Electron Transport Chain: Procaryotes

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Bacterial electron transport chain

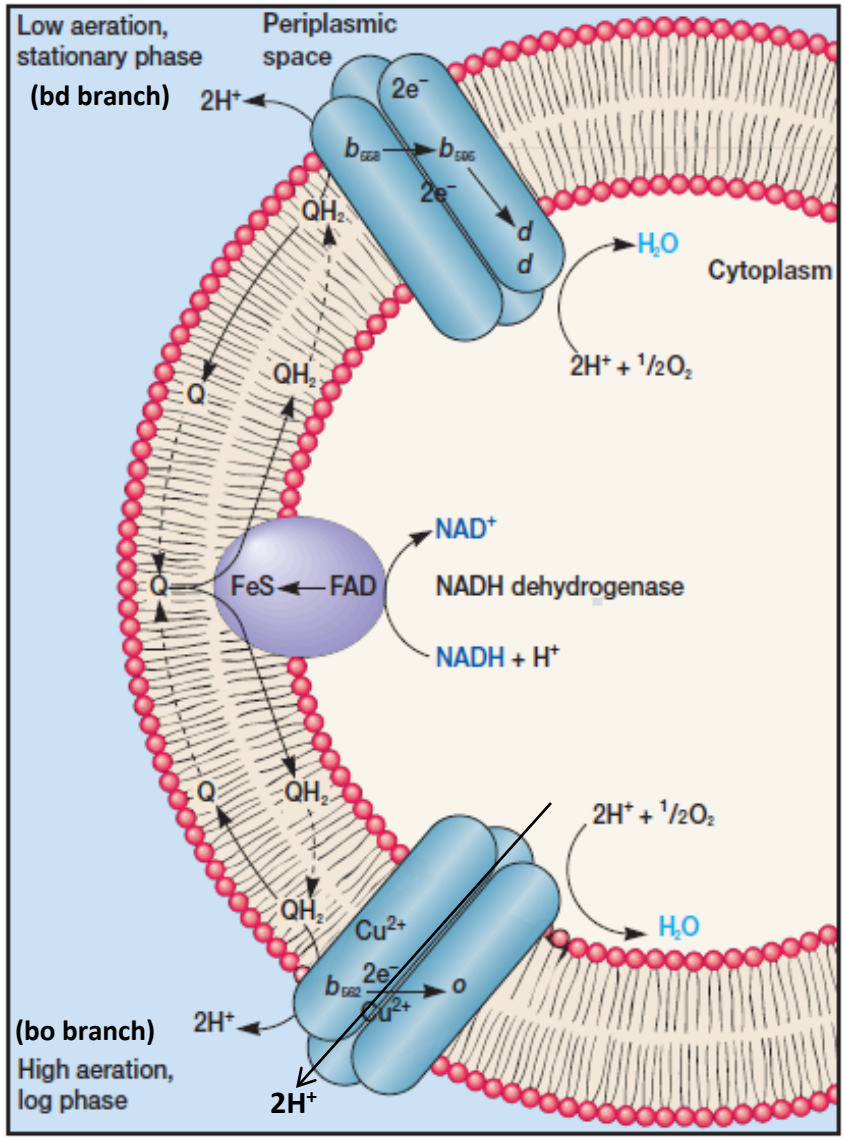
- Although some bacterial chains resemble the mitochondrial chain, they are frequently very different.
- They vary in their electron carriers (e.g., in their cytochromes) and may be extensively branched.
- Electrons often can enter at several points and leave through several terminal oxidases.
- Bacterial chains also may be shorter and have lower P/O ratios than mitochondrial transport chains.
- Thus procaryotic and eucaryotic electron transport chains differ in details of construction although they operate using the same fundamental principles.

E. coli Electron Transport Chain

- A simplified view of the *E. coli* transport chain is shown in (figure 5).
- Although it transports electrons from NADH to acceptors and moves protons across the plasma membrane, the *E. coli* chain is quite different from the mitochondrial chain.
- For example, it is branched and contains a quite different array of cytochromes.
- Coenzyme Q or ubiquinol donates electrons to both branches, but they operate under different growth conditions.
- The cytochrome *d* branch has very high affinity for oxygen and functions at low oxygen levels.
- It is not as efficient as the cytochrome *o* branch because it does not actively pump protons.
- The cytochrome *o* branch has moderately high affinity for oxygen, is a proton pump, and operates at higher oxygen concentrations.

Figure 5. The Aerobic Respiratory System of *E. coli.*

- NADH is the electron source.
- Ubiquinone-8 (Q) connects the NADH dehydrogenase with two terminal oxidase systems.
- The upper branch operates when the bacterium is in stationary phase and there is little oxygen.
- At least five cytochromes are involved: *b558, b595, b562, d,* and *o*.
- The lower branch functions when *E. coli* is growing rapidly with good aeration.

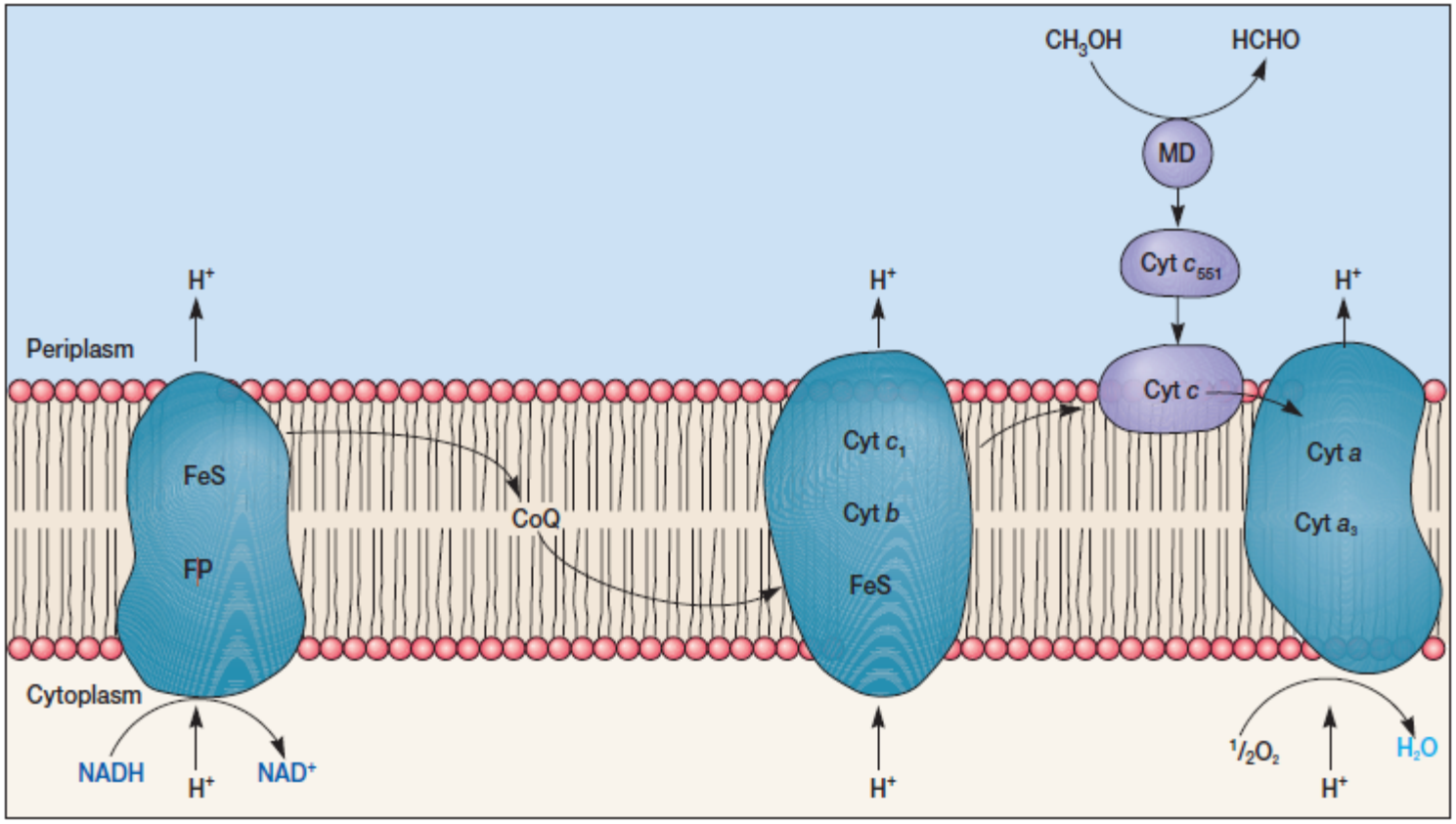


Paracoccus denitrificans Electron Transport Chain

- *Paracoccus denitrificans* is a gram-negative, facultative anaerobic soil bacterium that can grow heterotrophically with a variety of nutrients or autotrophically on H_2 and CO_2 with NO_3^- as the electron acceptor.
- The bacterium carries out either aerobic respiration or anaerobic respiration with nitrate as an acceptor.
- The aerobic electron transport chain has four complexes that correspond to the mitochondrial chain (figure 6).
- In addition to donors such as NADH and succinate, *Paracoccus* oxidizes methanol and methylamine and grows with them as the sole carbon source.
- The electrons enter the transport chain at the cytochrome *c* level.
- Methanol is oxidized to formaldehyde, which is converted to CO_2 and incorporated by the Calvin cycle.

Figure 6. *Paracoccus denitrificans:* aerobic transport chain

- The aerobic transport chain resembles a mitochondrial electron transport chain and uses oxygen as its acceptor.
- Methanol and methylamine can contribute electrons at the cytochrome *c level.*
- *Where,* methanol dehydrogenase (MD),

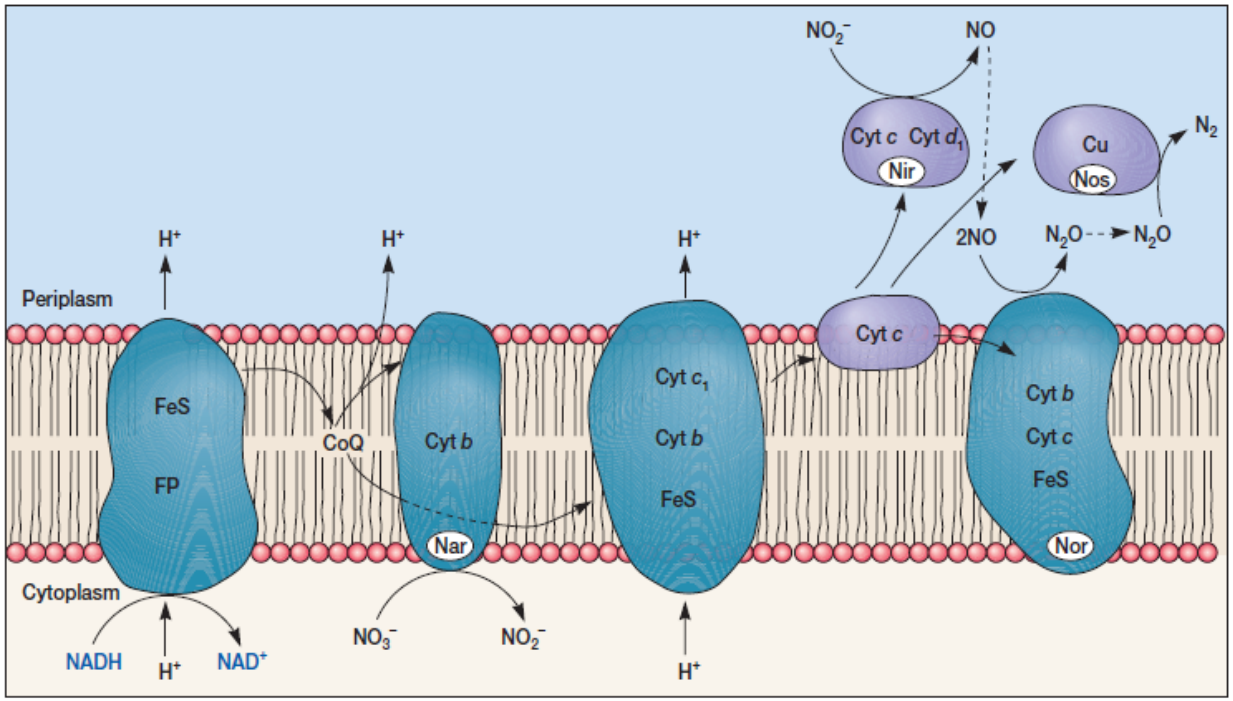


Paracoccus denitrificans: anaerobic transport chain

- When the bacterium is growing anaerobically with nitrate as its electron acceptor, the chain is structured quite differently (figure 7*).*
- The cytochrome aa3 complex does not function. Rather electrons from the cytochrome c level of the chain move to nitrite reductase, nitric oxide reductase, and nitrous oxide reductase.
- Nitrate reductase is supplied electrons by coenzyme Q.
- Not as many protons cross the membrane with this arrangement, but it does allow anaerobic growth.

Figure 7. *Paracoccus denitrificans:* anaerobic transport chain

- The highly branched anaerobic chain is made of both membrane and periplasmic proteins.
- Nitrate is reduced to diatomic nitrogen by the collective action of four different reductases that receive electrons from CoQ and cytochrome *c.*
- Abbreviations used: flavoprotein (FP), nitrate reductase (Nar), nitrite reductase (Nir), nitric oxide reductase (Nor), and nitrous oxide reductase (Nos).



Questions

- What are the different components of various complexes involve in eukaryotic respiratory electron transport chain?
- Write a short note on Q-cycle.
- Write an essay on respiratory electron transport system of eucaryotes.
- Explain respiratory electron transport process of bacteria.
  - *E. coli*
  - *Paracoccus denitrificans*
- What do you mean by oxidative phosphorylation? What are the steps of oxidative synthesis?
- Explain chemiosmotic model of ATP synthesis.
- Explain structure of ATP synthase.
- Explain binding change mechanism of ATP synthesis given by Paul D. Boyer.
- Differentiate between oxidative and substrate level phosphorylation.
- What is Pasteur effect? Briefly discuss.