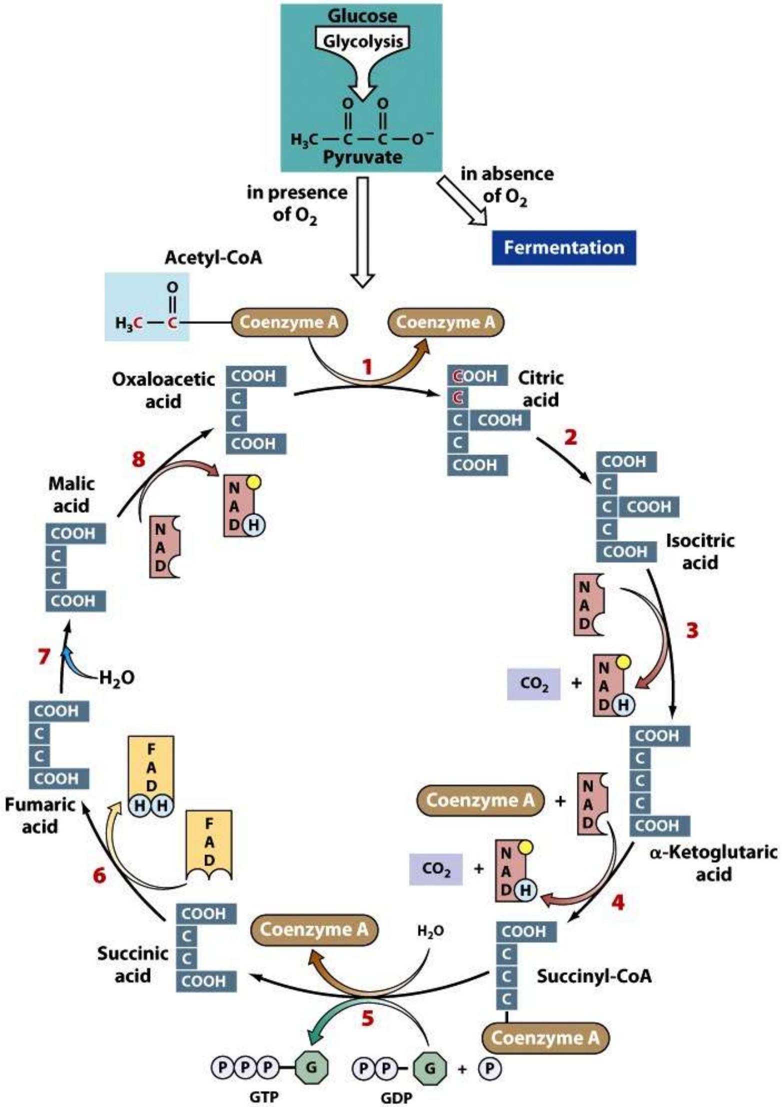


Figure 5-17 Microbiology, 7/e

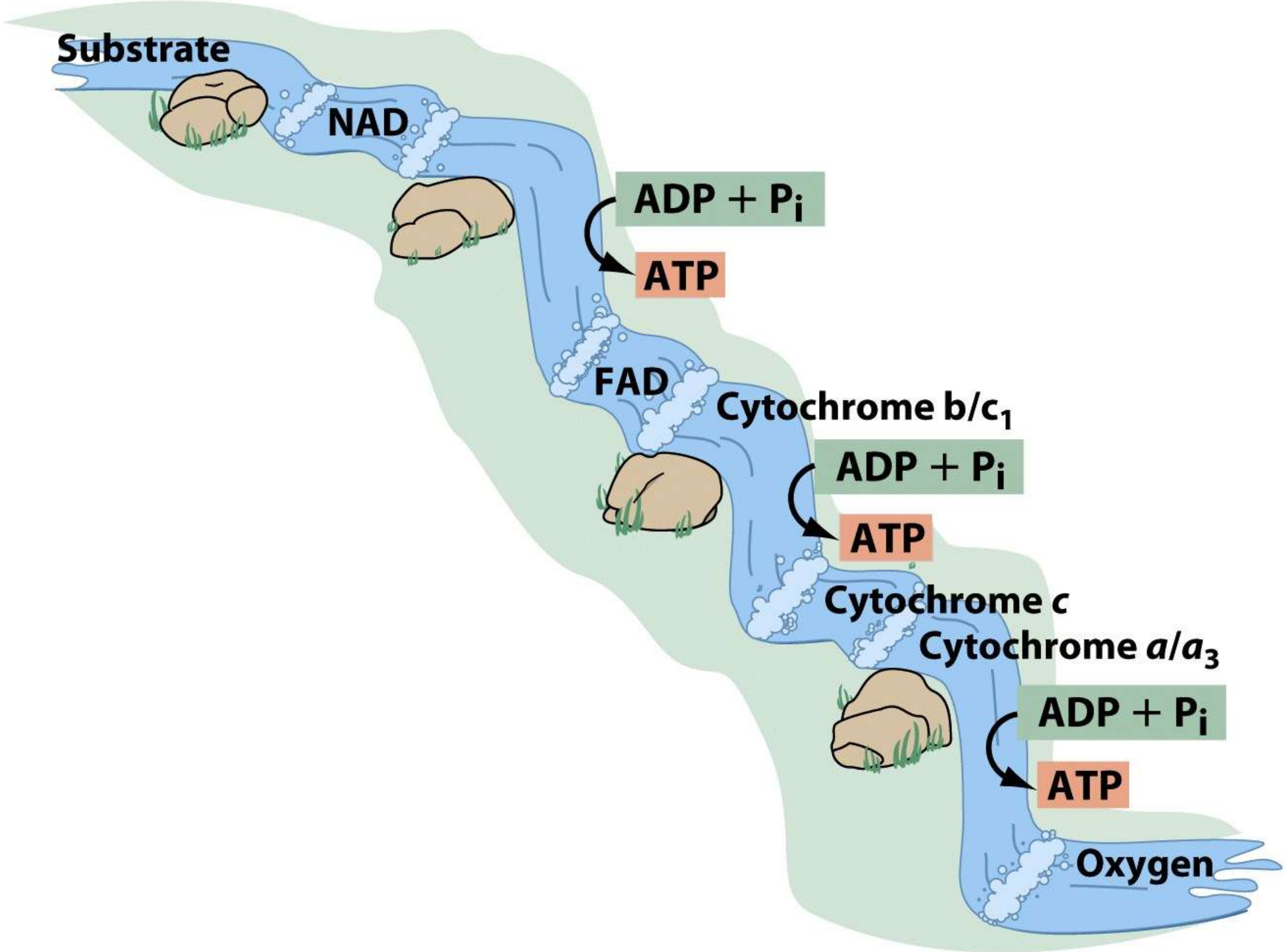
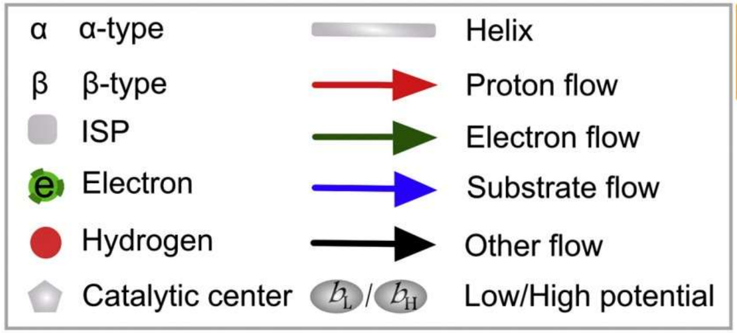
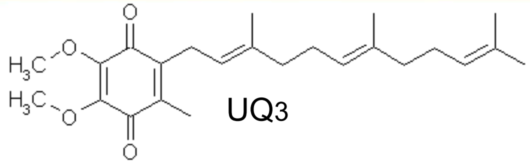


Figure 5-18 Microbiology, 7/e

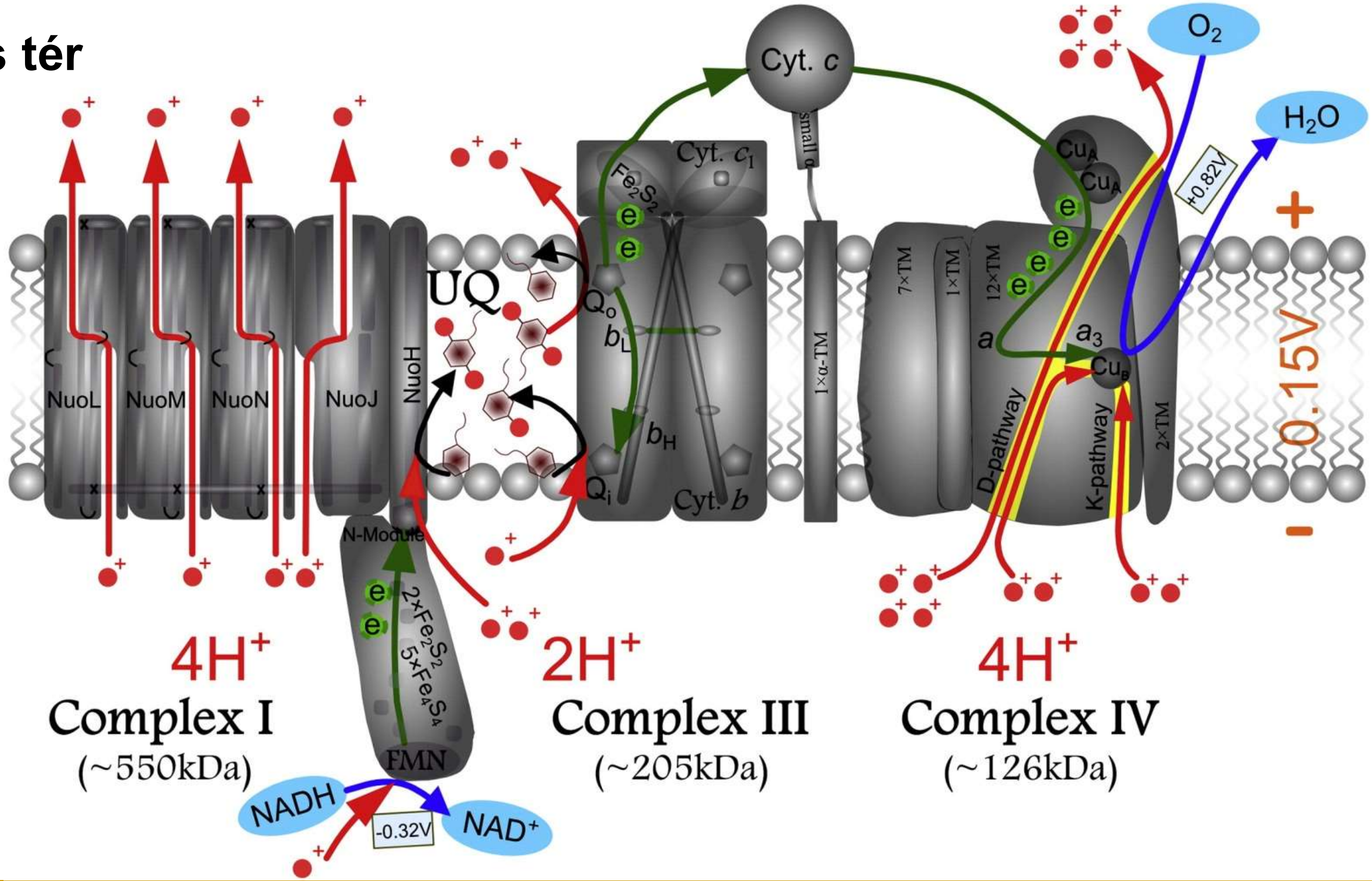


10 protons are pumped per 2e⁻



Periplazmás tér

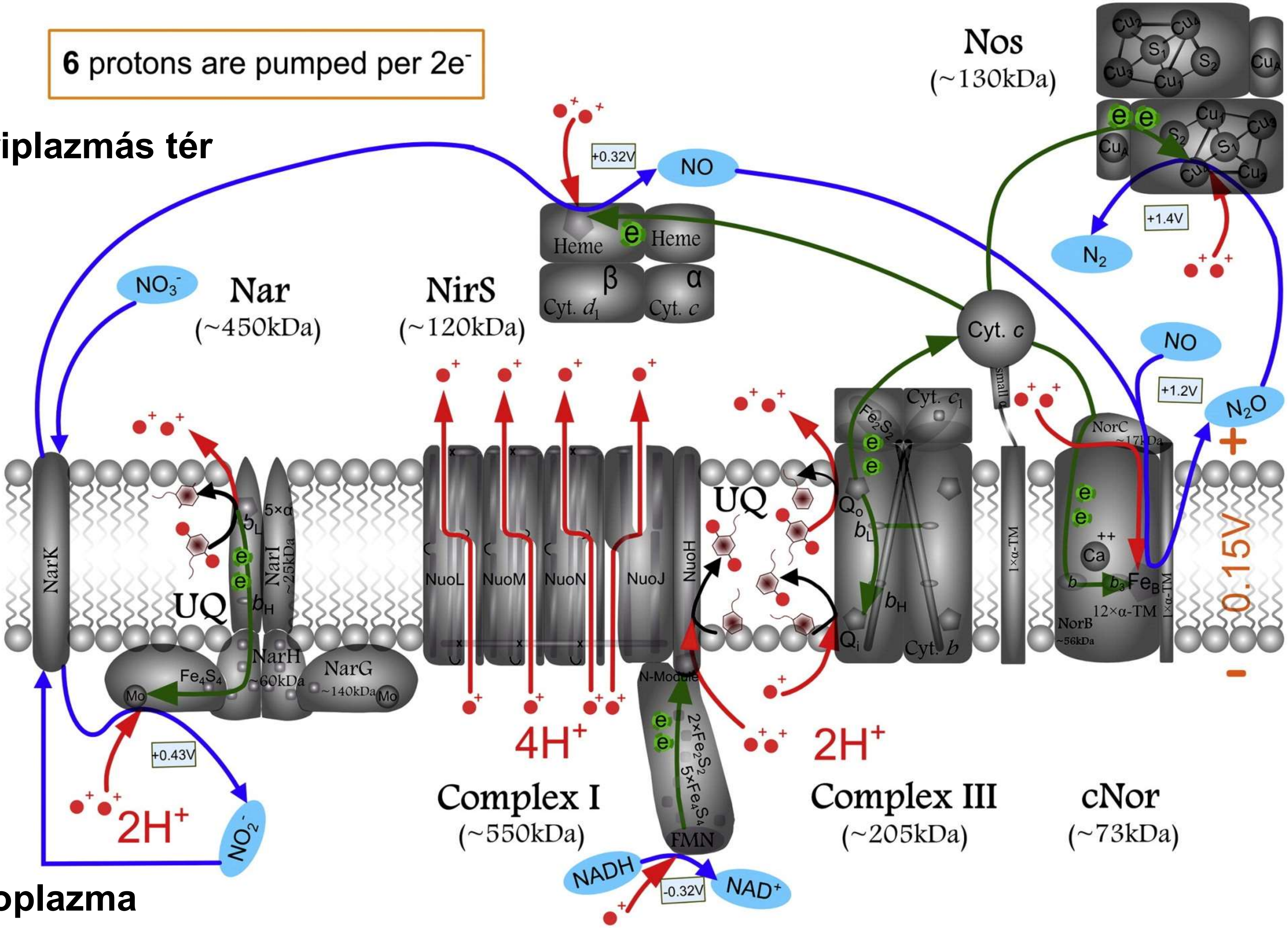
Citoplazma



Chen and Strous (2013) Denitrification and aerobic respiration,
Hybrid electron transport chains and co-evolution Biochimica et Biophysica Acta, *1827(2), 136-144*

6 protons are pumped per $2e^-$

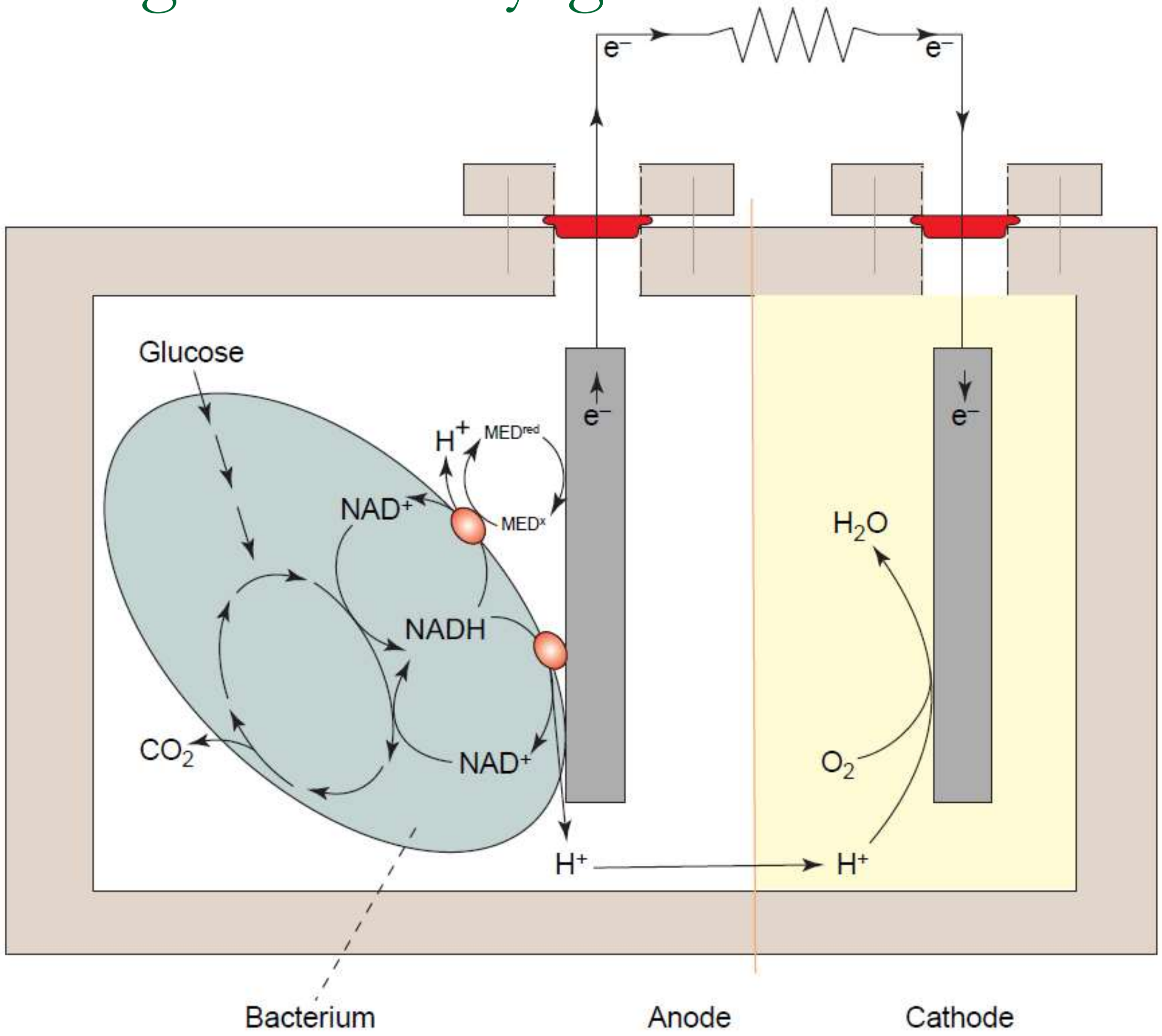
Periplazmás tér



Citoplazma

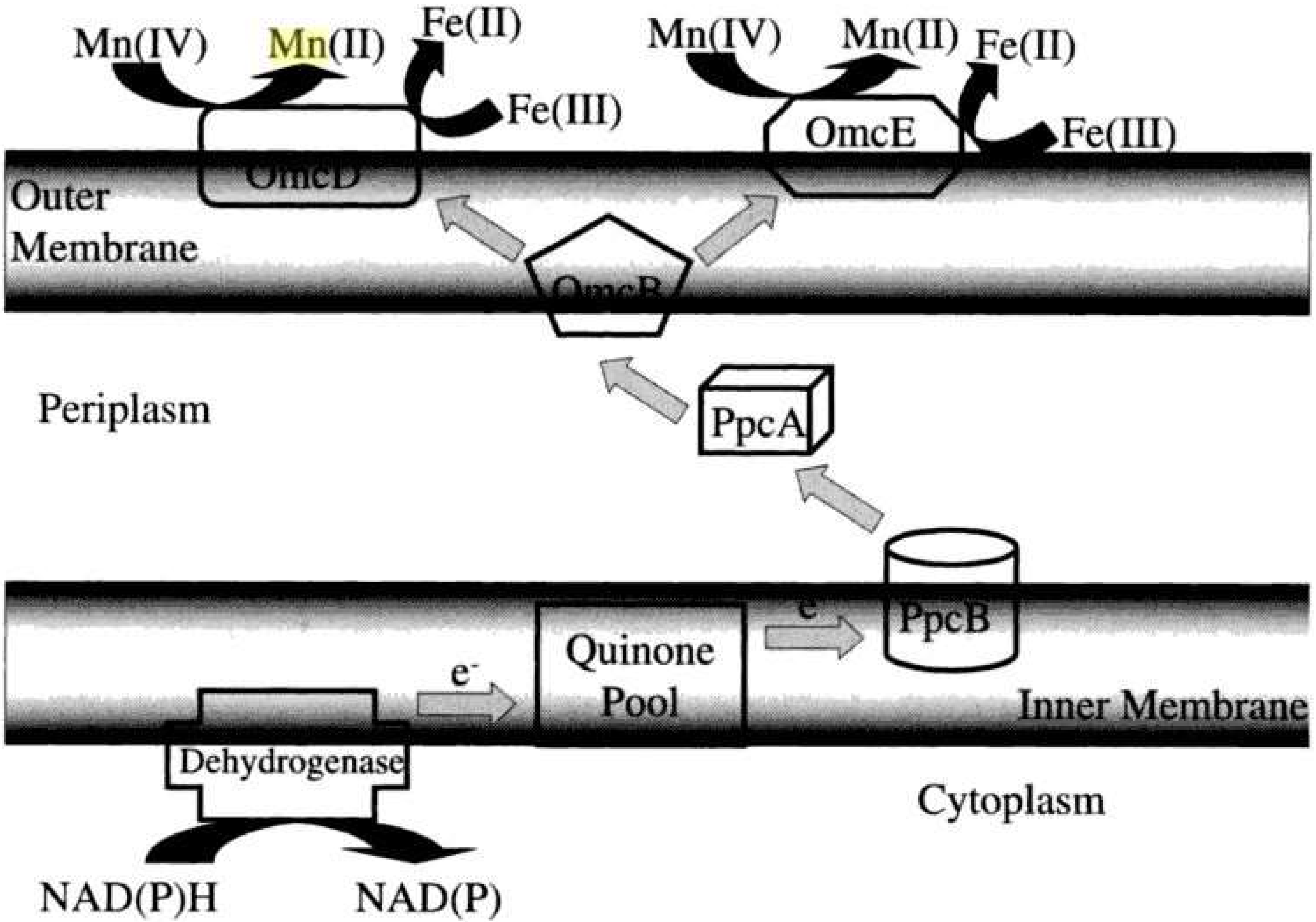
Chen and Strous (2013) Denitrification and aerobic respiration,
Hybrid electron transport chains and co-evolution Biochimica et Biophysica Acta, *1827(2), 136-144*

Mikrobiológiai üzemanyag cella



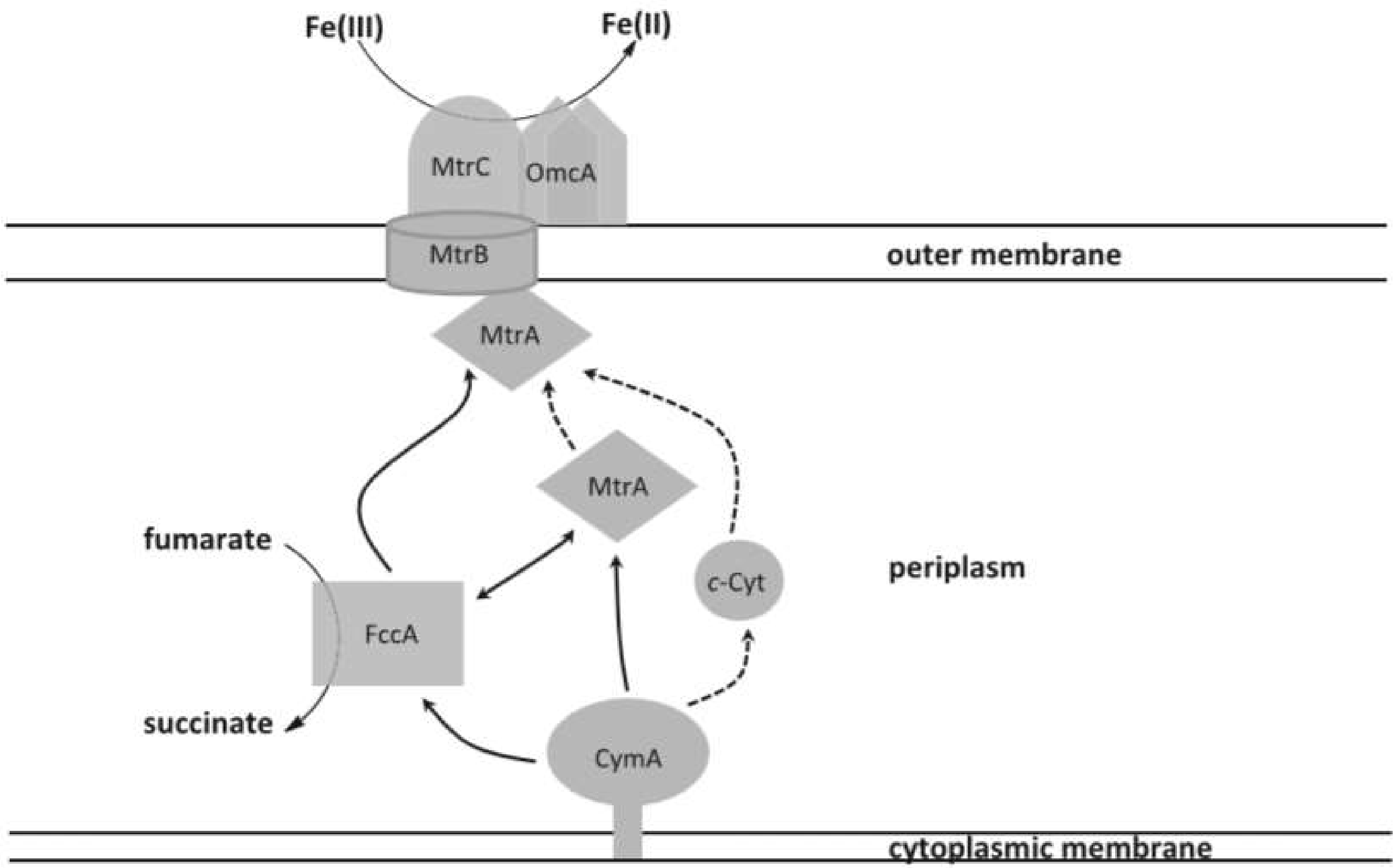
Rabaey and Verstraete (2005) TRENDS in Biotechnology

Elektron transzport lánc mechanizmusa a Geobacter nemzetség tagjainál



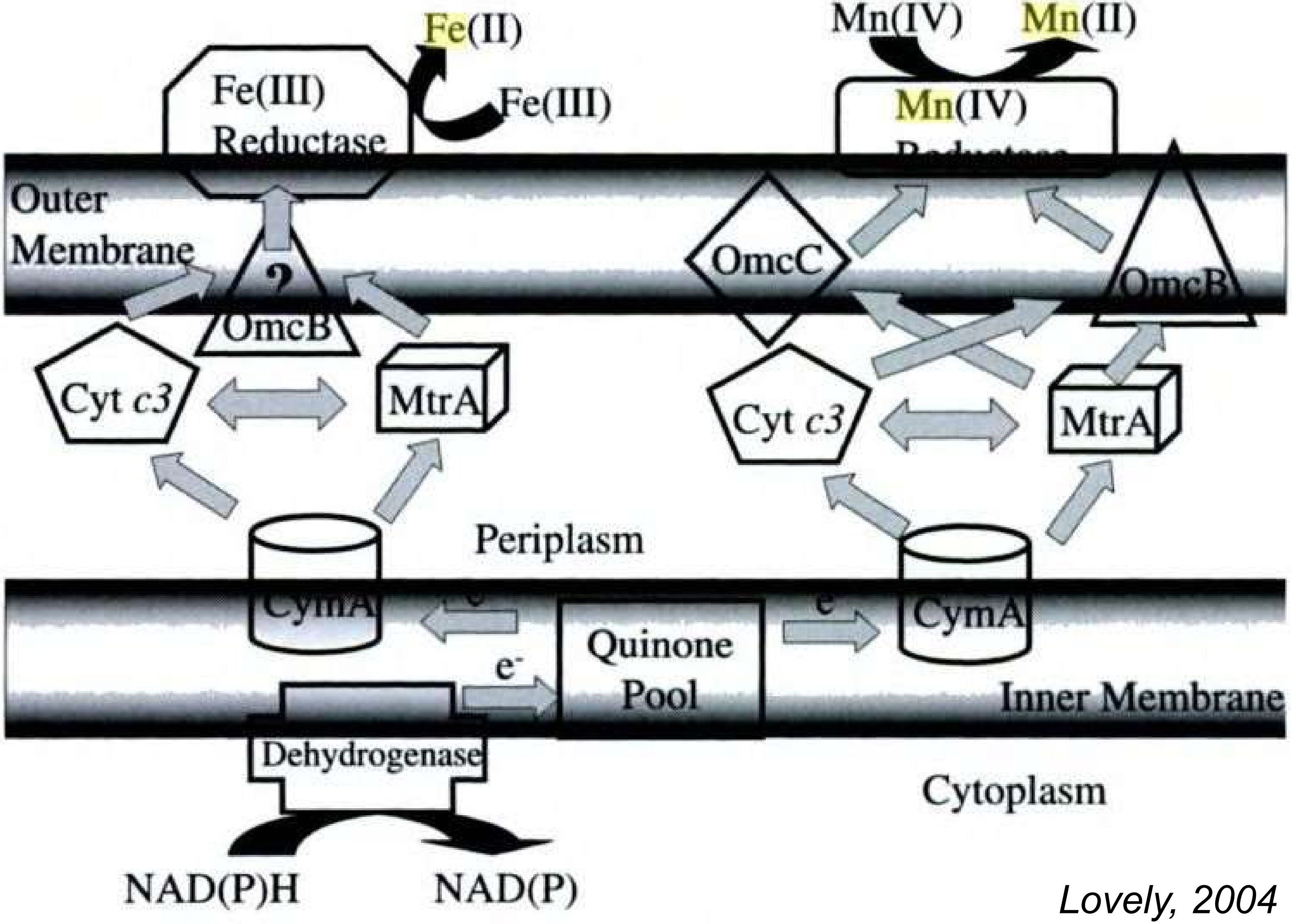
Lovely, 2004

Elektron transzport lánc mechanizmusa a Shewanella nemzetség tagjainál

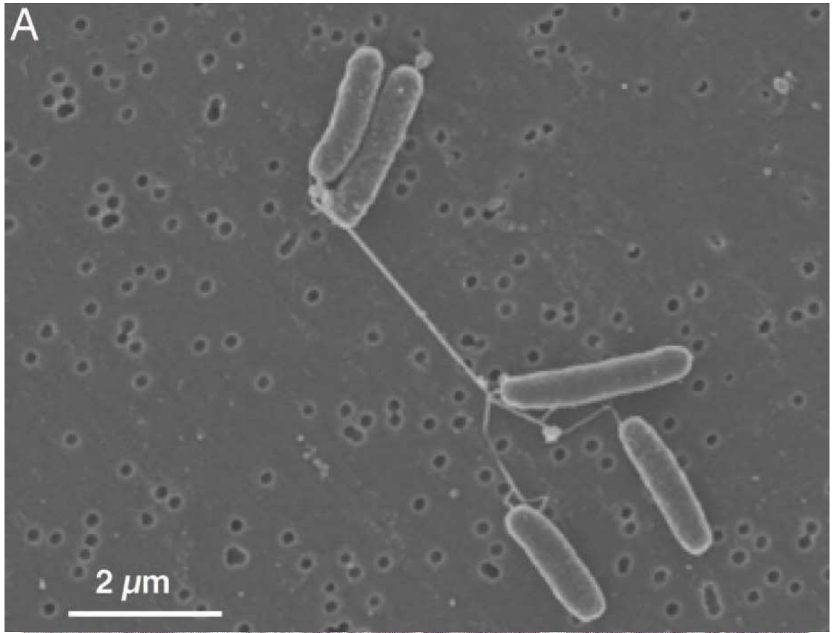


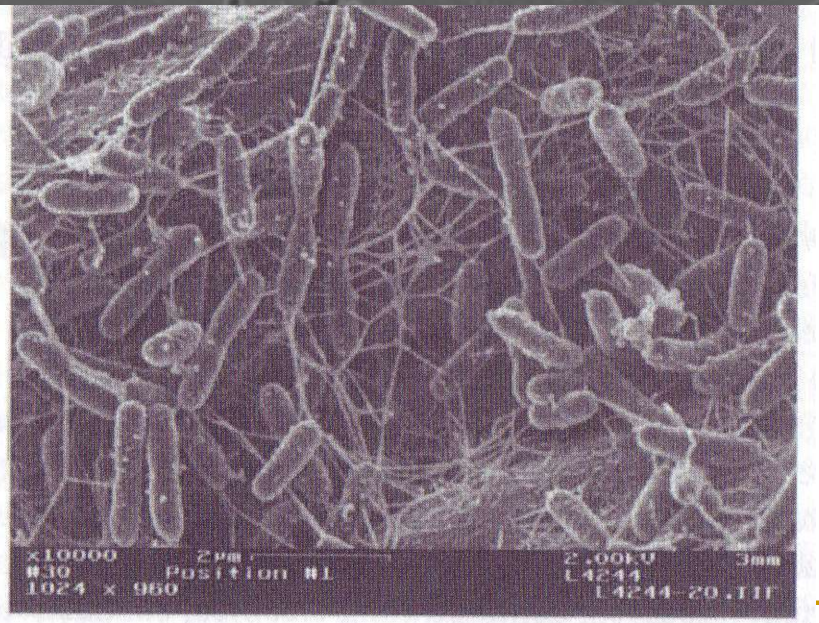
Richter et al. 2011

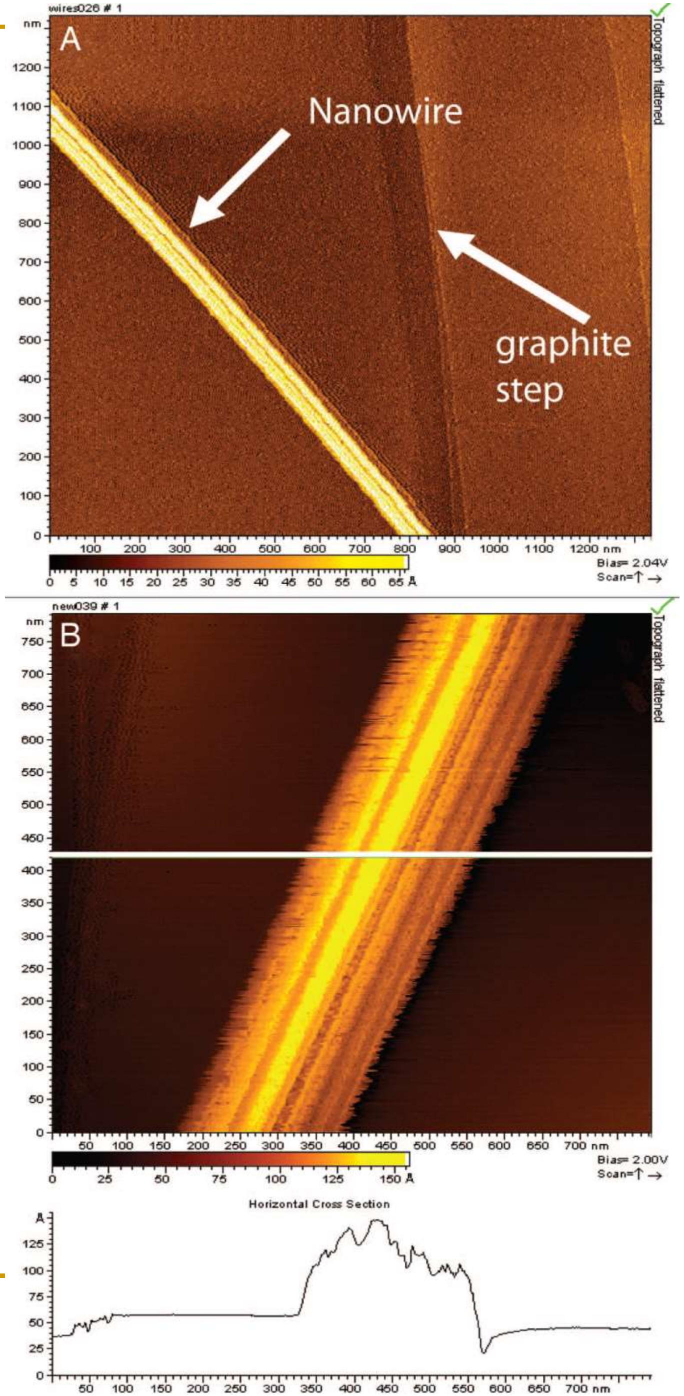
Elektron transzport lánc mechanizmusa a Shewanella nemzetség tagjainál



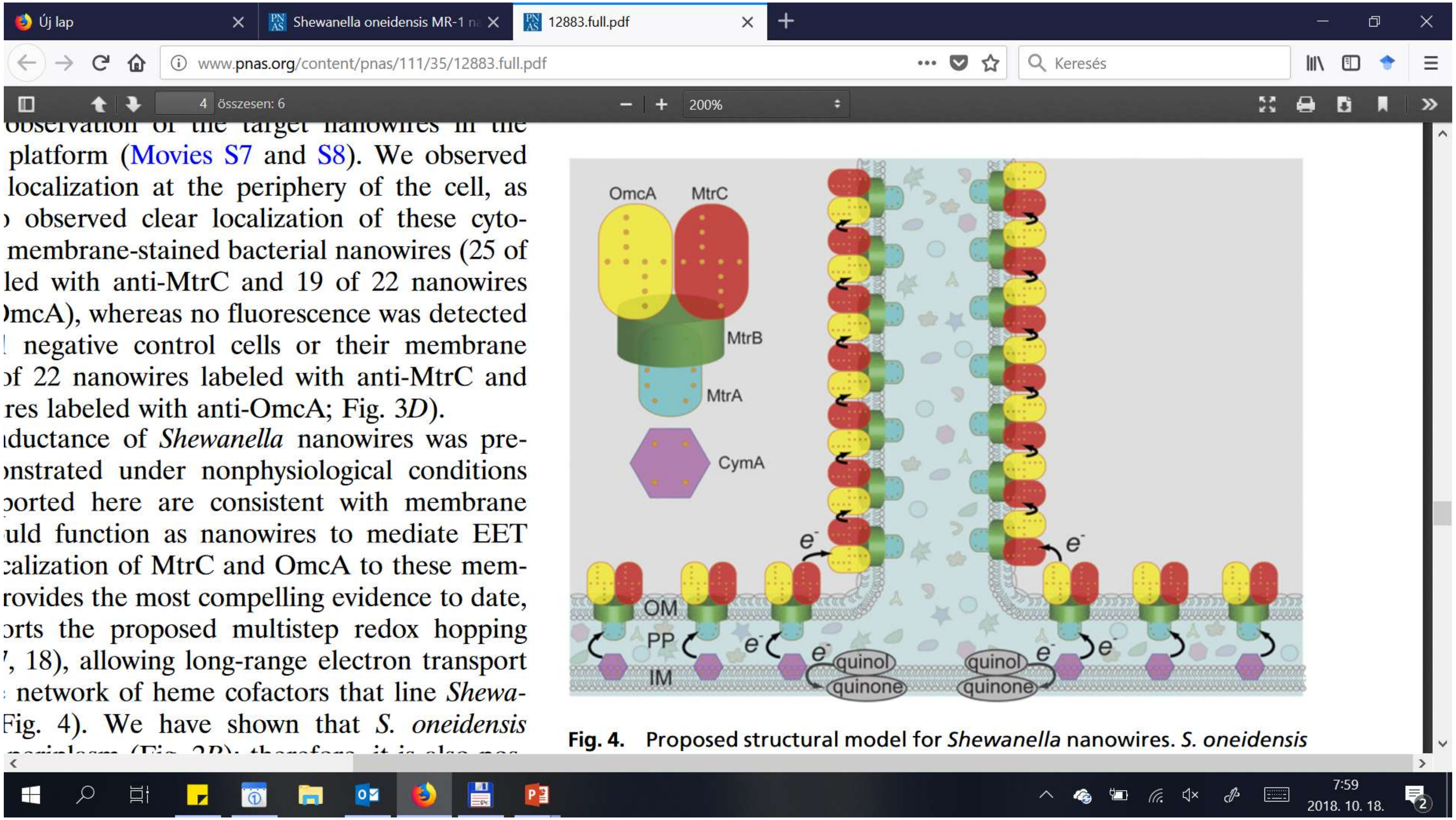
Lovely, 2004







Gorby et al. (2006) PNAS



platform (Movies S7 and S8). We observed
localization at the periphery of the cell, as
observed clear localization of these cyto-
membrane-stained bacterial nanowires (25 of
led with anti-MtrC and 19 of 22 nanowires
mcA), whereas no fluorescence was detected
negative control cells or their membrane
of 22 nanowires labeled with anti-MtrC and
res labeled with anti-OmcA; Fig. 3*D*).
ductance of *Shewanella* nanowires was pre-
nstrated under nonphysiological conditions
ported here are consistent with membrane
uld function as nanowires to mediate EET
alization of MtrC and OmcA to these mem-
rovides the most compelling evidence to date,
orts the proposed multistep redox hopping
, 18), allowing long-range electron transport
network of heme cofactors that line *Shewa-*
Fig. 4). We have shown that *S. oneidensis*

Fig. 4. Proposed structural model for *Shewanella* nanowires. *S. oneidensis*

<u>Shewanella oneidensis MR-1 nanowires are outer membrane and periplasmic extensions of the extracellular electron transport components</u>

<u>S Pirbadian</u>, SE Barchinger… - Proceedings of the …, 2014 - National Acad Sciences

Reakciók redoxpotenciálja

Table I

Redox reaction	E'_0 (mV)
$2H^+ + 2e^- \rightarrow H_2$	−420
$Ferredoxin(Fe^{3+}) + e^- \rightarrow Ferredoxin(Fe^{2+})$	−420
$NAD^+ + H^+ + 2e^- \rightarrow NADH$	−320
$S + 2H^+ + 2e^- \rightarrow H_2S$	−274
$SO_4^{2-} + 10H^+ + 8e^- \rightarrow H_2S + 4H_2O$	−220
$Pyruvate^{2-} + 2H^+ + 2e^- \rightarrow Lactate^{2-}$	−185
$FAD + 2H^+ + 2e^- \rightarrow FADH_2$	−180
$Fumarate^{2-} + 2H^+ + 2e^- \rightarrow Succinate^{2-}$	+31
$Cytochrome\ b(Fe^{3+}) + e^- \rightarrow Cytochrome\ b(Fe^{2+})$	+75
$Ubiquinone + 2H^+ + 2e^- \rightarrow UbiquinoneH_2$	+100
$Cytochrome\ c(Fe^{3+}) + e^- \rightarrow Cytochrome\ c(Fe^{2+})$	+254
$NO_3^- + 2H^+ + 2e^- \rightarrow NO_2^- + H_2O$	+421
$NO_2^- + 8H^+ + 6e^- \rightarrow NH_4^+ + 2H_2O$	+440
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+771
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+840

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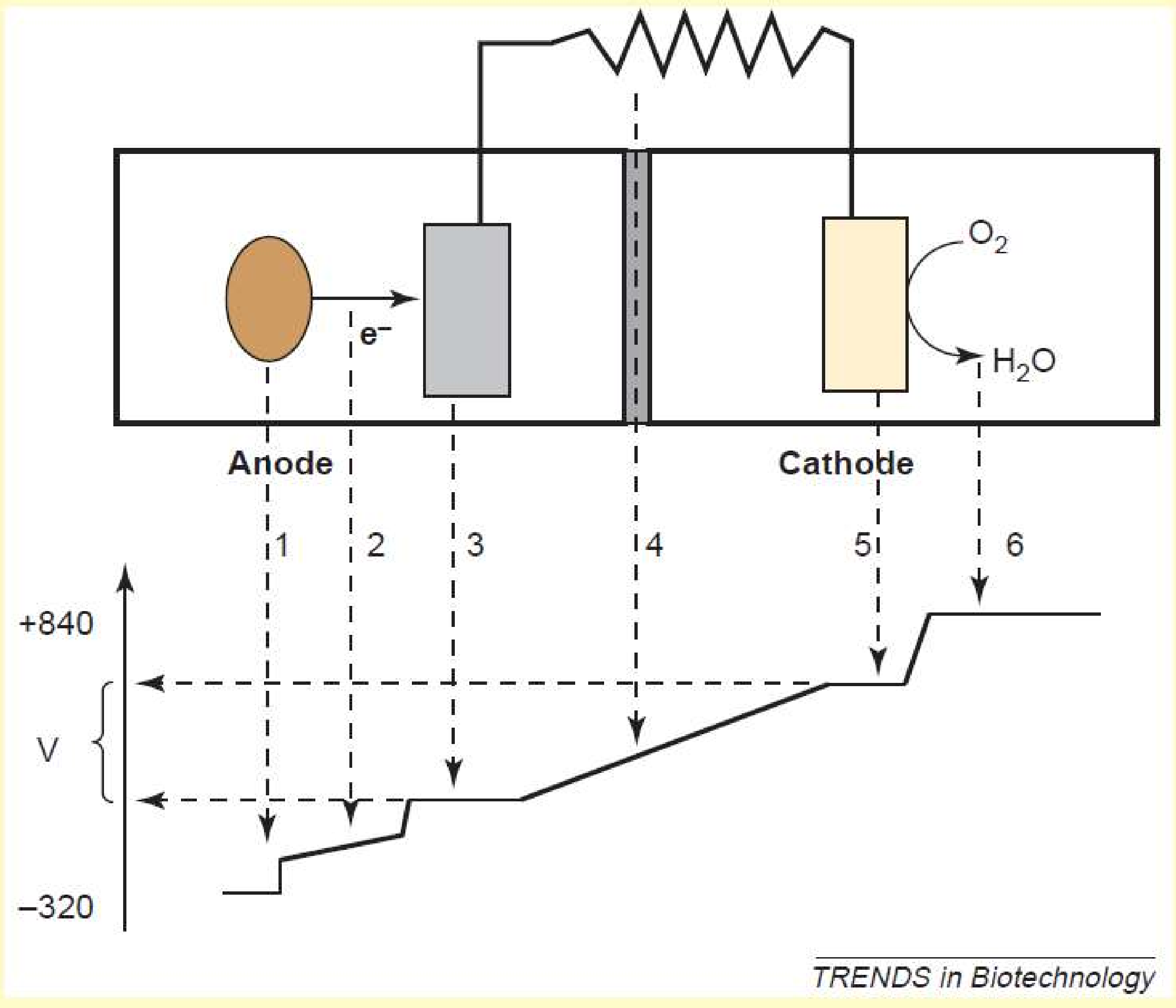
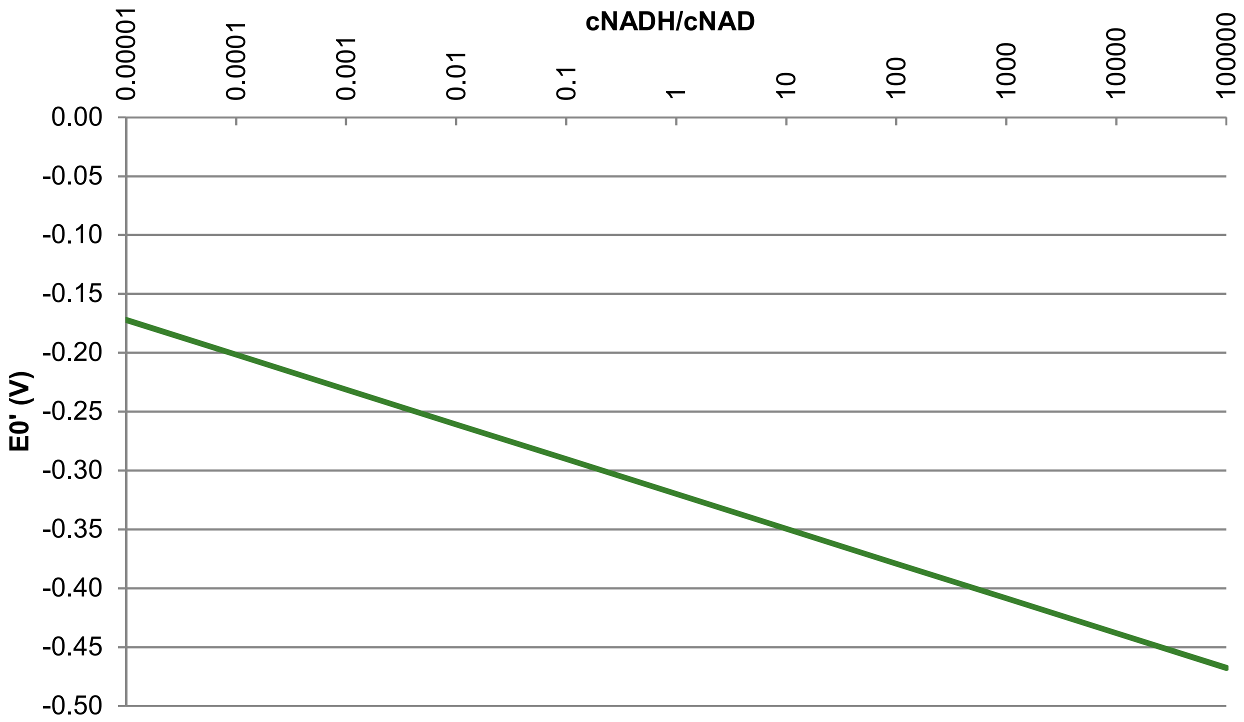
Reakciók redoxpotenciálja



Rabaey and Verstraete (2005) TRENDS in Biotechnology

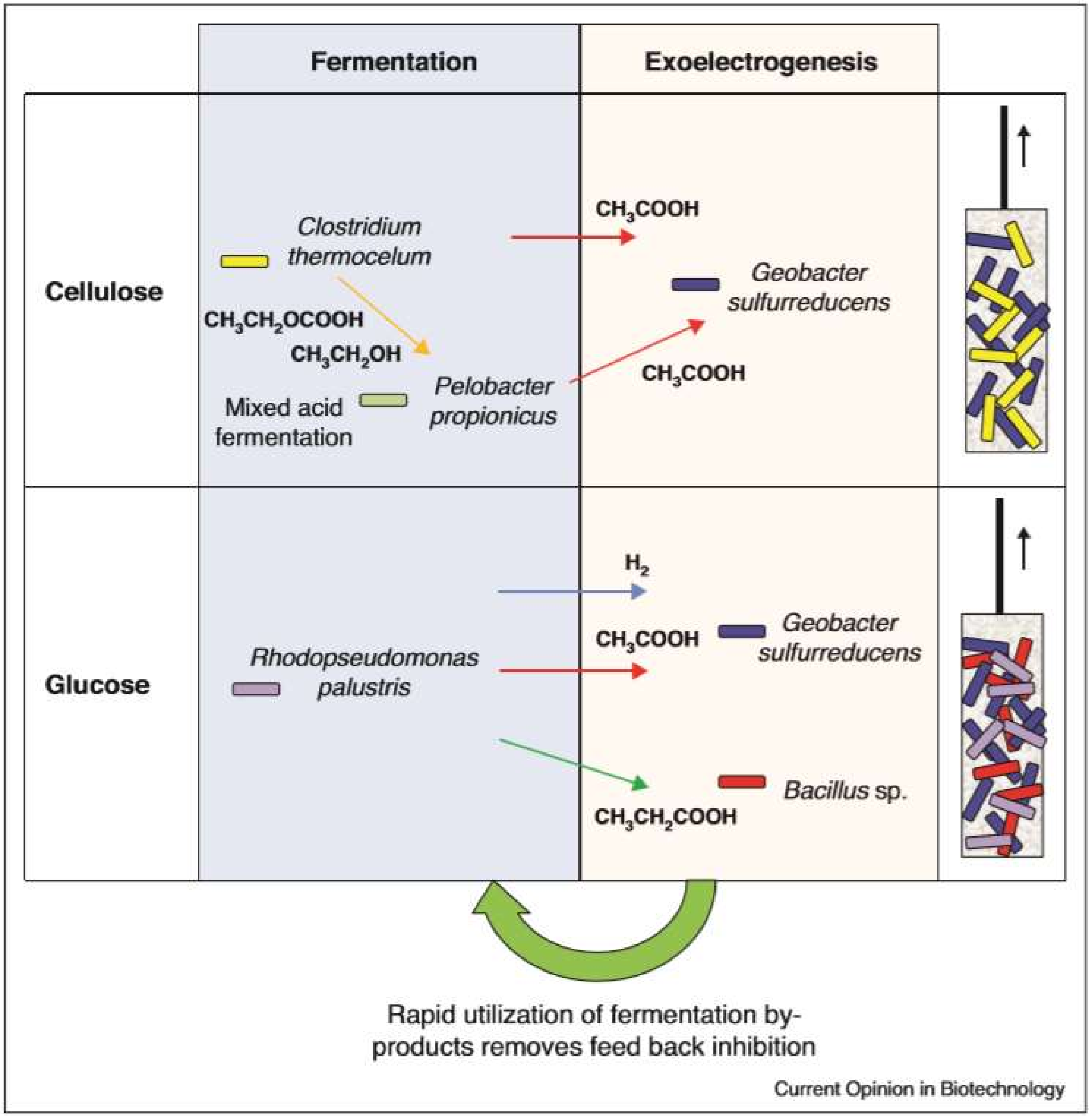
Potenciál a NADH/NAD arány függvényében



Microbes used in MFCs

Microbes	Substrate	Applications
Actinobacillus succinogenes	Glucose	Neutral red or thionin as electron mediator (Park and Zeikus, 2000; Park and Zeikus, 1999; Park et al., 1999)
Aeromonas hydrophila	Acetate	Mediator-less MFC Pham et al. (2003)
Alcaligenes faecalis, Enterococcus gallinarum, Pseudomonas aeruginosa	Glucose	Self-mediate consortia isolated from MFC with a maximal level of 4.31 W m^{-2}. Rabaey (2004)
Clostridium beijerinckii	Starch, glucose, lactate, molasses	Fermentative bacterium Niessen et al. (2004b)
Clostridium butyricum	Starch, glucose, lactate, molasses	Fermentative bacterium (Niessen et al., 2004b; Park et al., 2001)
Desulfovibrio desulfuricans	Sucrose	Sulphate/sulphide as mediator (Ieropoulos et al., 2005a; Park et al., 1997)
Erwinia dissolven	Glucose	Ferric chelate complex as mediators Vega and Fernandez, (1987)
Escherichia coli	Glucose sucrose	Mediators such as methylene blue needed. (Schroder et al., 2003; Ieropoulos et al., 2005a; Grzebyk and Pozniak, 2005)
Geobacter metallireducens	Acetate	Mediator-less MFC Min et al. (2005a)
Geobacter sulfurreducens	Acetate	Mediator-less MFC (Bond and Lovley, 2003; Bond et al., 2002)
Gluconobacter oxydans	Glucose	Mediator (HNQ, resazurin or thionine) needed Lee et al. (2002)
Klebsiella pneumoniae	Glucose	HNQ as mediator biomineralized manganese as electron acceptor (Rhoads et al., 2005; Menicucci et al., 2006)
Lactobacillus plantarum	Glucose	Ferric chelate complex as mediators (Vega and Fernandez, 1987)
Proteus mirabilis	Glucose	Thionin as mediator (Choi et al., 2003; Thurston et al., 1985)
Pseudomonas aeruginosa	Glucose	Pyocyanin and phenazine-1-carboxamide as mediator (Rabaey et al., 2004, 2005a)
Rhodoferax ferrireducens	Glucose, xylose sucrose, maltose	Mediator-less MFC (Chaudhuri and Lovley, 2003; Liu et al., 2006)
Shewanella oneidensis	Lactate	Anthraquinone-2,6-disulfonate (AQDS) as mediator (Ringeisen et al., 2006)
Shewanella putrefaciens	Lactate, pyruvate, acetate, glucose	Mediator-less MFC (Kim et al., 1999a,b); but incorporating an electron mediator like Mn (IV) or NR into the anode enhanced the electricity production (Park and Zeikus, 2002)
Streptococcus lactis	Glucose	Ferric chelate complex as mediators (Vega and Fernandez, 1987)

Du et. al. 2007


Fermentation
Exoelectrogenesis
Cellulose
Clostridium thermocelum
CH3CH2OCOOH
CH3CH2OH
Mixed acid fermentation
Pelobacter propionicus
CH3COOH
Geobacter sulfurreducens
CH3COOH
Glucose
Rhodopseudomonas palustris
H2
CH3COOH
Geobacter sulfurreducens
Bacillus sp.
CH3CH2COOH
Rapid utilization of fermentation by-products removes feed back inhibition
Current Opinion in Biotechnology

Kiely, 2011