

## Lecture 6

### Energy

Cellular Energetics

Energy carrying molecules

ATP Synthesis

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## Overview of cellular energetics in a heterotroph

Heterotrophs get energy and small molecules from breakdown of large organic molecules (e. g. animals)

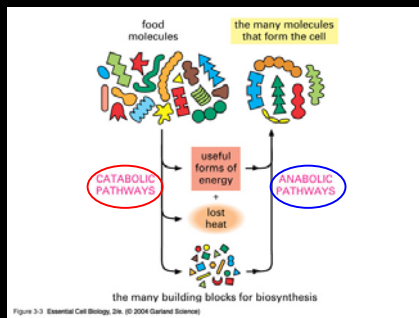


Fig. 3-3

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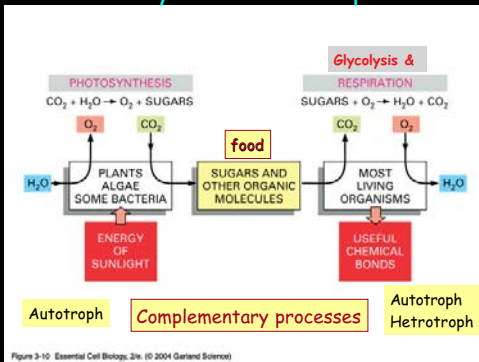
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## Photosynthesis and Respiration



Next two lectures

ECB Fig. 3-10

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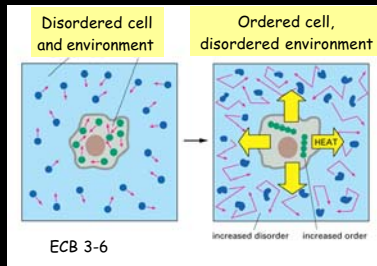
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## Cells obey the 2nd law of thermodynamics

Systems change spontaneously in direction that increases disorder (entropy)

Yet cells are highly ordered structurally (organelles) and biochemically (polymers etc)



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## Lecture 6

### Energy carrying molecules in cellular energetics

Electrochemical gradients

ATP

Redox reactions

NADH, NADPH

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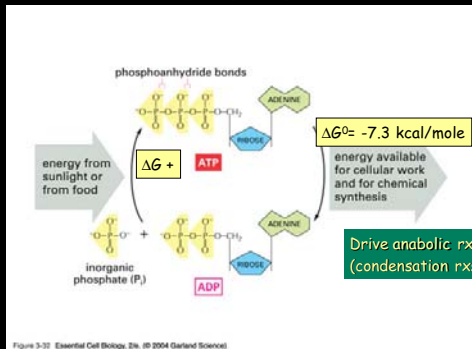
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## ATP stores energy in phosphoanhydride bond



ECB Fig. 3-32

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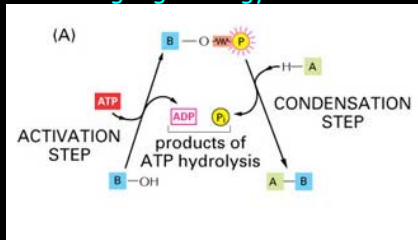
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Pi of ATP is transferred to other molecules forming high energy intermediates




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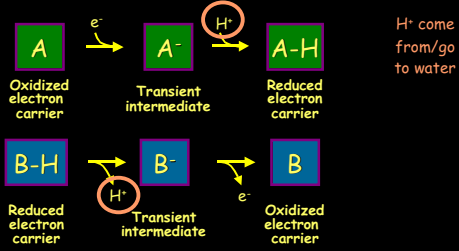
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Oxidation and Reduction

Reactions involving movement of electron from one molecule to another

Molecule gaining an electron becomes REDUCED  
Molecule donating an electron becomes OXIDIZED




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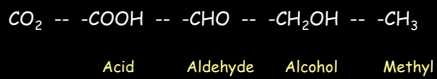
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Assessing the state of oxidation/reduction




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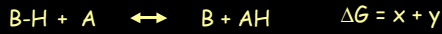
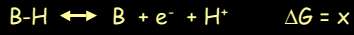
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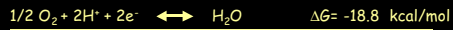
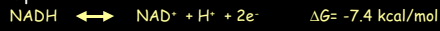
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### Coupling of redox Reactions

Oxidation of one molecule coupled to reduction of another



Example




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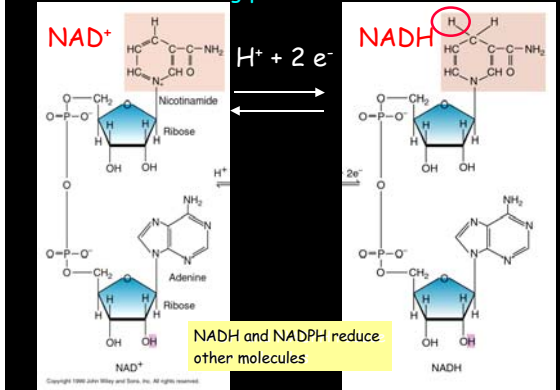
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### Cells store reducing power as NADH and NADPH




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### Forms of stored energy in cells

Electrochemical gradients

Covalent bonds (ATP)

Reducing power (NADH)

During ATP synthesis, photosynthesis, respiration and glycolysis these forms of energy are converted from one to another

Next two lectures

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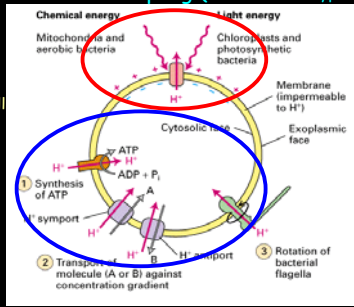
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### Chemiosmotic coupling (chemiosmotic hypothesis)

Bacterial cell



Light (plants, bacteria) or chemical energy (plants, animals, bacteria) drives  $H^+$  out of cell  
 $H^+$  flows back into cell to turn bacterial flagella, drive coupled transport and synthesize ATP

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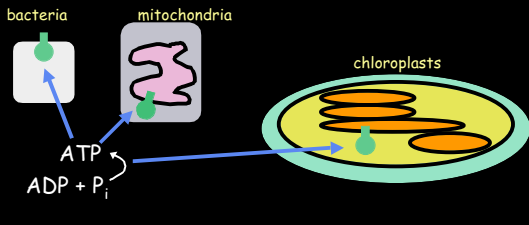
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### Where in the cell is ATP made?

1. Bacterial plasma membrane
2. Mitochondrial inner membrane
3. Chloroplast thylakoid membrane




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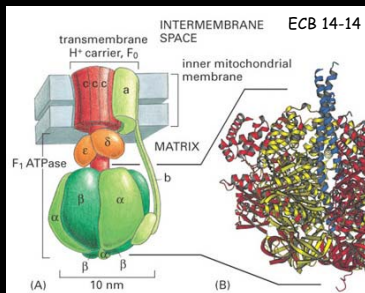
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### ATP synthase

Bacterial, mito and chloro proteins are related evolutionarily




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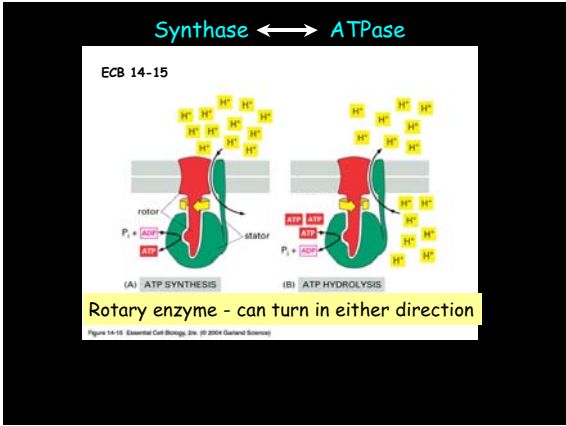
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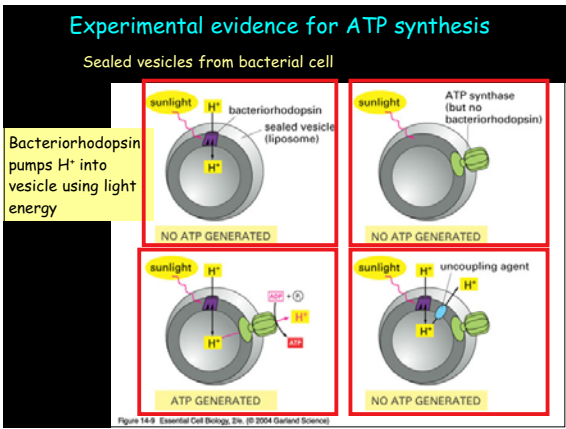
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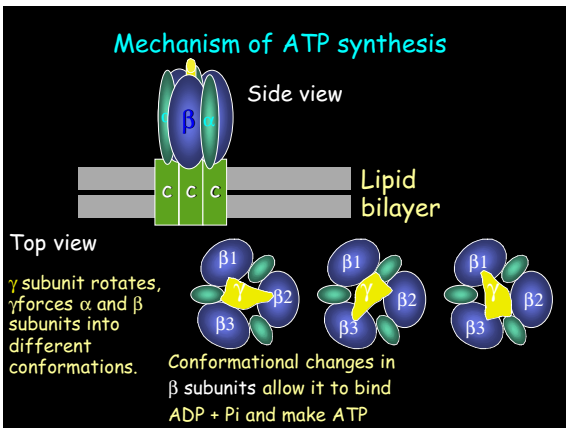
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## ATP synthesis movies

[ATPSYN~1.MOV](#)

[L6 movies/14.4-ATP\\_synthase\\_disco.mov](#)

See animation on ECB Interactive CD

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