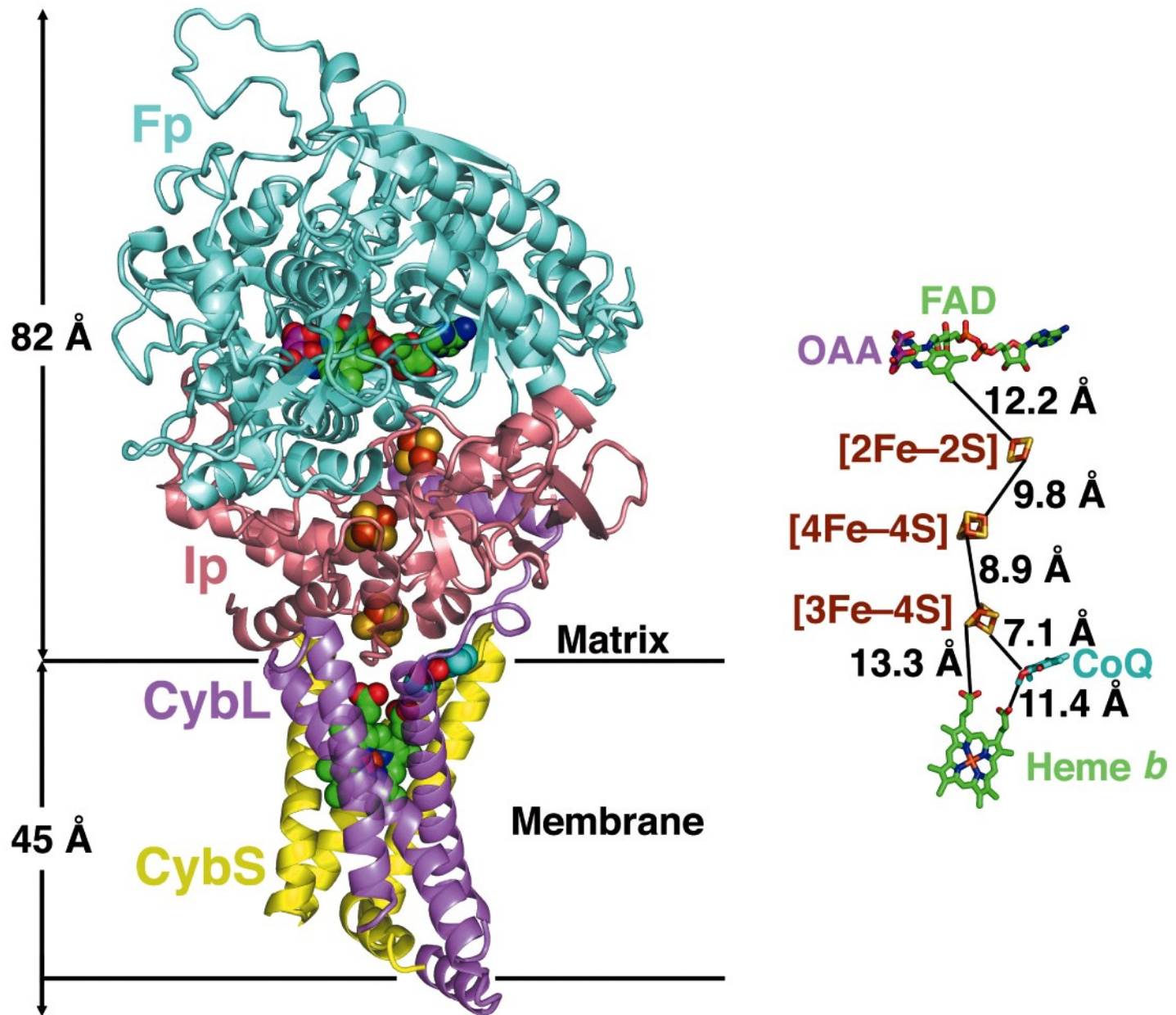


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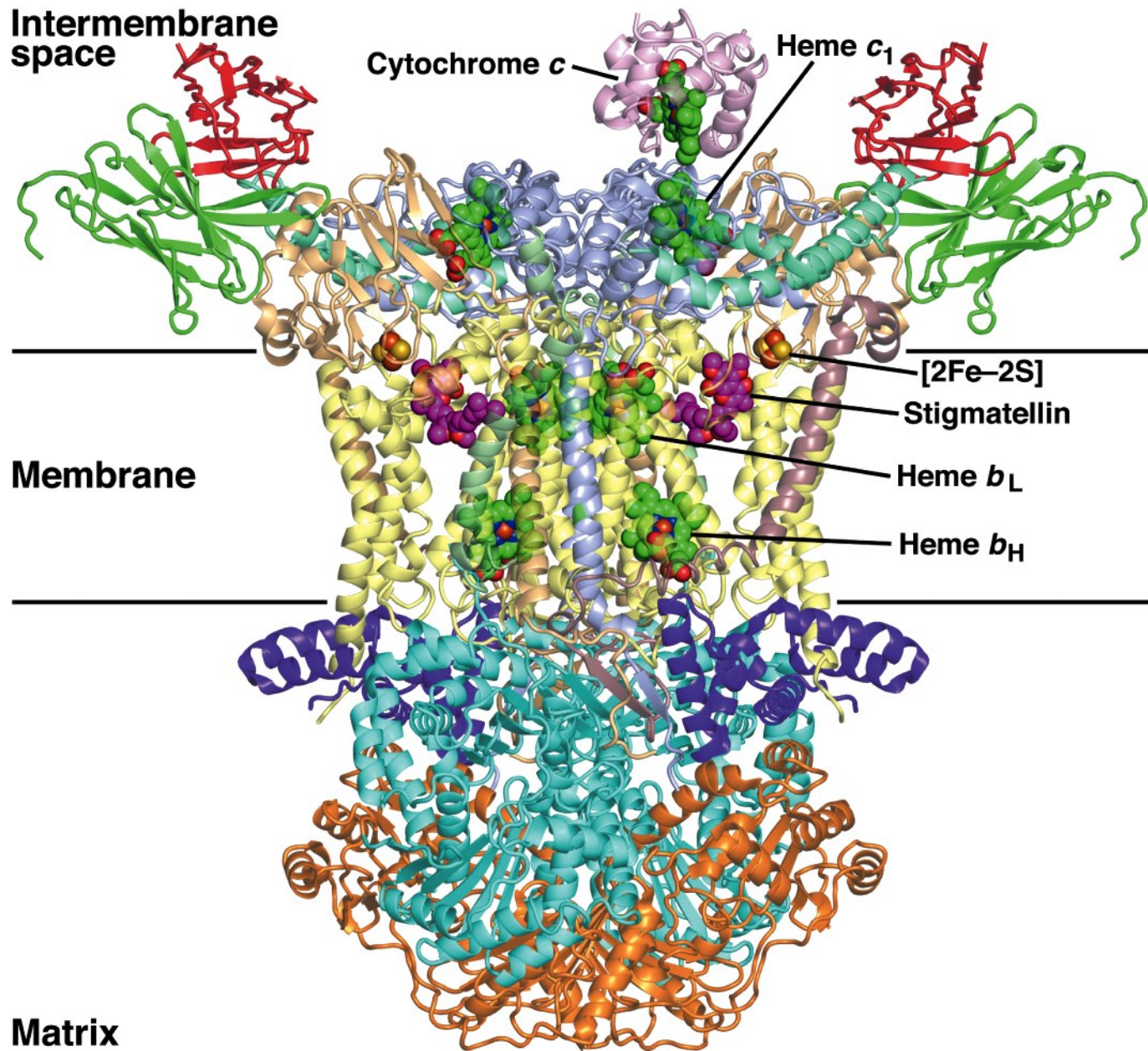


Figure 22-23

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**Intermembrane  
space**

**Membrane**

**Matrix**

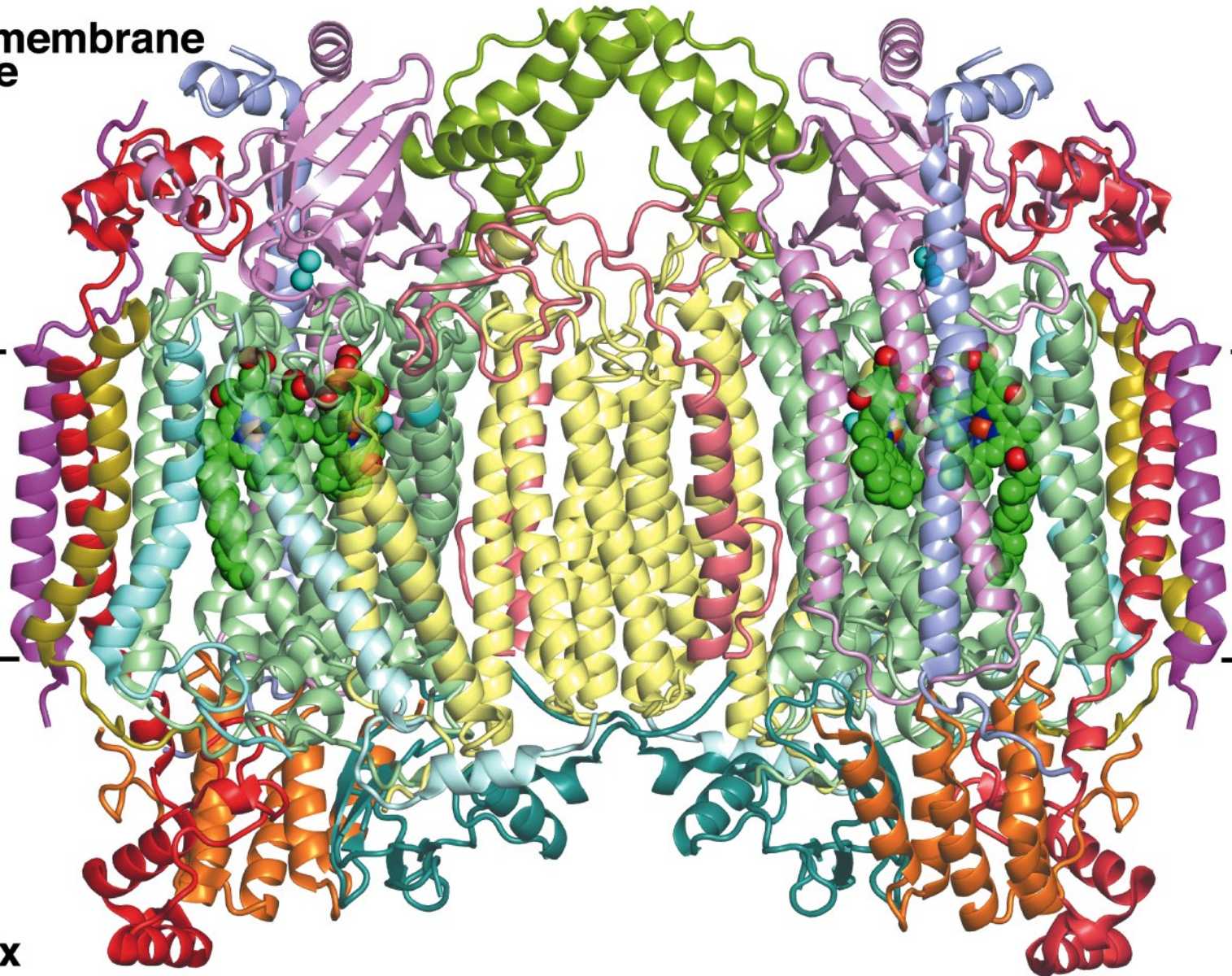


Figure 22-24

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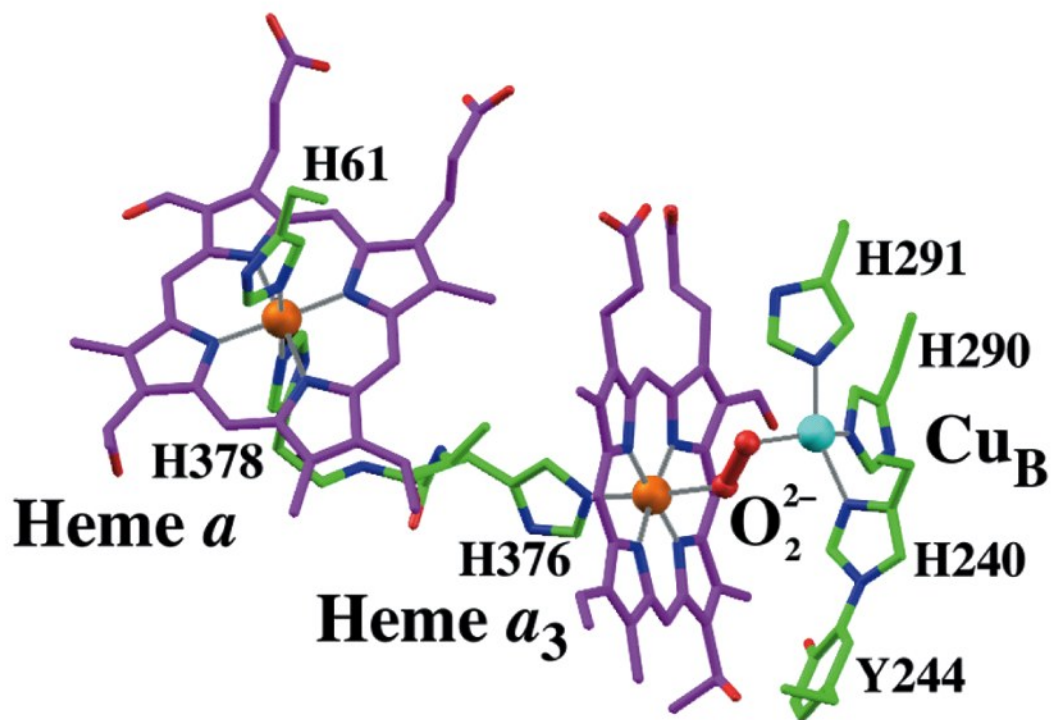
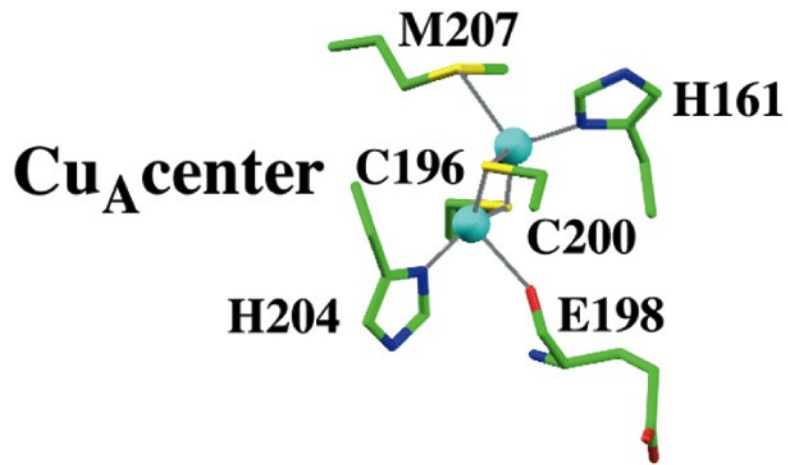


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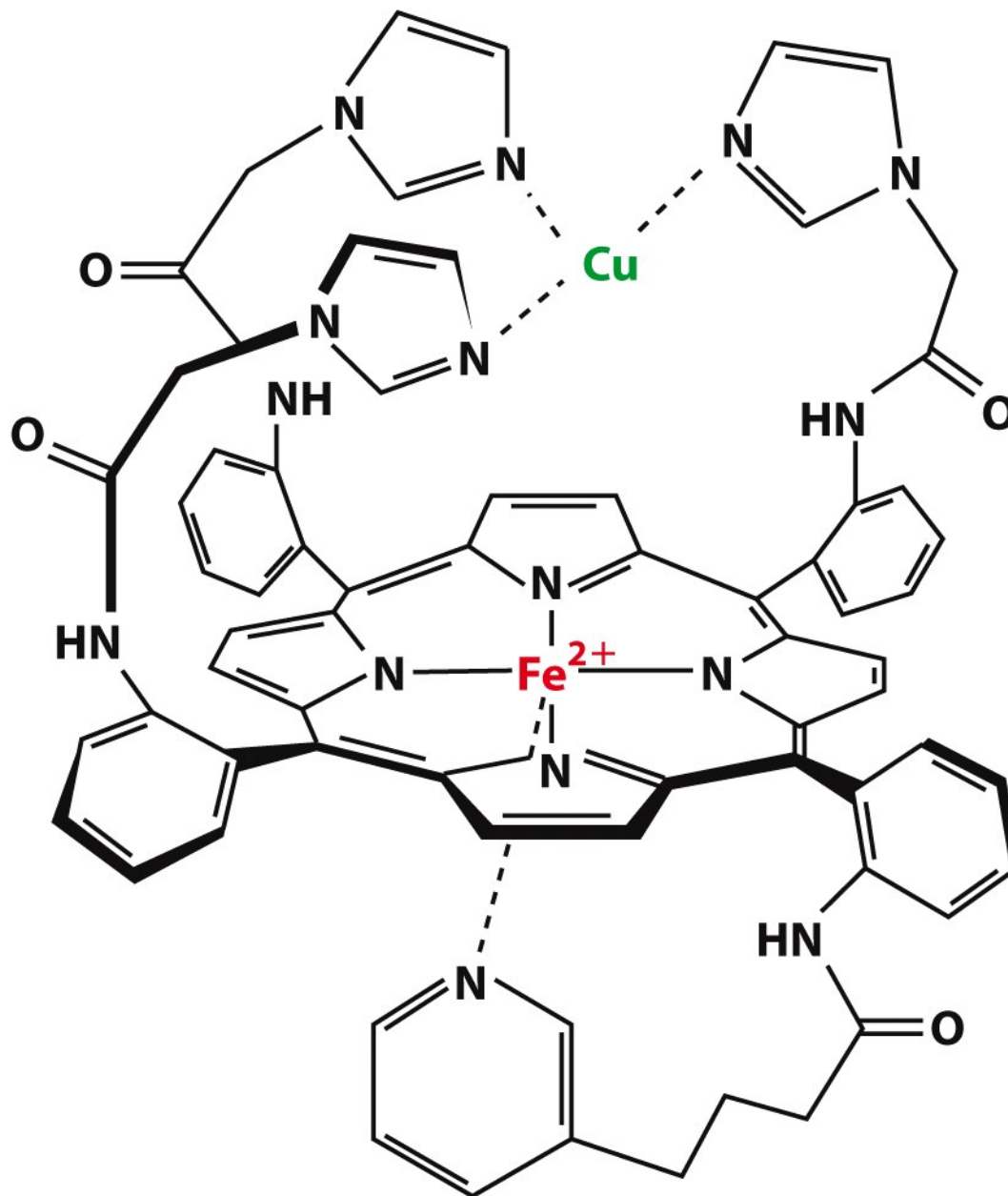


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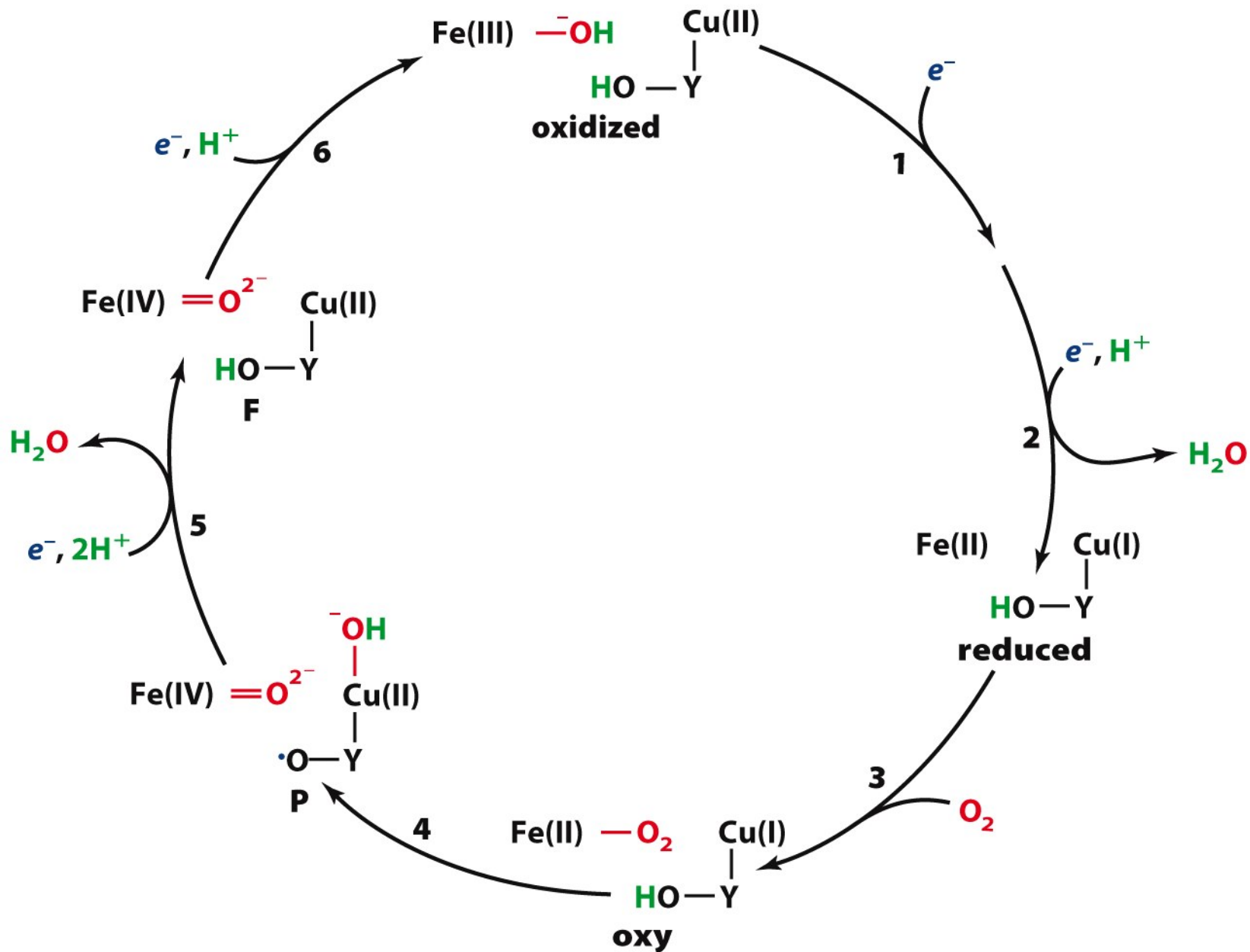


Figure 22-27

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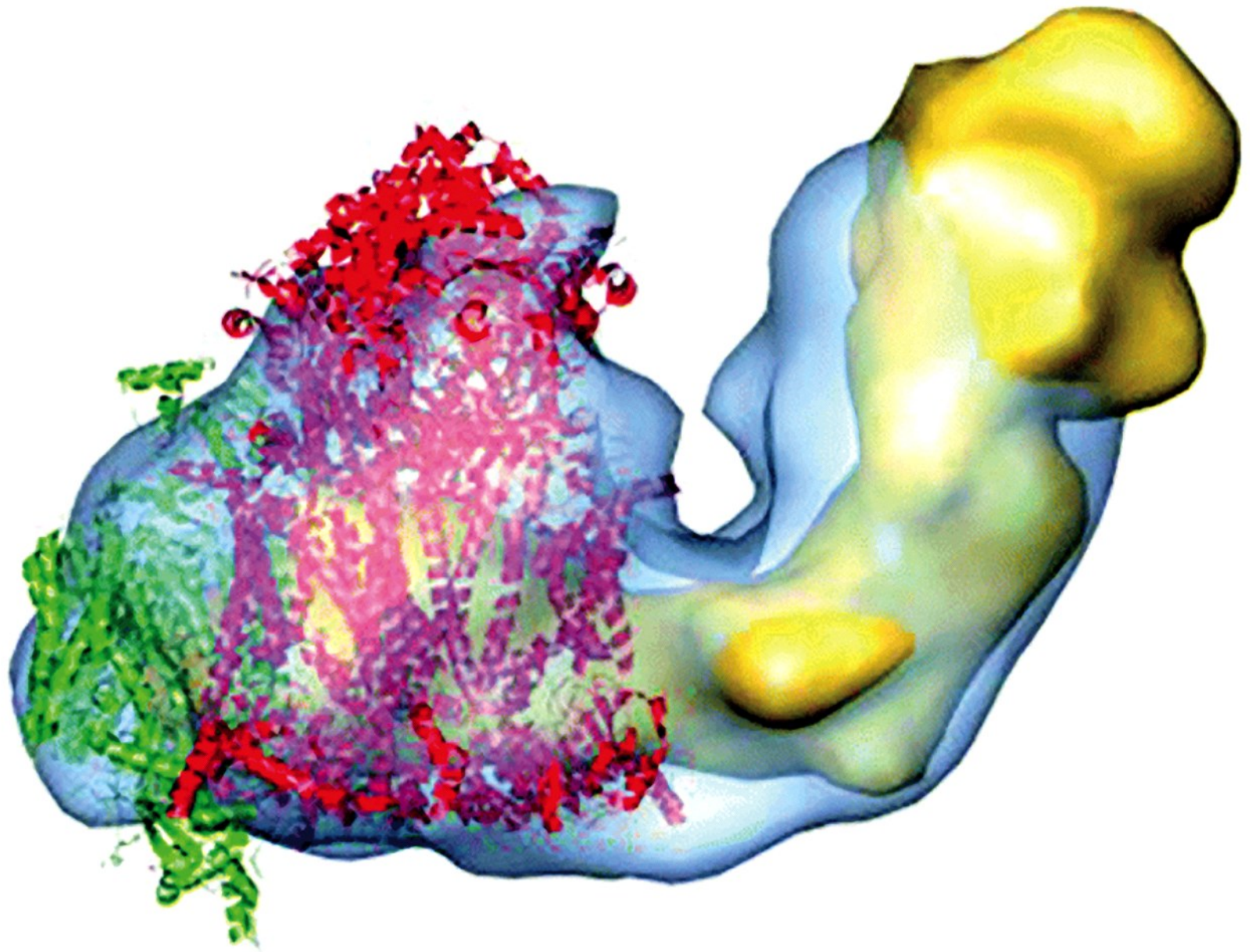


Figure 22-28  
Courtesy of Eva Schäfer, Birbeck College, London, U.K.

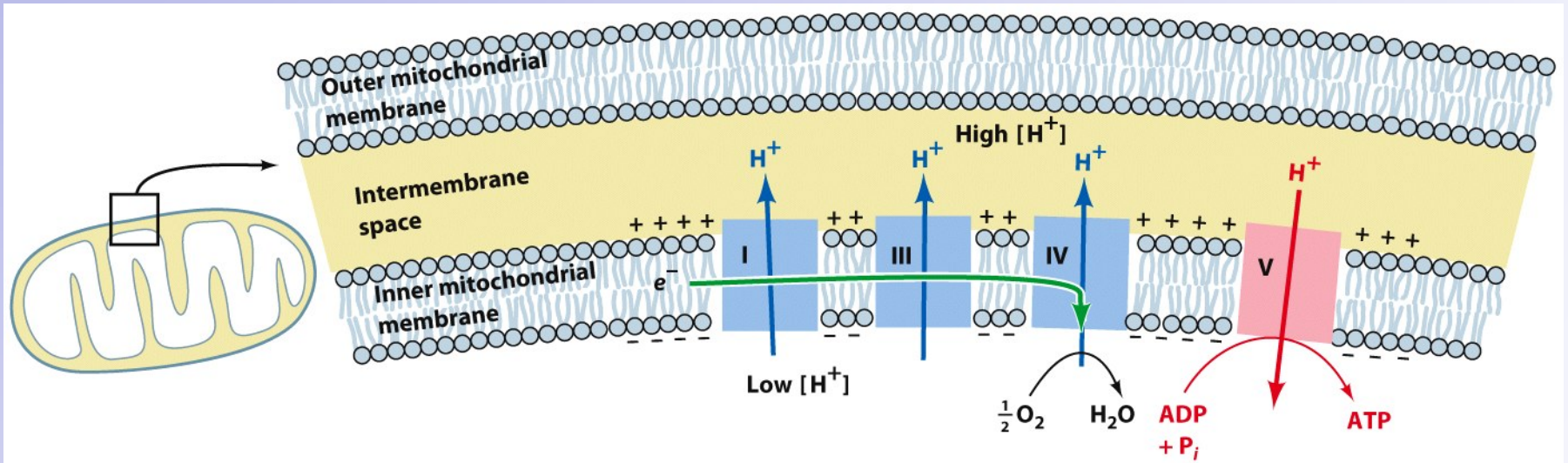


Figure 22-29

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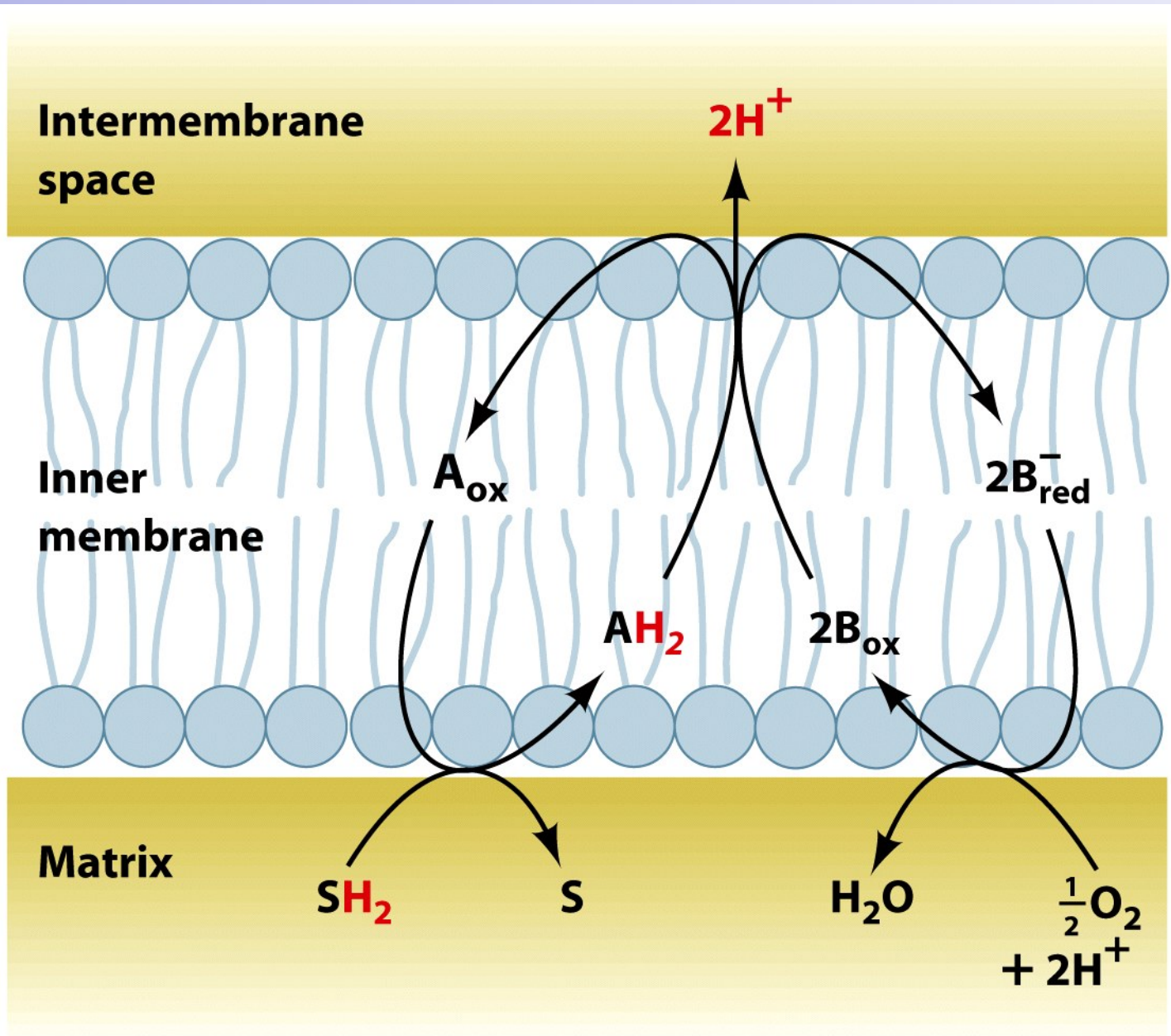
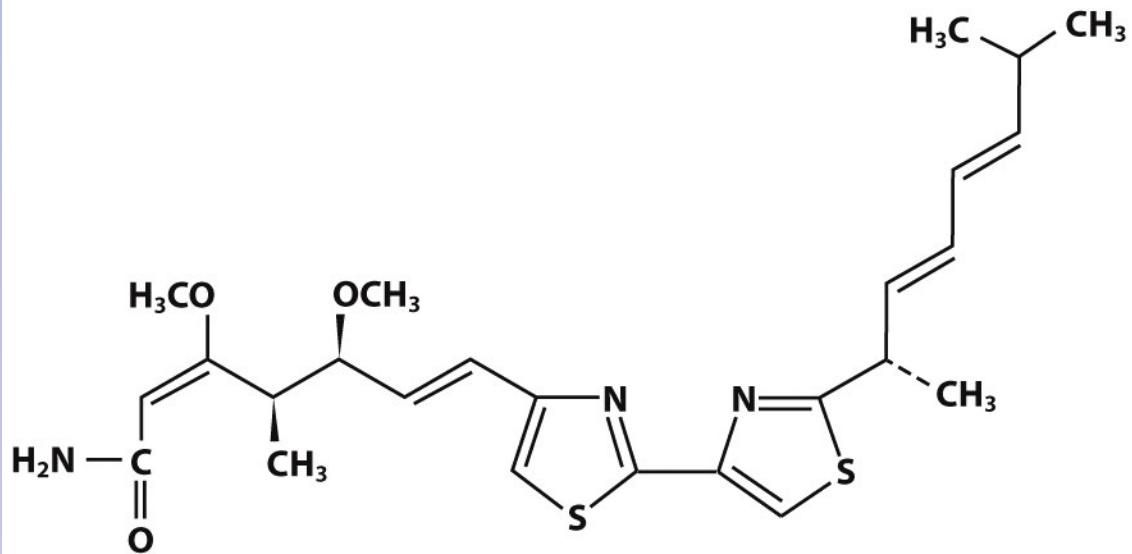


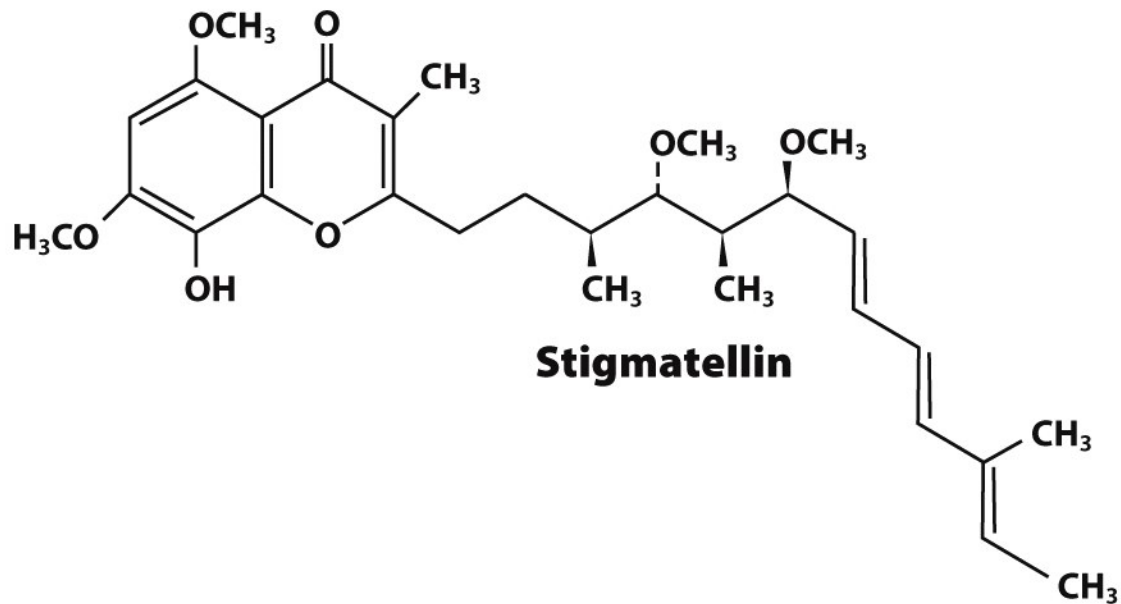
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**Myxothiazol**



**Stigmatellin**

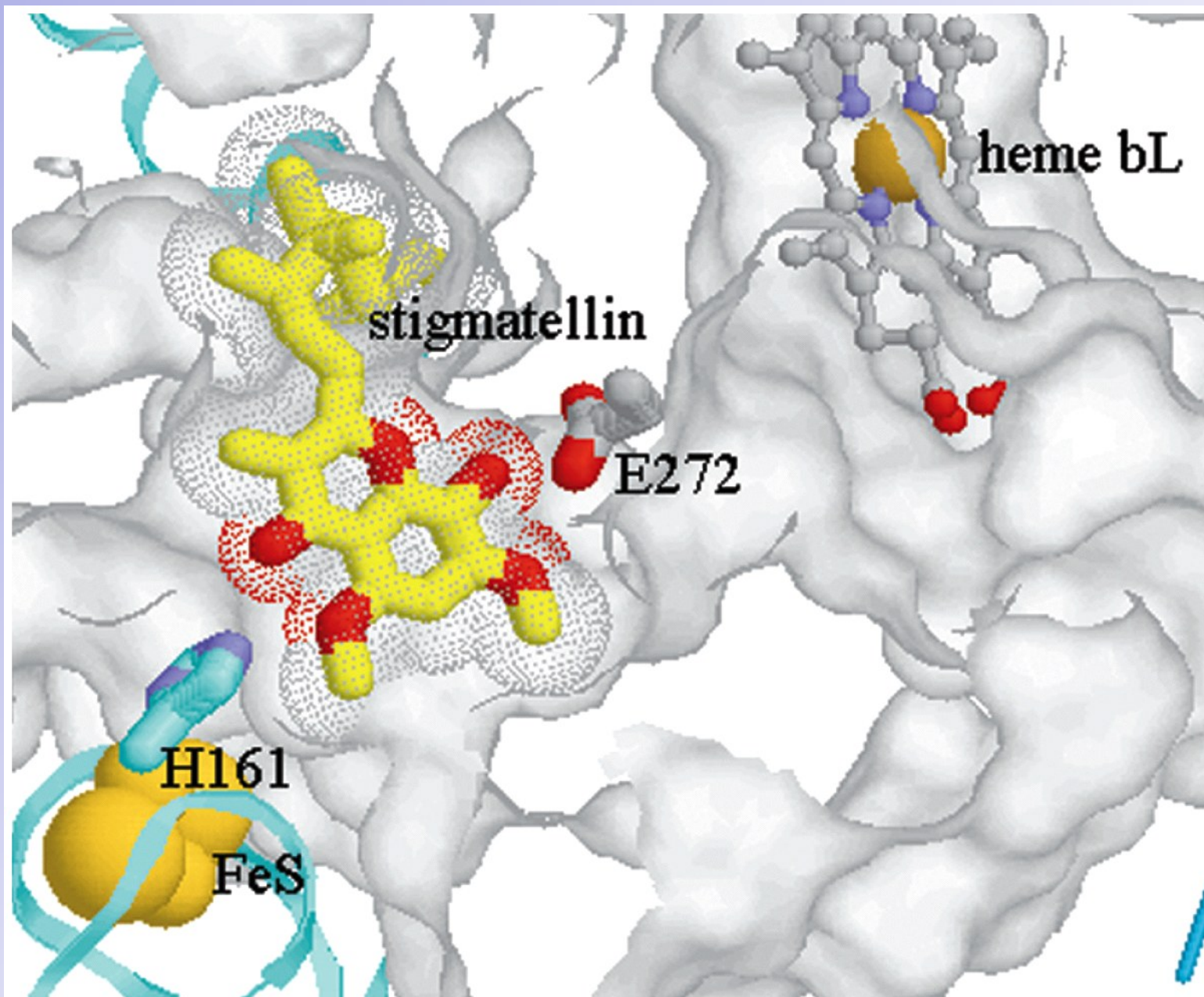


Figure 22-32a

Courtesy of Antony Crofts, University of Illinois at Urbana-Champaign, and Edward Berry, University of California at Berkeley. PDBid 3BCC.

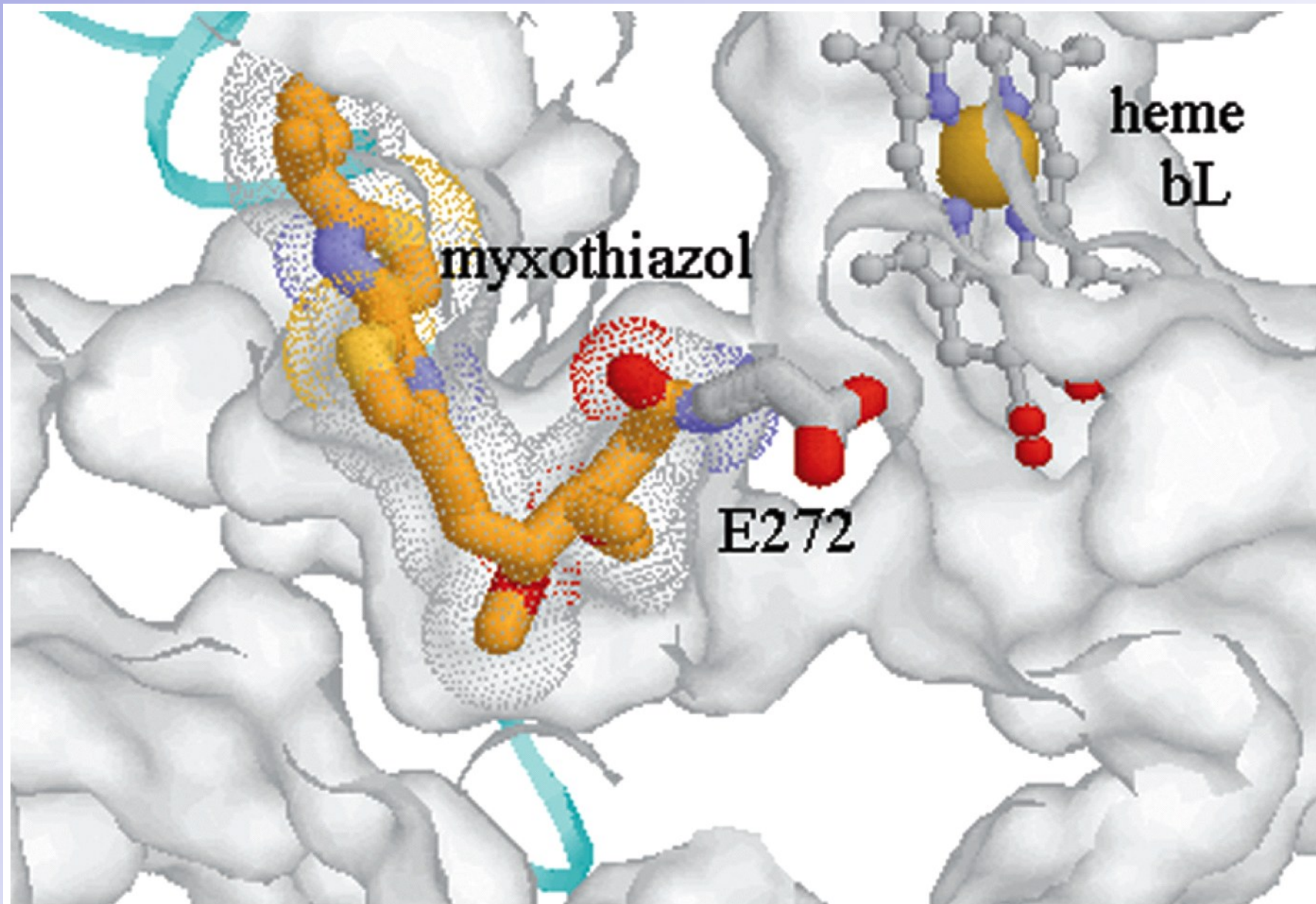


Figure 22-32b

Courtesy of Antony Crofts, University of Illinois at Urbana-Champaign, and Edward Berry, University of California at Berkeley. PDBid 3BCC.

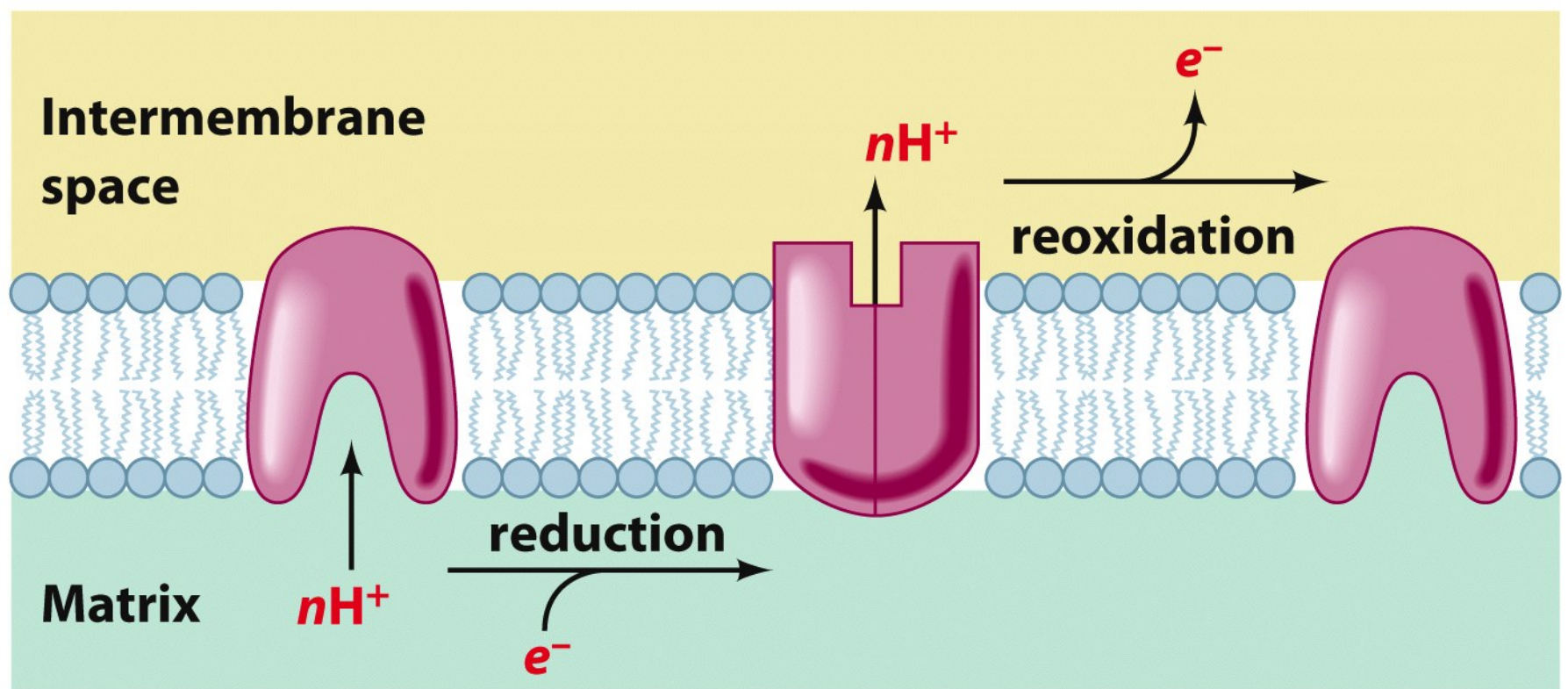


Figure 22-33

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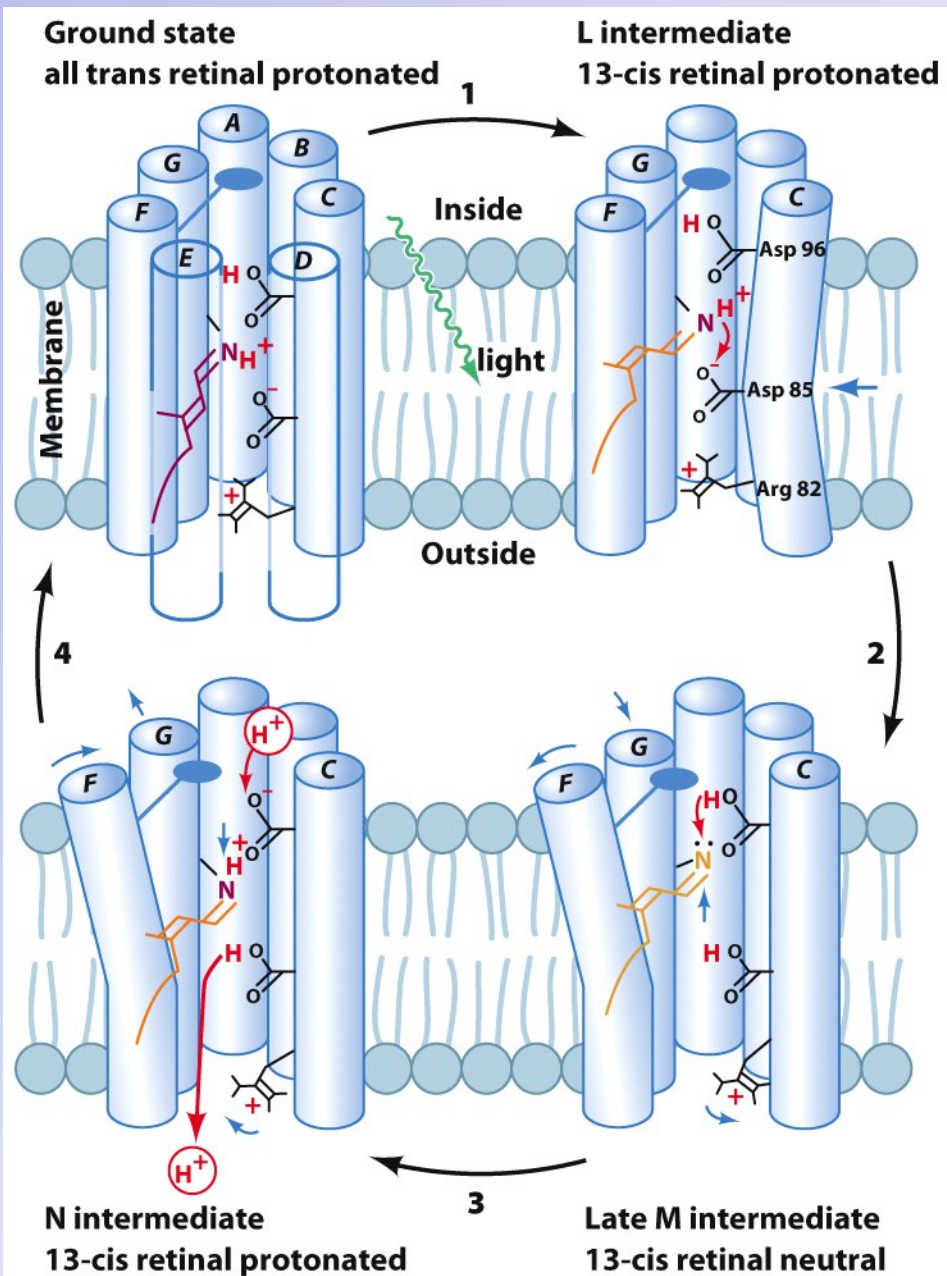


Figure 22-34

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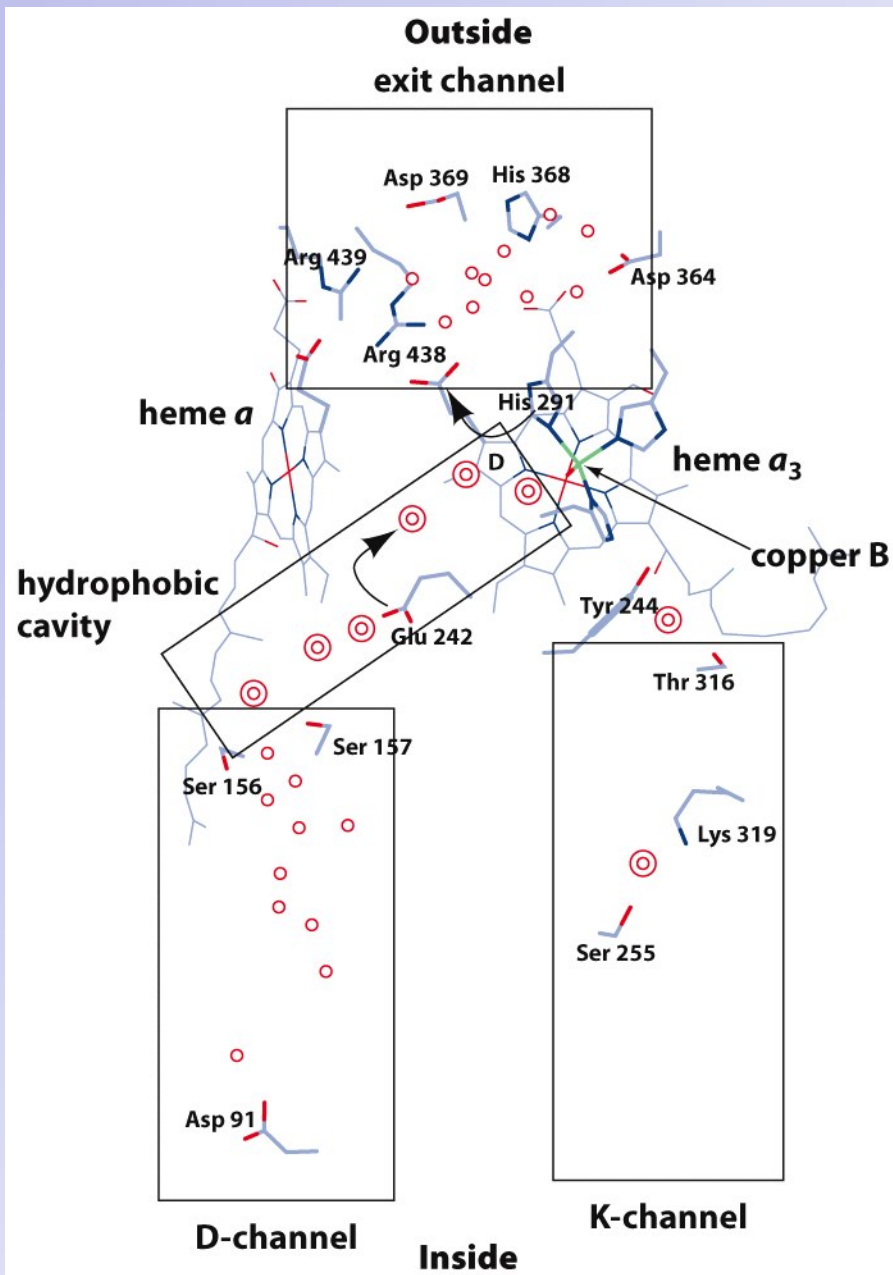
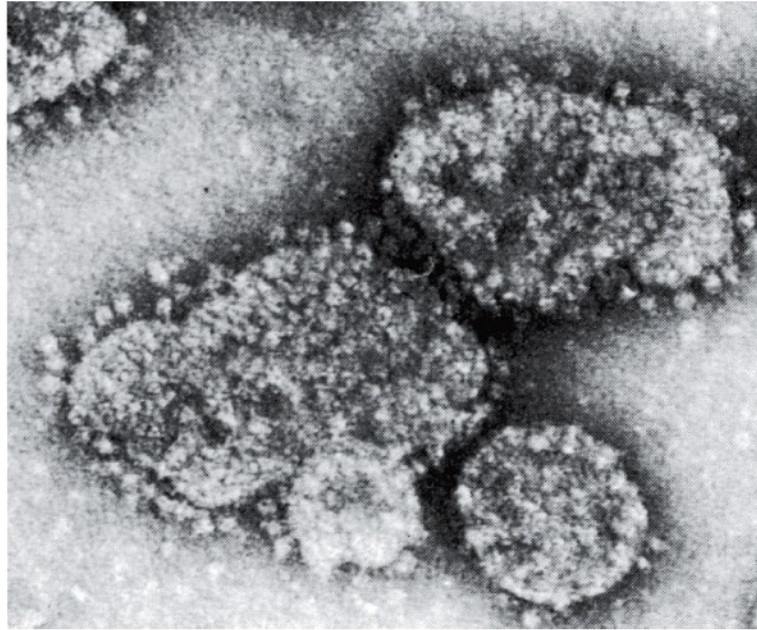


Figure 22-35  
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**(a)**



**(b)**



**(c)**

Figure 22-36 part 1

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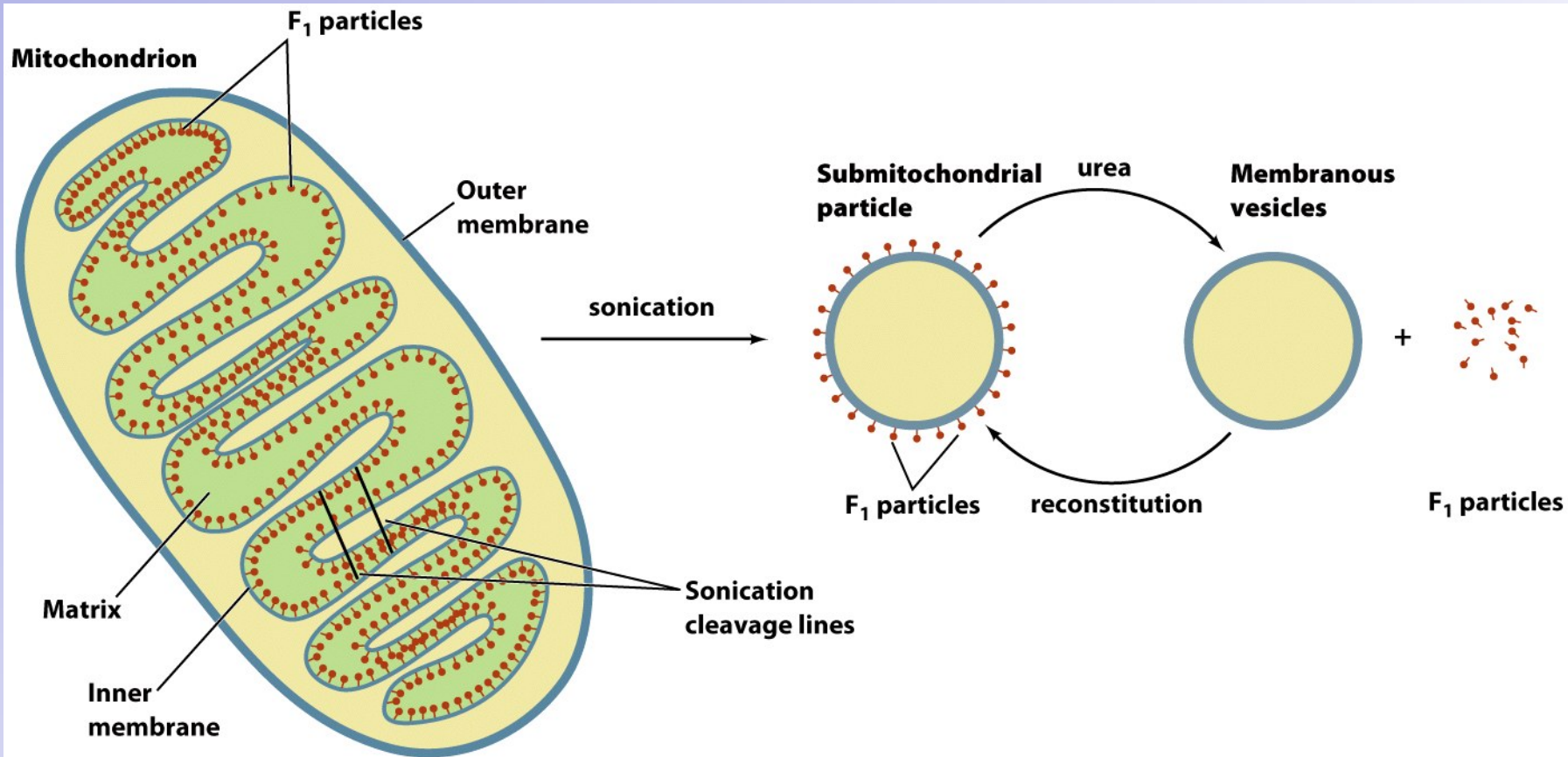


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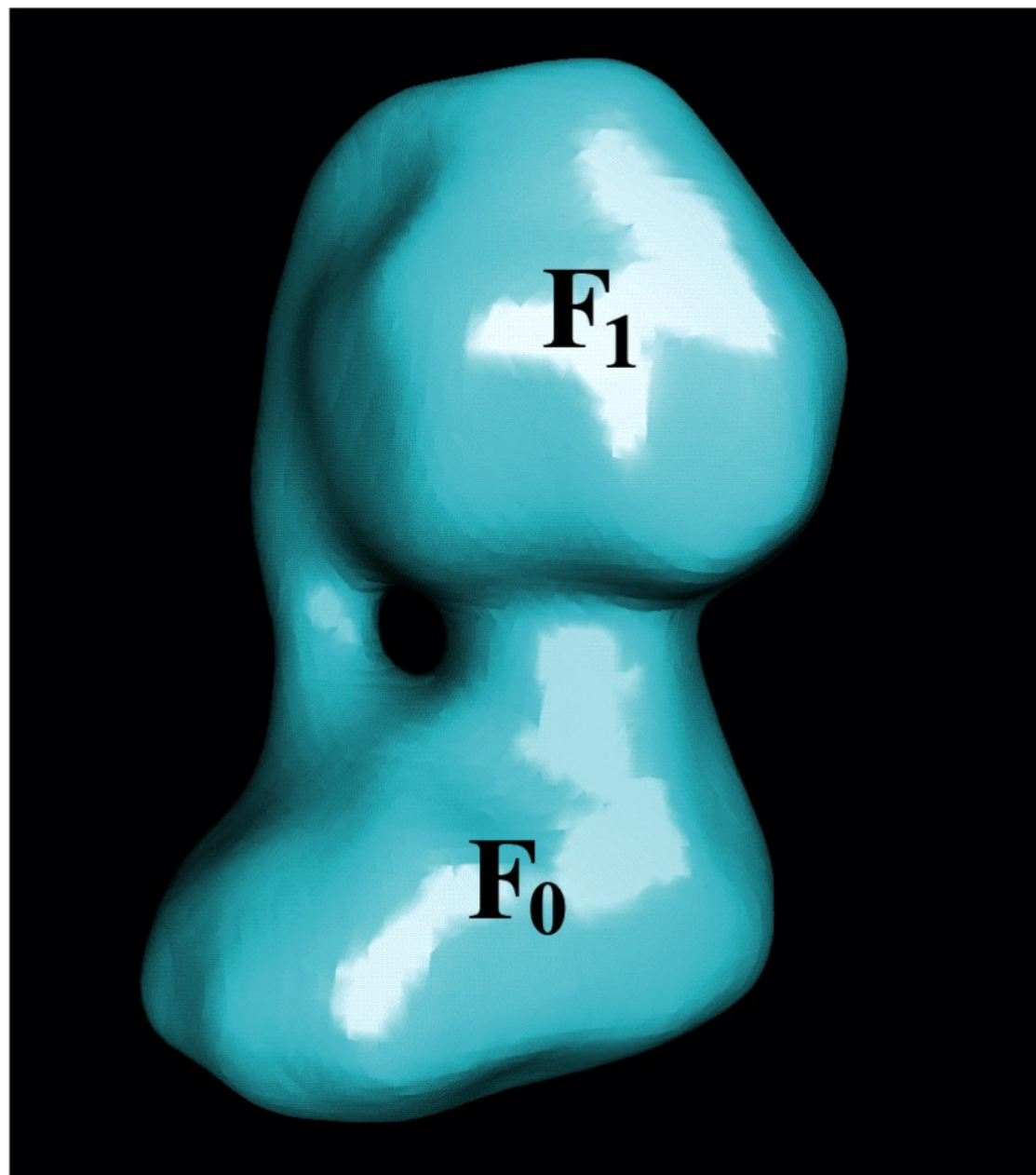


Figure 22-37

Courtesy of John Rubinstein, University of Toronto, Canada, and John Walker and Richard Henderson, MRC Laboratory of Molecular Biology, Cambridge, U.K.

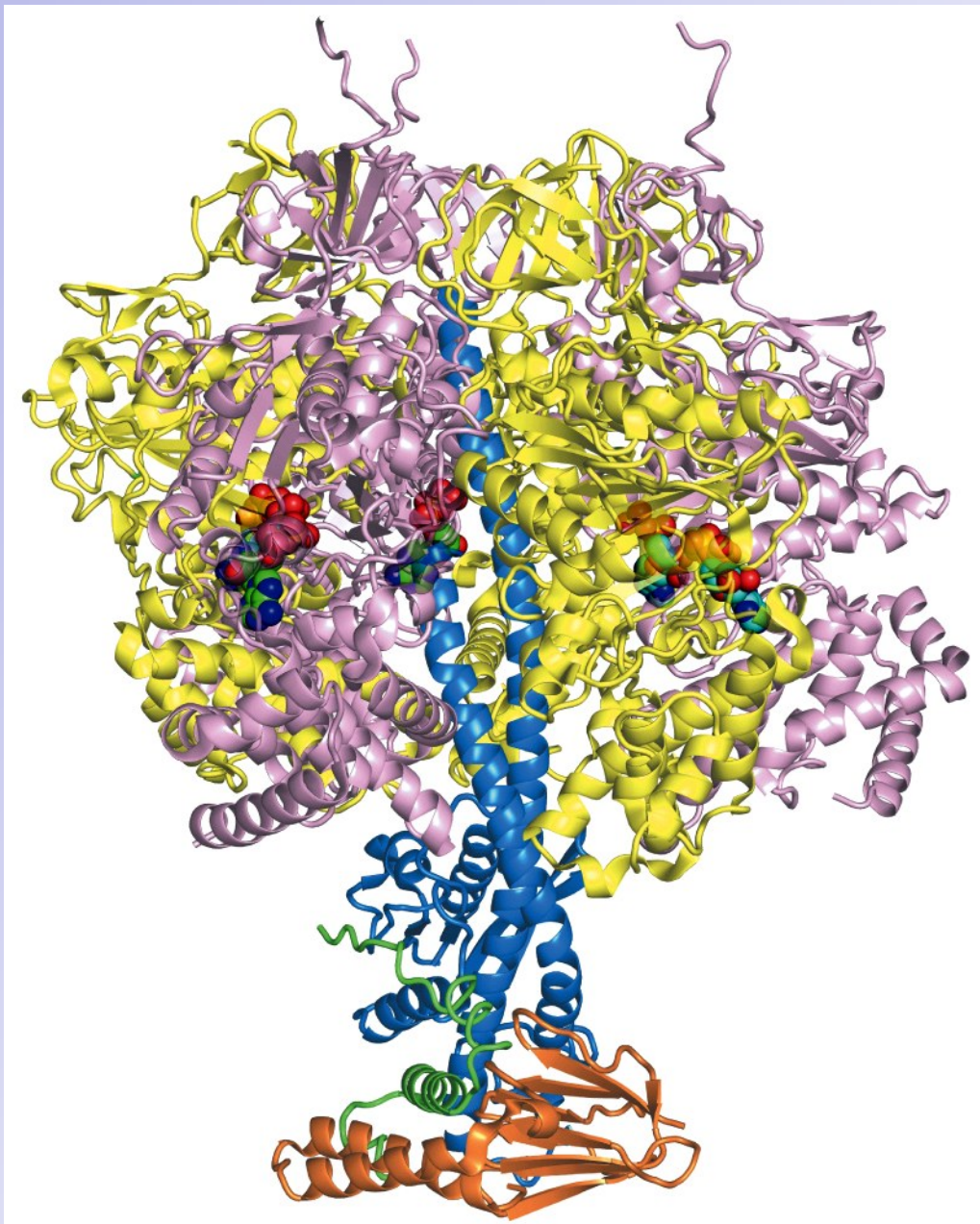


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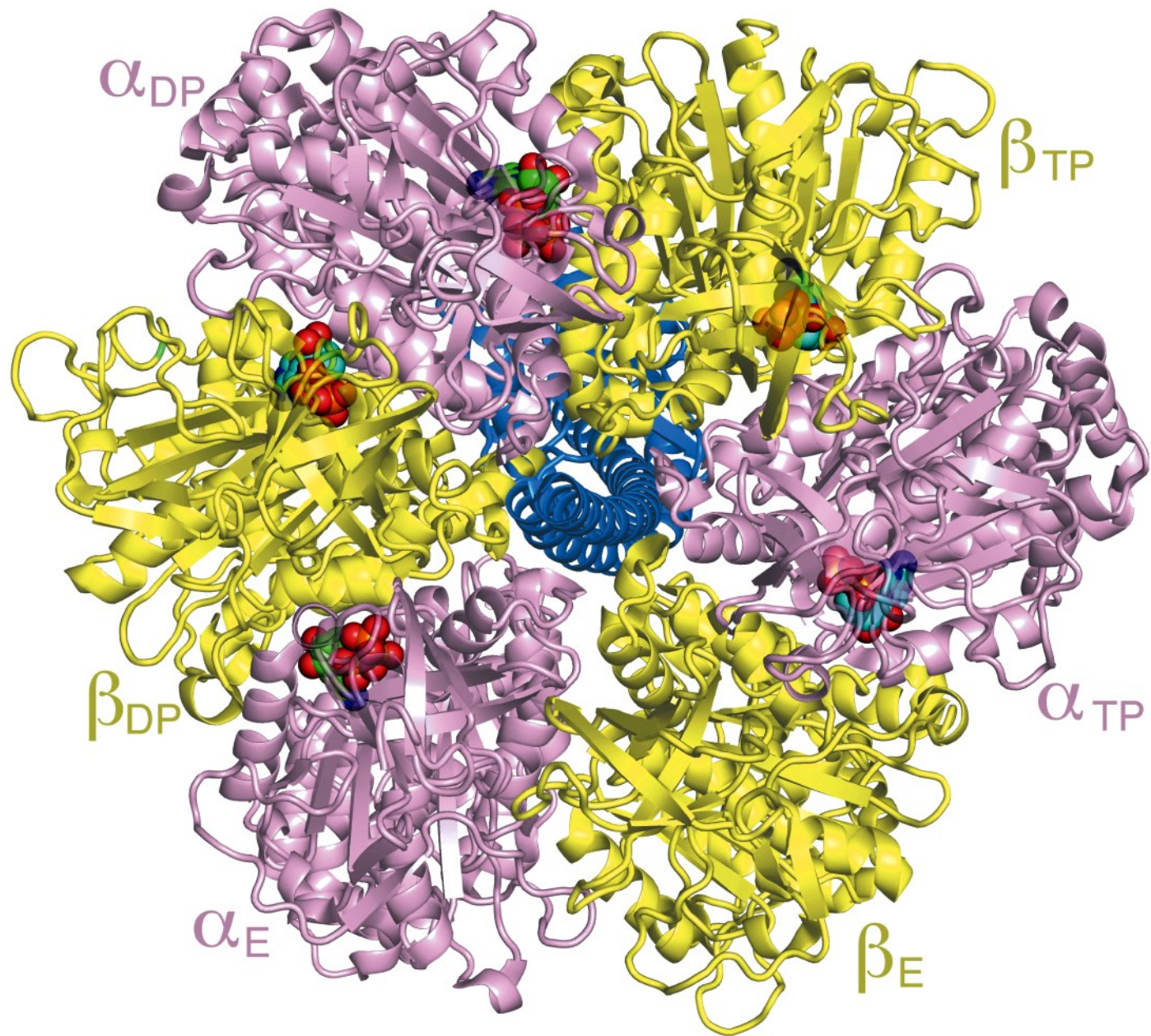


Figure 22-38b

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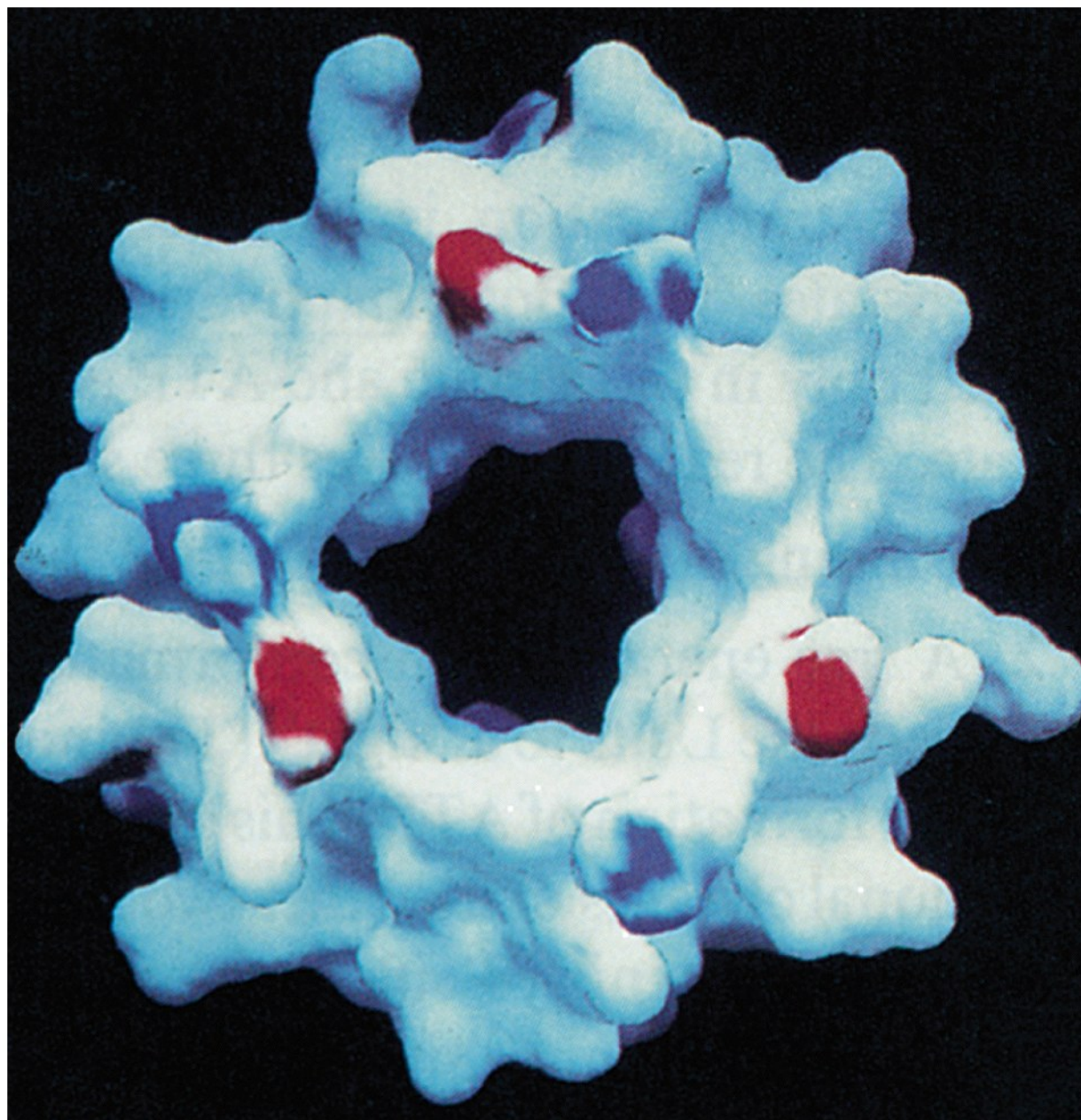


Figure 22-38c

From Abrahams, J.P., Leslie, A.G.W., Lutter, R., and Walker, J.E., *Nature* 370, 621 (1994). PDBid 1BMF.

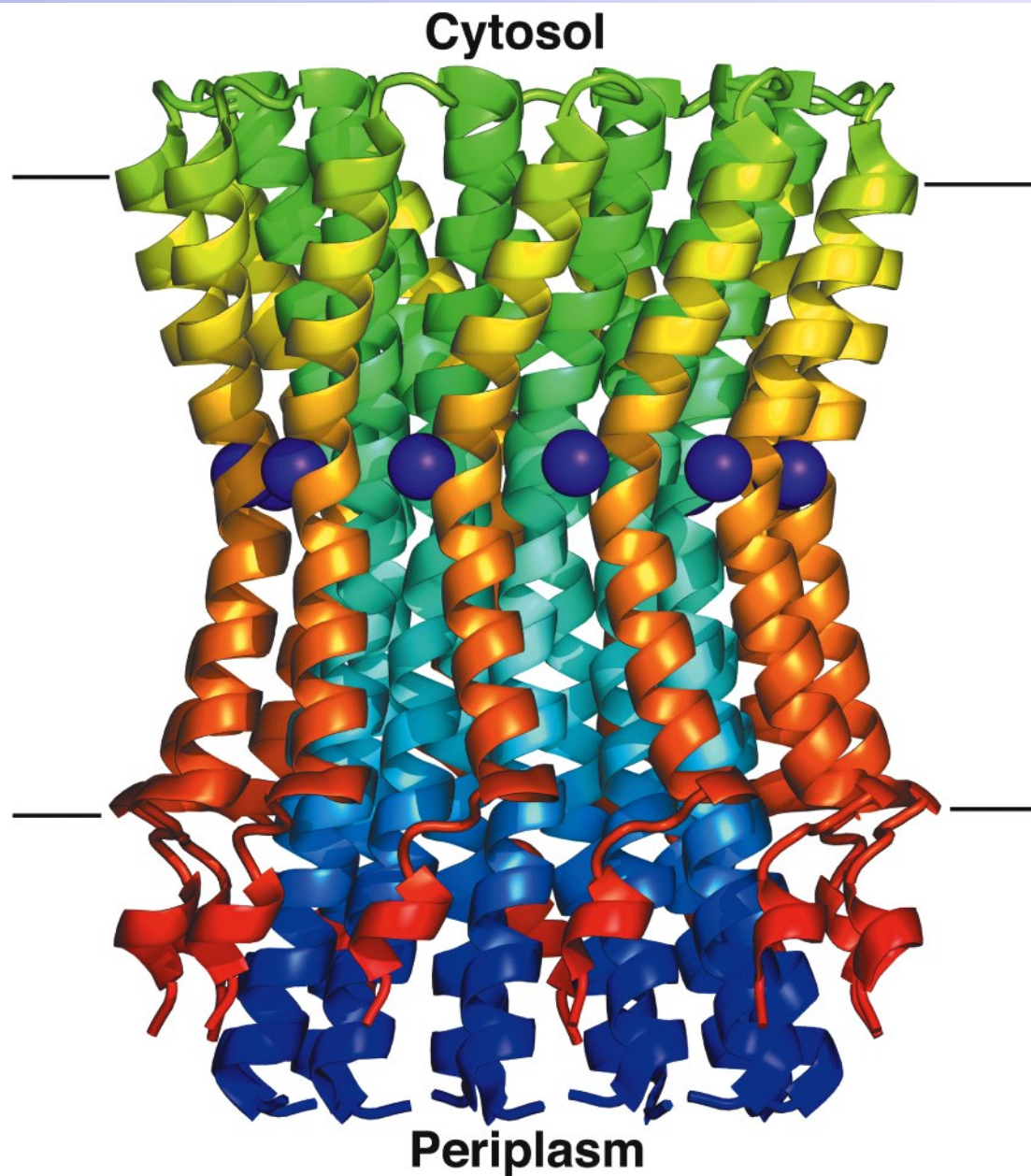


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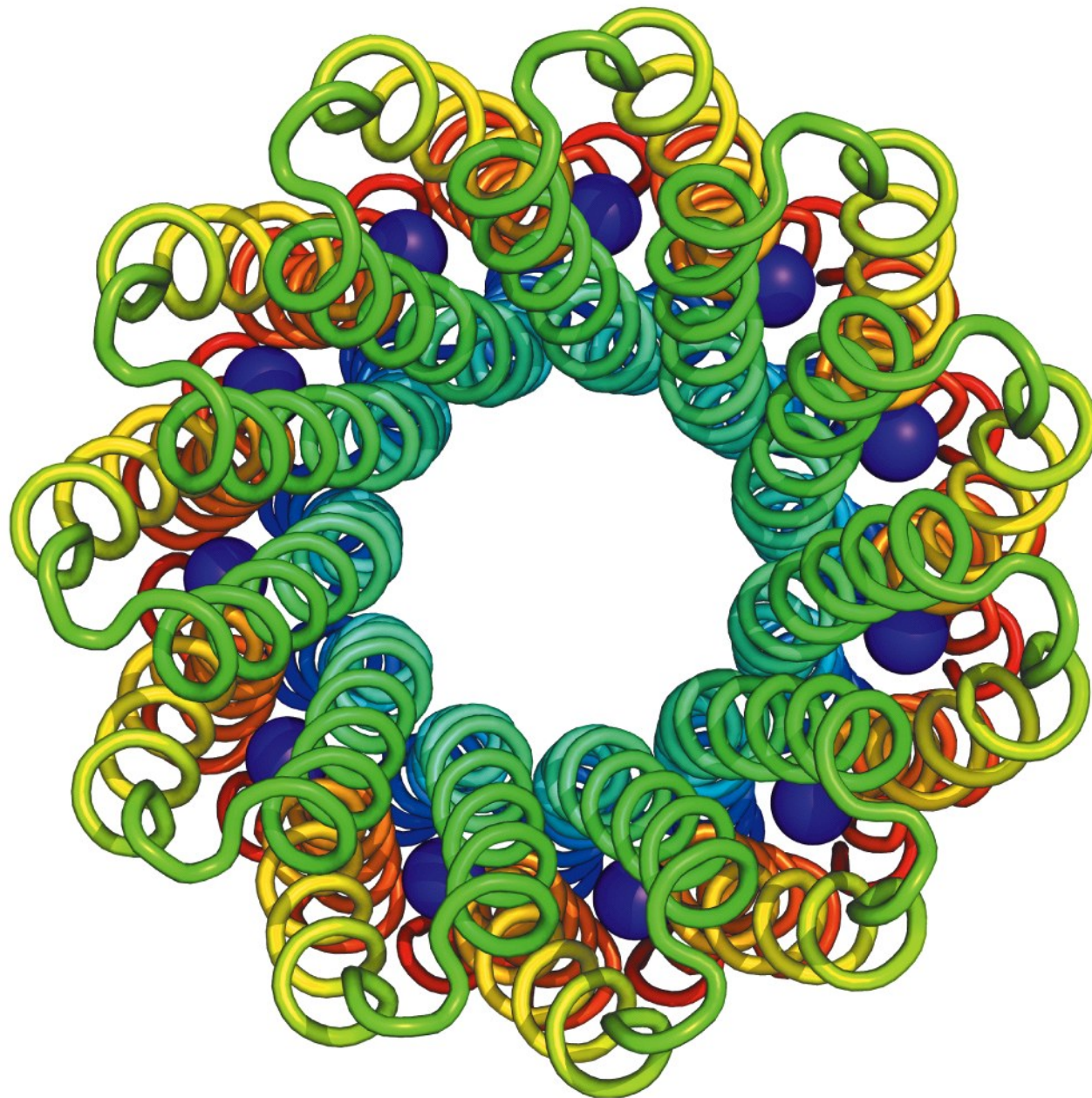


Figure 22-39b

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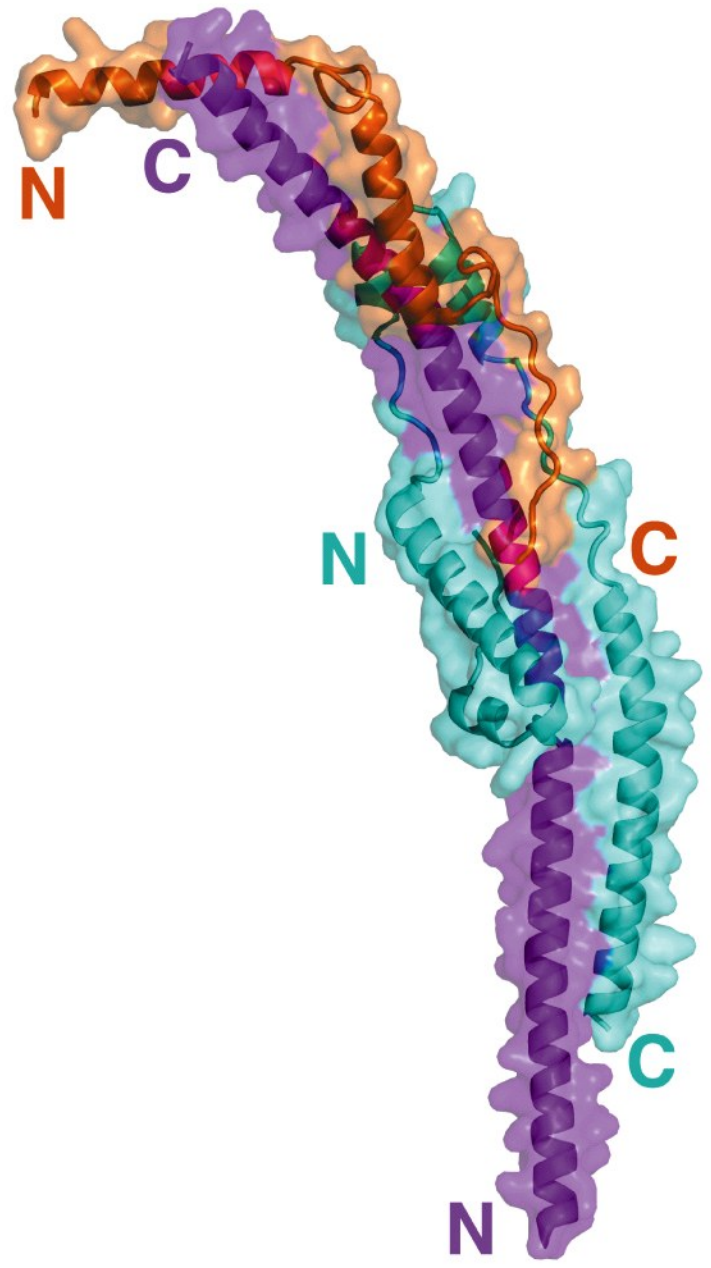


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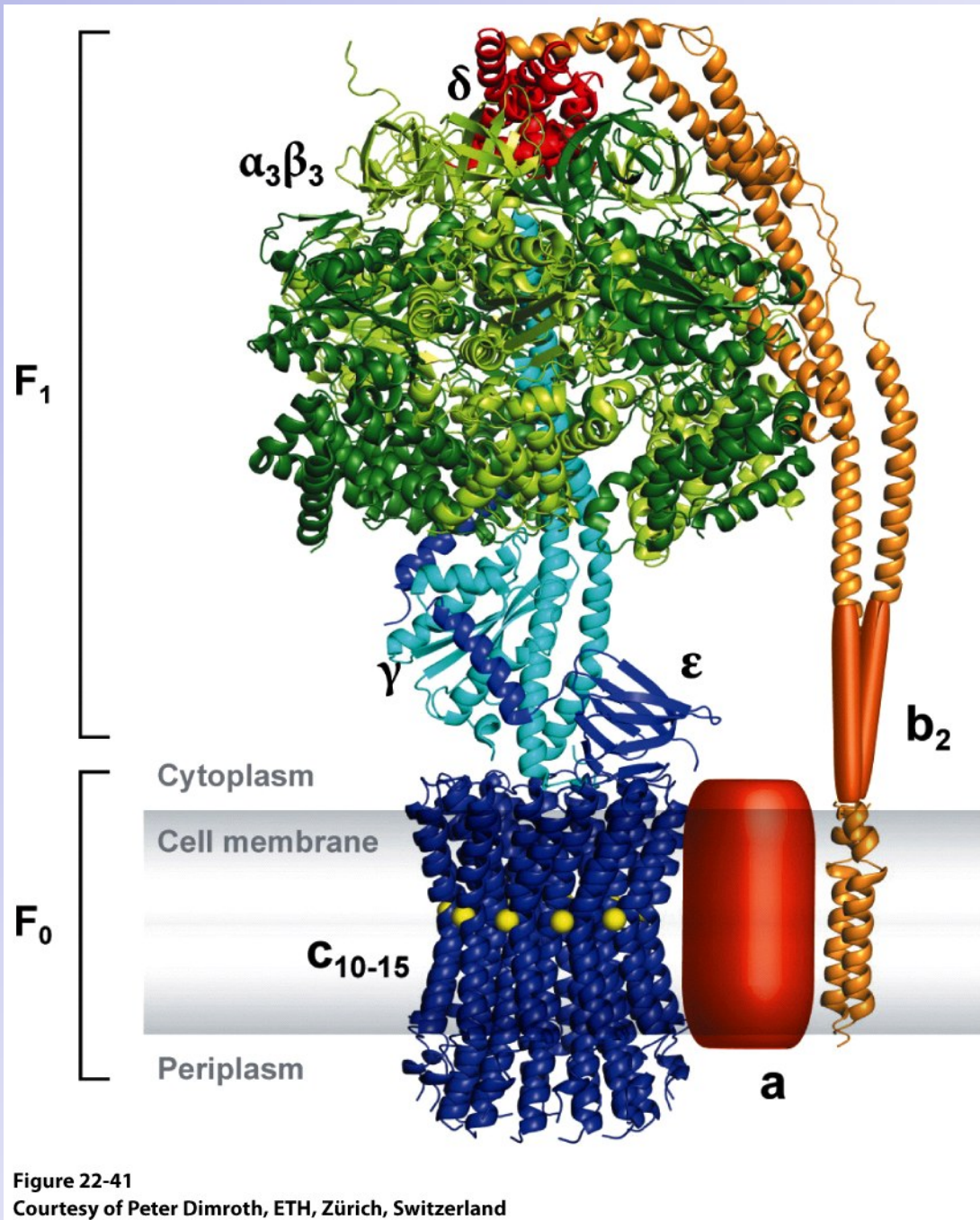


Figure 22-41  
Courtesy of Peter Dimroth, ETH, Zürich, Switzerland

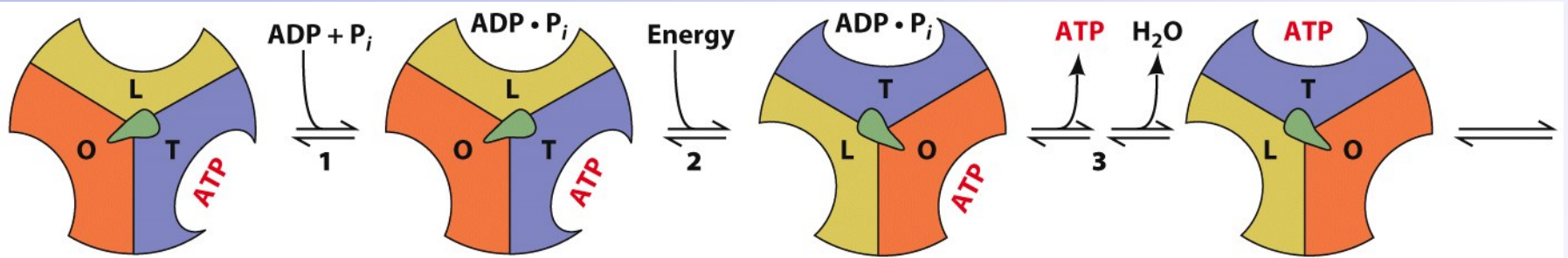


Figure 22-42  
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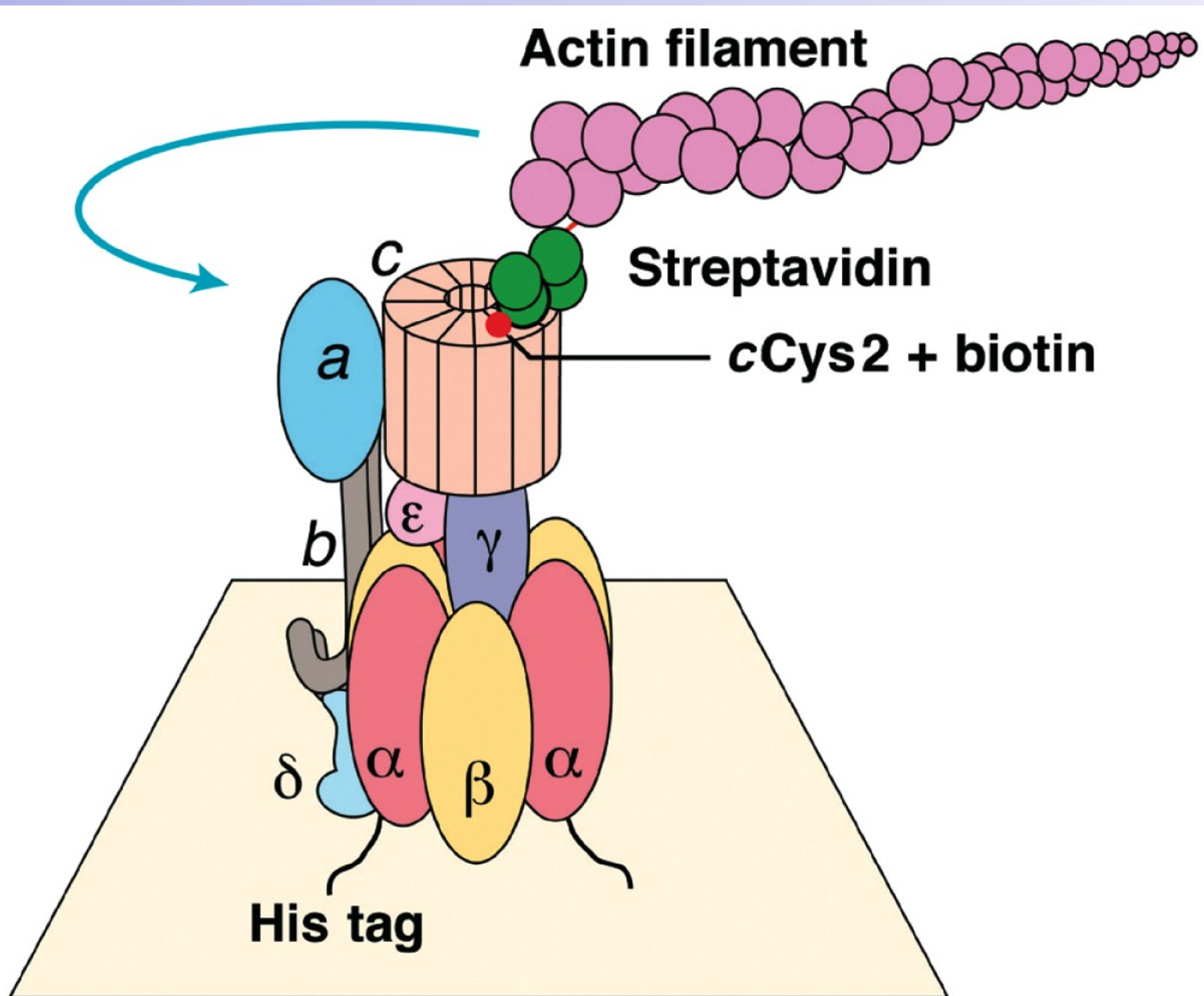


Figure 22-43a  
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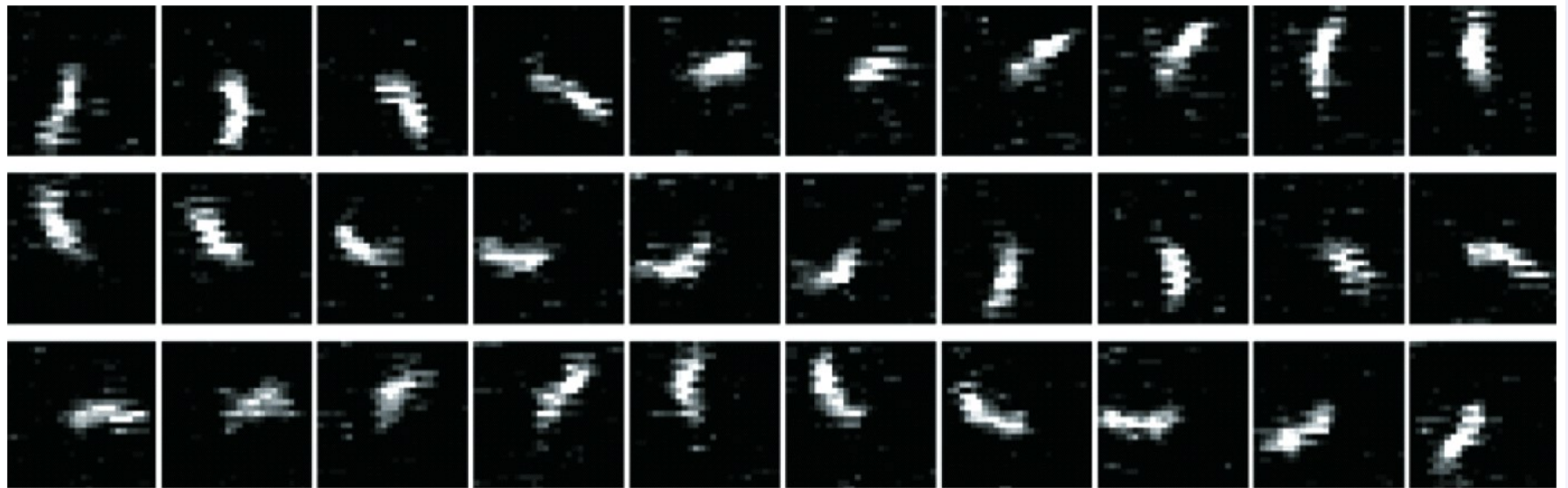


Figure 22-43b  
Courtesy of Masamitsu Futai, Osaka University, Osaka, Japan

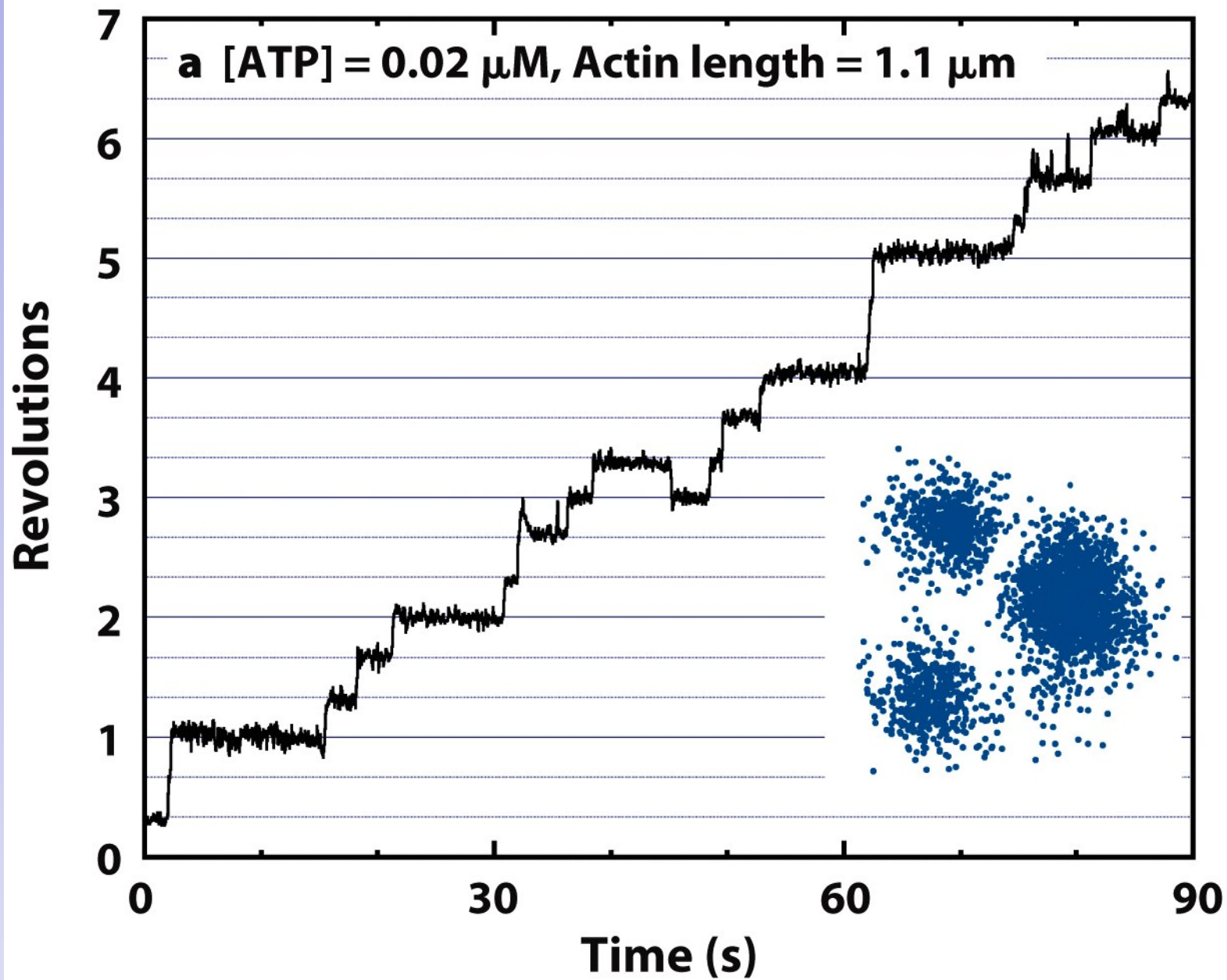


Figure 22-44  
Courtesy of Kazuhiko Kinosita, Jr., Keio University, Yokohama, Japan

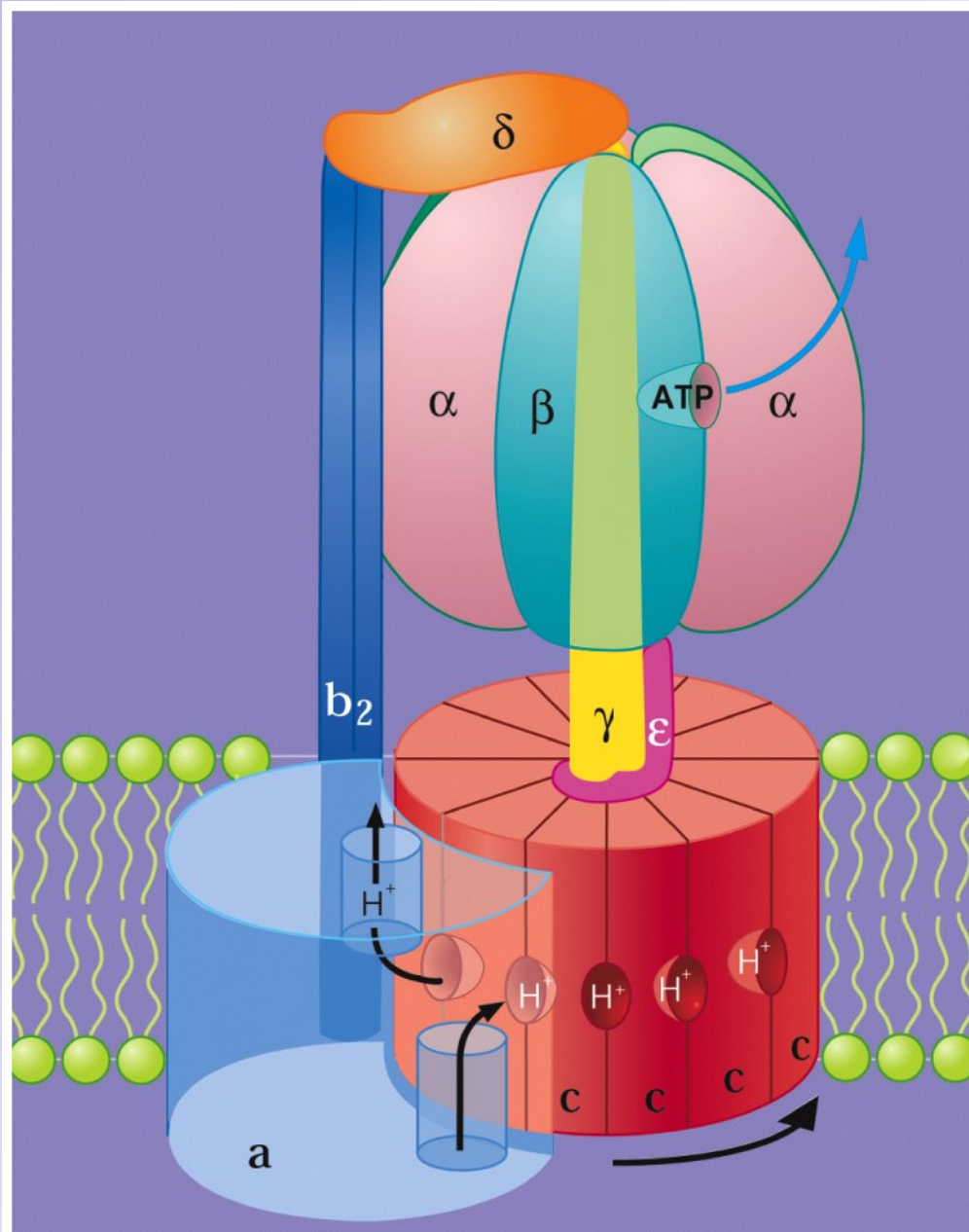


Figure 22-45

Courtesy of Richard Cross, State University of New York, Syracuse, New York

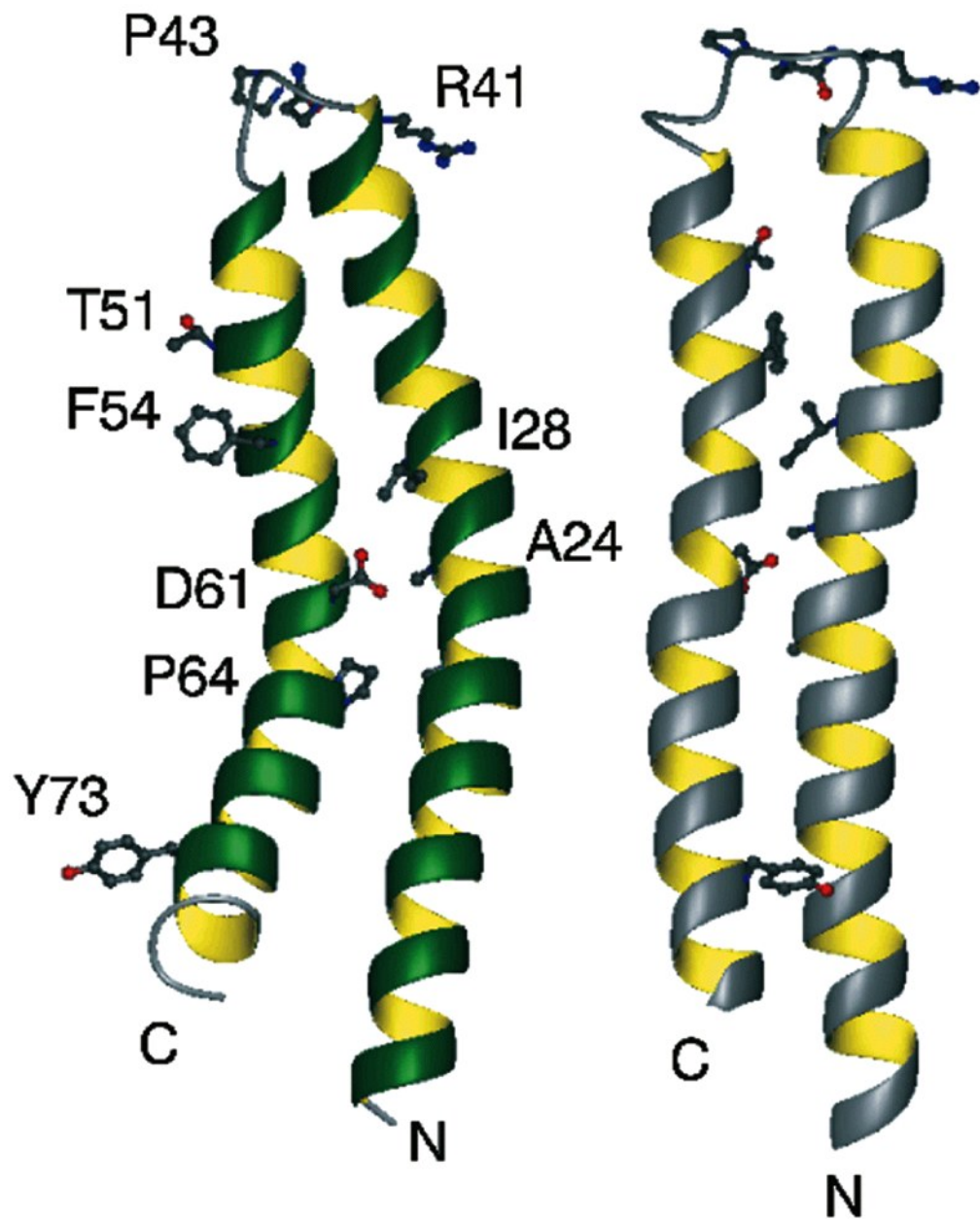


Figure 22-46  
Courtesy of Mark Girvin, Albert Einstein College of Medicine

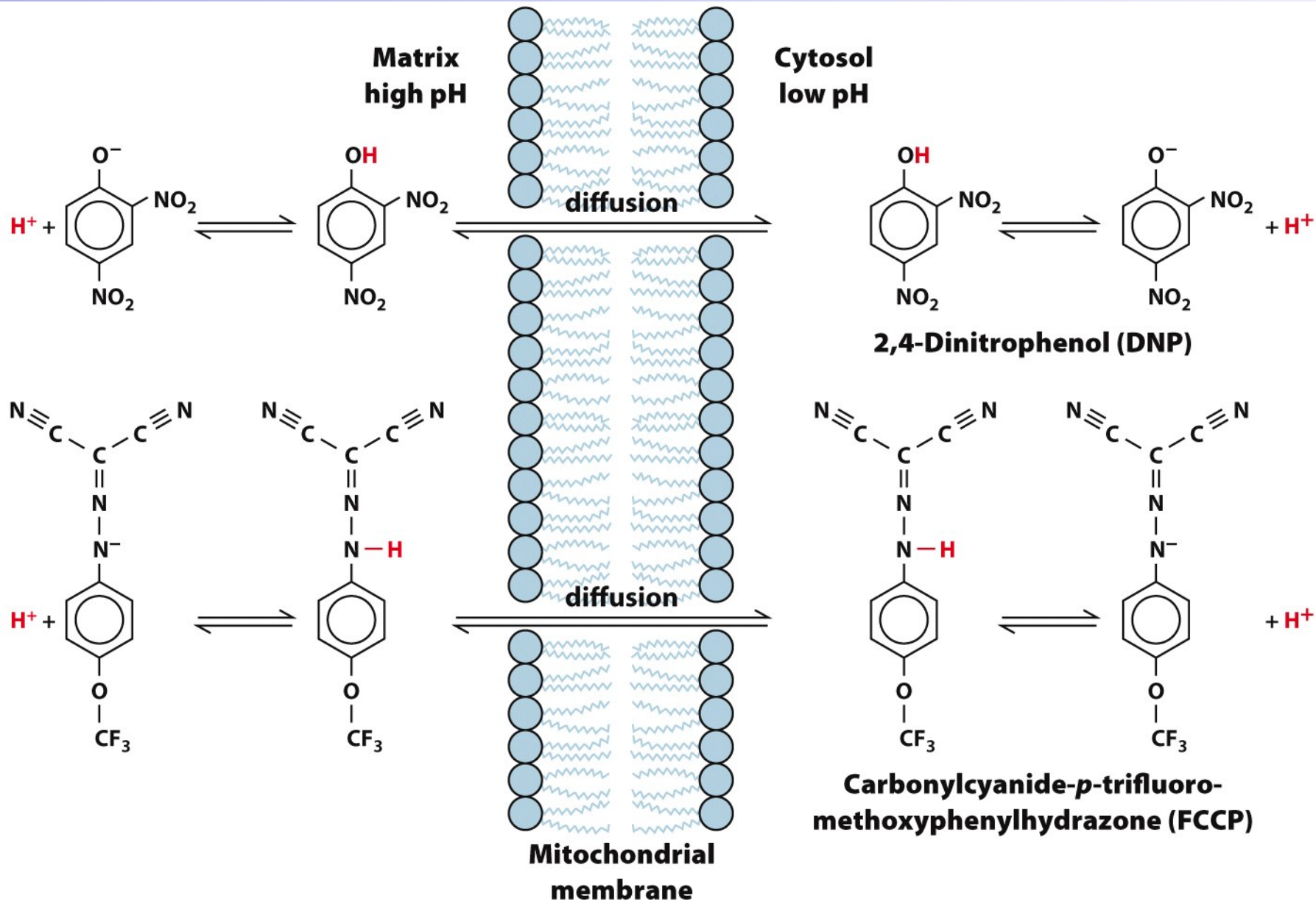


Figure 22-47

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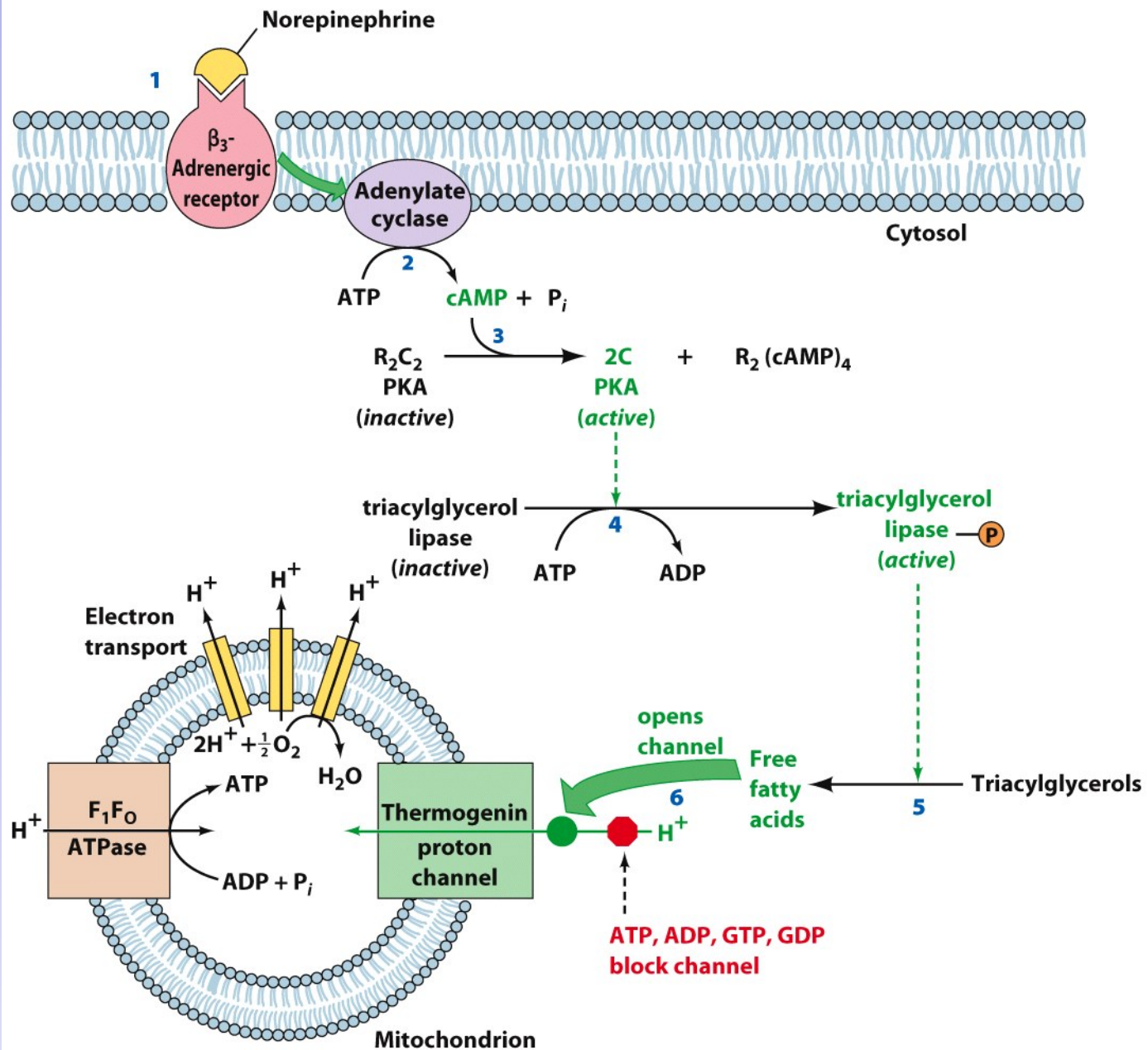


Figure 22-48

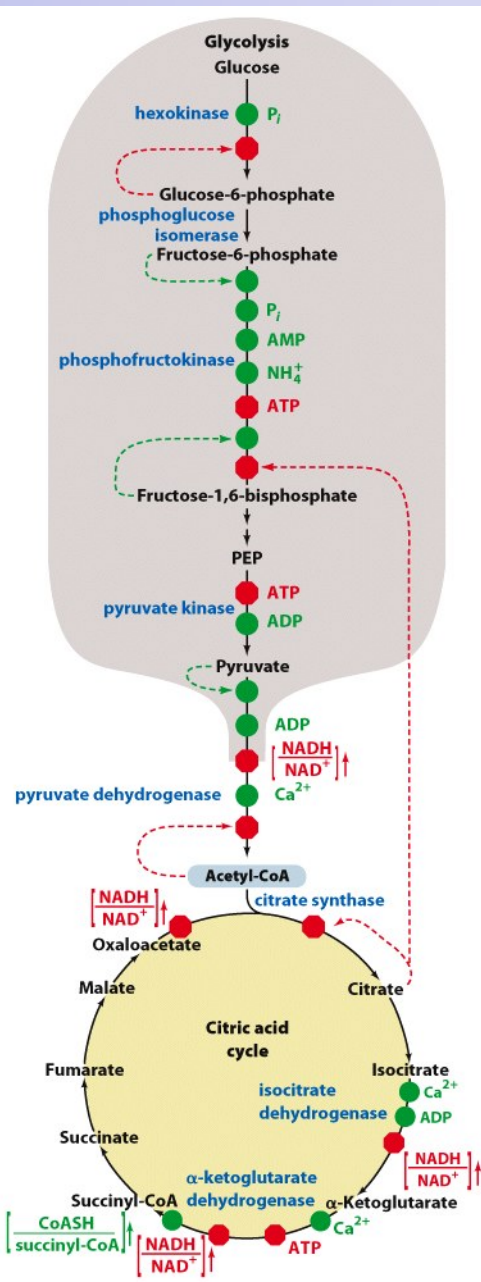


Figure 22-49  
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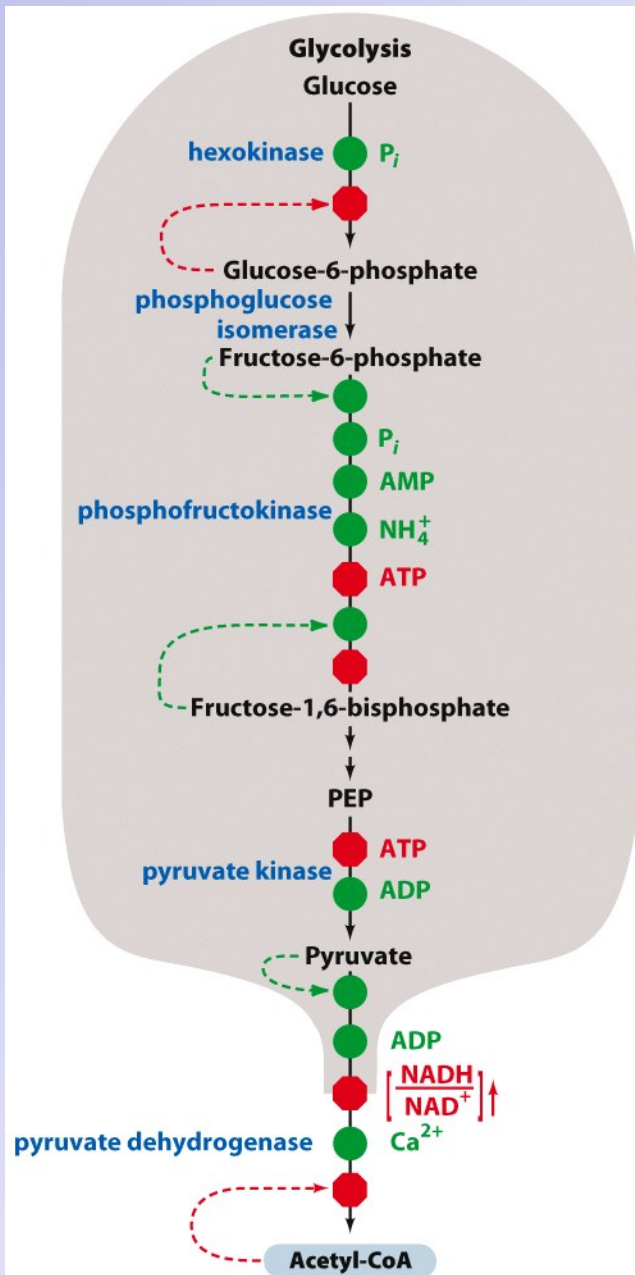


Figure 22-49 part 1  
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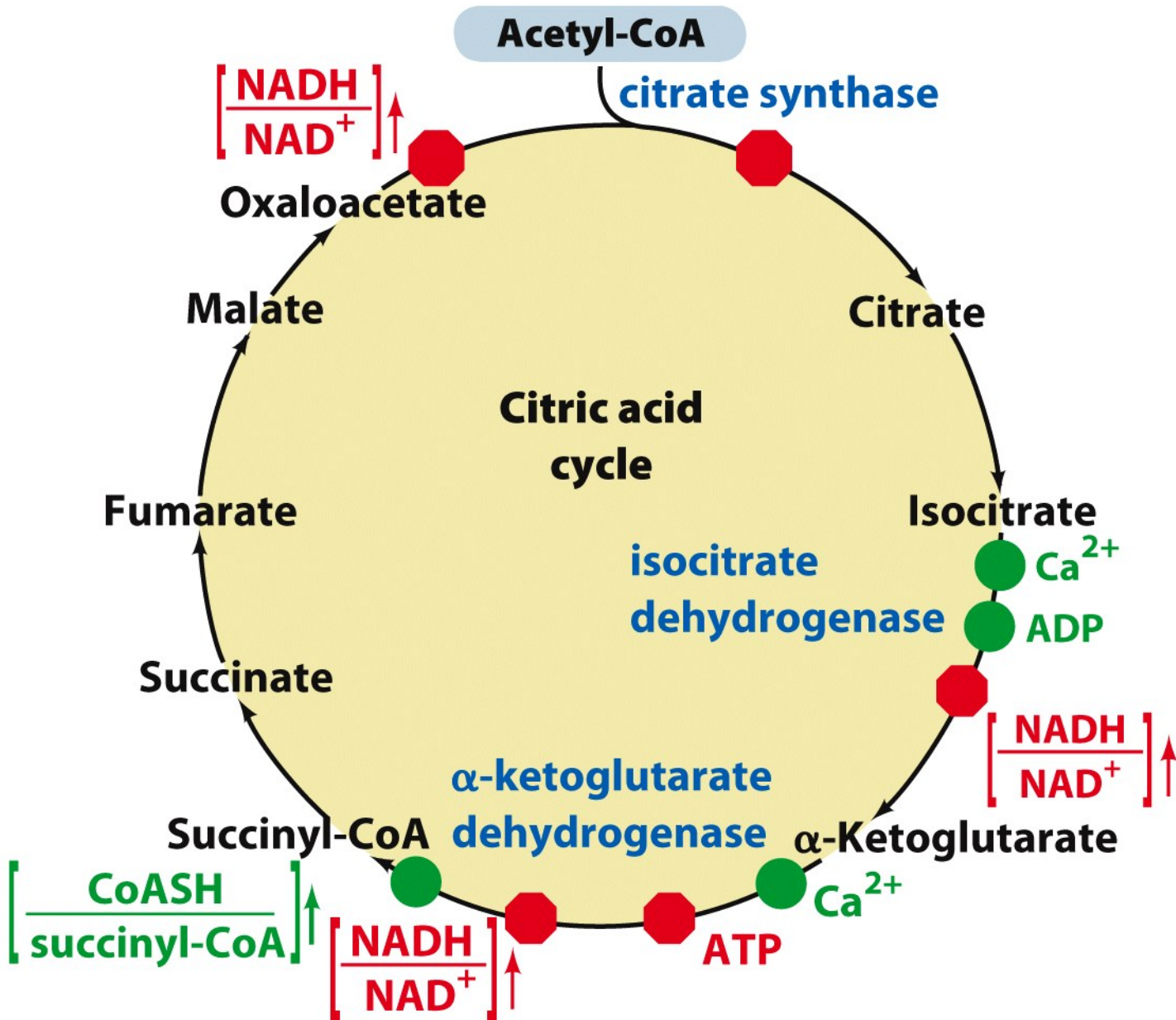
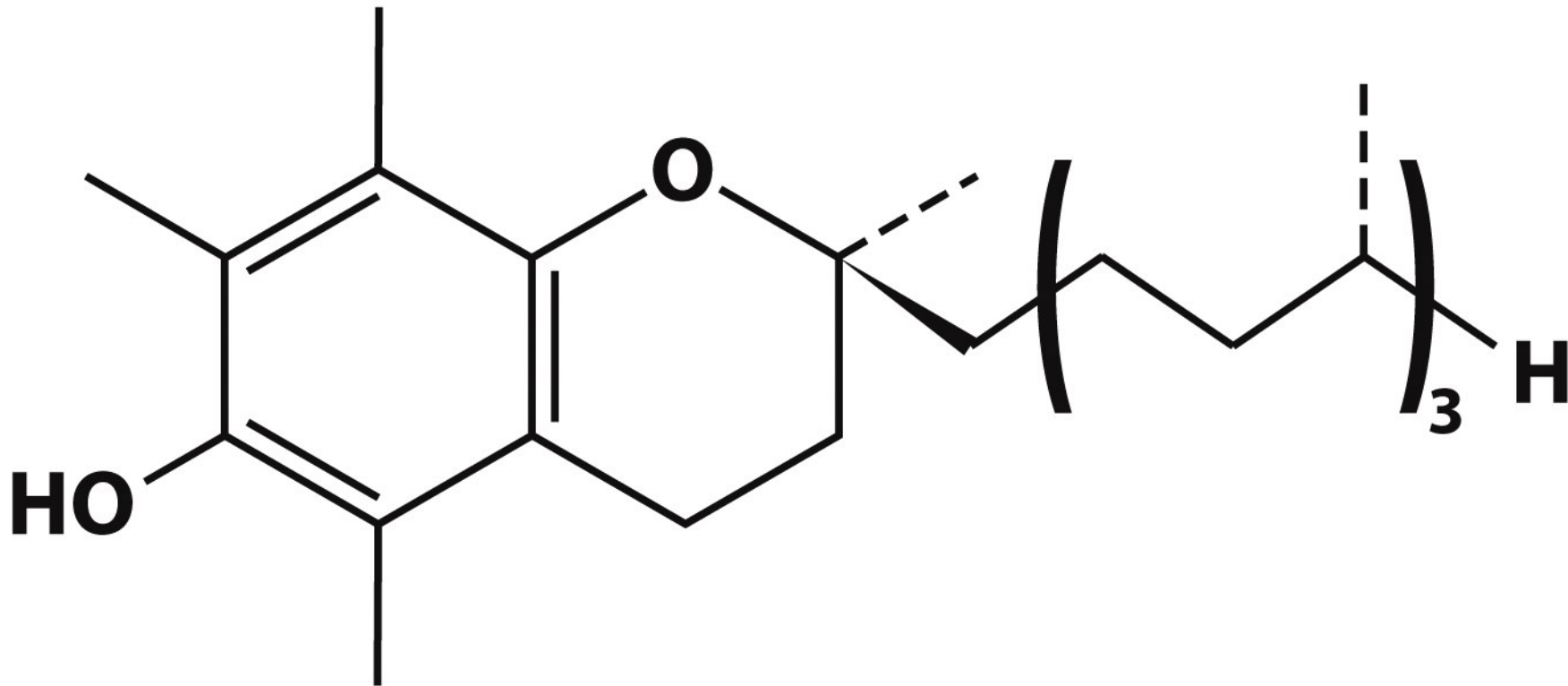


Figure 22-49 part 2



# $\alpha$ -Tocopherol (vitamin E)

Unnumbered 22 p866

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