Tema 4. Electron Transport

Cap. 4 pages 120 - 145
The generation of energy for growth-related physiological processes in respiring prokaryotes is by coupling the flow of electrons in membranes to the creation of an electrochemical proton gradient.

\[-n\Delta E_h = y\Delta p\]

\[#\text{protons extruded}\]

\[#\text{e transferred}\]
Who is responsible for the movement of the electrons through the membrane?

The electron carriers are either proteins or lipids!

1) **Flavoproteins** which carry a hydrogen and an electron

2) **Quinones** are lipids which carry a hydrogen and an electron

3) **Iron-sulfur proteins** which carry only electrons

4) **Cytochromes** which carry only electrons

The electrons are not carried in the protein, but in a non-protein portion called **Prosthetic group**
Prosthetic groups

1) **Flavoproteins** is a flavin, either flavin adenine dinucleotide (FAD) or flavin mononucleotide (FMN)

2) **Iron-sulfur proteins** is a cluster of iron-sulfur (FeS)

3) **Cytochromes** is heme.
Flavoproteins (Fp)

Flavin comes from the Latin flavius, which means yellow.

The flavins (FAD, FMN) are synthesized by cells from the vitamin riboflavin (B$_2$).
Quinones

Their hydrophobic lipid nature allow them to transfer electrons to carries that are not mobile.

The isoprenoid side chains contribute the hydrophobicity.

Menaquinones are derivatives of vitamin K and differ from UQ in being a naphthoquinone.

They also have a lower $E_h$ and are used predominately during anaerobic respiration.
Iron-sulfur proteins

They contain non-heme iron and Usually acid-labile sulfur.

These proteins cover a wide range of potentials -400mV to +350 mV.

Example: ferredoxin
The iron is the electron carrier and is oxidized to ferric or reduced to ferrous ion during e- transport.

Different types of heme:
- a, b, c, d, and o.

D and o have only been found in prokaryotic cytochrome oxidases

They can usually be identified by spectrophotometry.
In Mitochondria

Organization of the electron carriers

- NADH dehydrogenase
- Ubiquinol-cytochrome c oxidoreductase
- Succinate dehydrogenase
- Cytochrome aa₃ oxidase

Eₗₒ = -320 mV
Eₗₒ = +815 mV

Complexes:
- Complex I: NADH dehydrogenase
- Complex II: Succinate dehydrogenase
- Complex III: Ubiquinol-cytochrome c oxidoreductase
- Complex IV: Cytochrome aa₃ oxidase

Coupling sites for Proton extrusion
In bacteria

**Aerobic respiration**

\[ AH_2 \rightarrow \text{dehydrogenase} \rightarrow \text{quinone} \rightarrow c \rightarrow \text{aa}_3 \rightarrow O_2 \]

This creates flexibility, oxidases with different affinity to oxygen, they could differ in \( \Delta p \).

Adaptability to environmental conditions: E. coli can use a reductase or an oxidase depending on oxygen availability.

**Anaerobic respiration**

\[ AH_2 \rightarrow \text{dehydrogenase} \rightarrow \text{quinone} \rightarrow \text{reductase} \rightarrow Y \]
How to identify a coupling site?

The # of ATP’s made for every 2e- transfer to oxygen is called the P/O ratio. It is equal to the # of ATP formed per oxygen consumed.

You could use P/2e- when the e- acceptor is not O₂

NADH → O₂ → P/O ratio = 3

succinate → O₂ → P/O ratio = 2

Each coupling site is characterized by a drop in midpoint potential of about 200 mV.
The Q loop

Note that the electron carriers alternate between those that carry both $H_2$ and e- and those that only carry e-.
Q cycle (explains observations of e- transfer in mitochondria, chloroplasts, and many bacteria)

P site can be inhibited by myxothiazol and stigmatellin.

N site is inhibited by antimycin.
**E. coli**

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<thead>
<tr>
<th></th>
<th>O₂</th>
<th>NO₃</th>
<th>fumarate</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQ</td>
<td>3%</td>
<td>30%</td>
<td>74%</td>
</tr>
<tr>
<td>UQ</td>
<td>60%</td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>DMQ</td>
<td>37%</td>
<td>70%</td>
<td>16%</td>
</tr>
</tbody>
</table>

- NADH dehydrogenase NDH1
- NADH dehydrogenase NDH2

- High affinity to O₂
- NDH1 and bo → 8H⁺
- NDH2 and bd → 2H⁺
**Paracoccus denitrificans**
Non-fermenting G-, facultative anaerobe

- NADH dehydrogenase NDH1
- UQ
- bc$_1$
- cyt, bb$_3$
- aa$_3$
- O$_2$
- Nitrate reductase
- Nitrite reductase
- Nitric oxide reductase
- Nitrous oxide reductase
- NO$_3^-$
- NO$_2^-$
- NO
- N$_2$O
- $\frac{1}{2}$N$_2$
Wolinella succinogenes

G-, anaerobe isolated from the rumen.