The role of ATP in metabolism

MUDr. Martin Vejražka, PhD.

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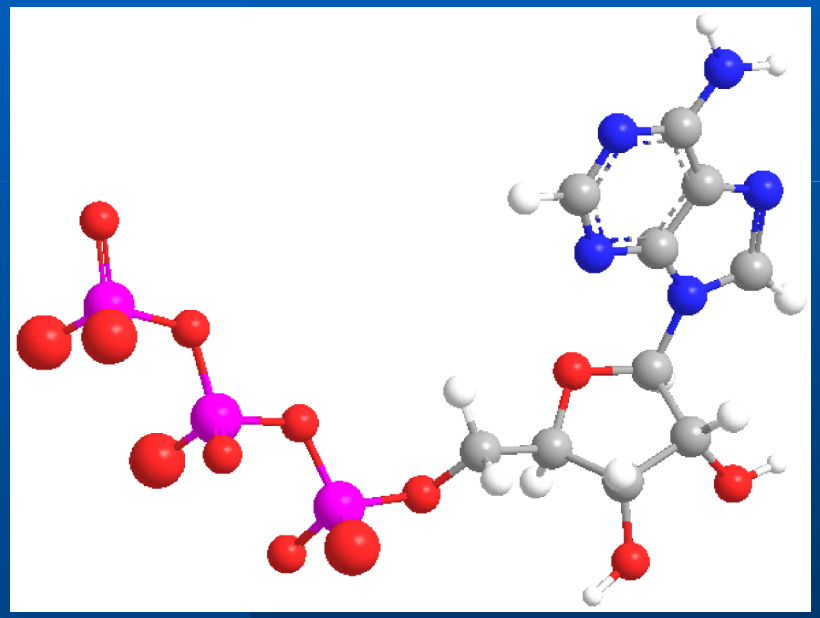
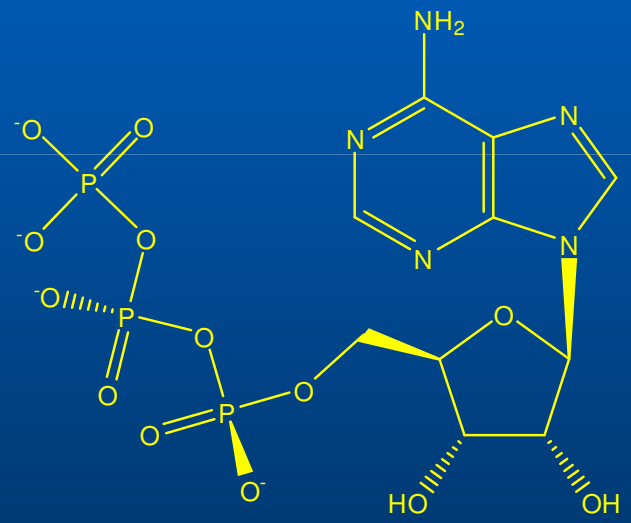
Adenosin triphosphate (ATP)





ATP, ADP, AMP a cAMP

- Macroergic compound
- Role in signaling
  - cAMP
  - AMP
- Binds transitive metals
- RNA

What is macroergic bond???

… back to thermodynamics

Thermodynamics

- Two axioms
- Abstract quantities (entropy, enthalpy…)
- Idealised processes and stuffs (reversible action, universal gas…)
- Is not interested in inner structure of materia
- Does not deal with time, rate of processes

- „Simple“ and „easy to understand“ system

Thermodynamic functions

U inner energy

H enthalpy = heat content

S entropy = measure of randomness

F free energy

G free enthalpy

Cannot be measured absolutely, changes are quantified
Standard quantities (G^0, S^0…) defined for
certain „standard state“

Enthalpy

- **Constant volume:**

$$\Delta U = Q$$

Δ inner energy = reaction heat

- **Constant pressure**

$$\Delta H = Q$$

  - **a part of energy corresponds to mechanical work**

Enthalpy

- **ΔH … heat exchanged between the system and its surrounding**
- **H … heat content – how much heat can be maximally produced by the system**
- **If volume is not changed: equal to change in inner energy**

Free enthalpy

- **A portion of enthalpy can be used to increase arrangement of the system**

$$\Delta G = \Delta H - T \cdot \Delta S$$

Free enthalpy

inclination to react	=	decrease in energy of system	+	increase in randomness of system

$\Delta G < 0$ … reaction runs spontaneously
$\Delta G = 0$ … equilibrium
$\Delta G > 0$ … need for energy

Free enthalpy

$\Delta G = \Delta G^{0'} +$
$RT \cdot \ln[\text{products}]/[\text{reactants}]$

ΔG^0 … all concentrations 1 mol/l

$\Delta G^{0'}$ … + aquaeous sol., pH = 7,0

$\Delta G^0 = - RT \cdot \ln K'$

Course of reaction

$$\Delta G = \Delta G^{0'} + RT \cdot \ln[\text{products}]/[\text{reactants}]$$

Can run?
$\Delta G < 0$

Real concentration of compounds

Properties of reaction
K

Course of reaction

$$\Delta G = \Delta G^{0'} + RT \cdot \ln[\text{products}]/[\text{reactants}]$$

Coupling of reactions

Taking products away
Increasing reactant concentration

… back to ATP …

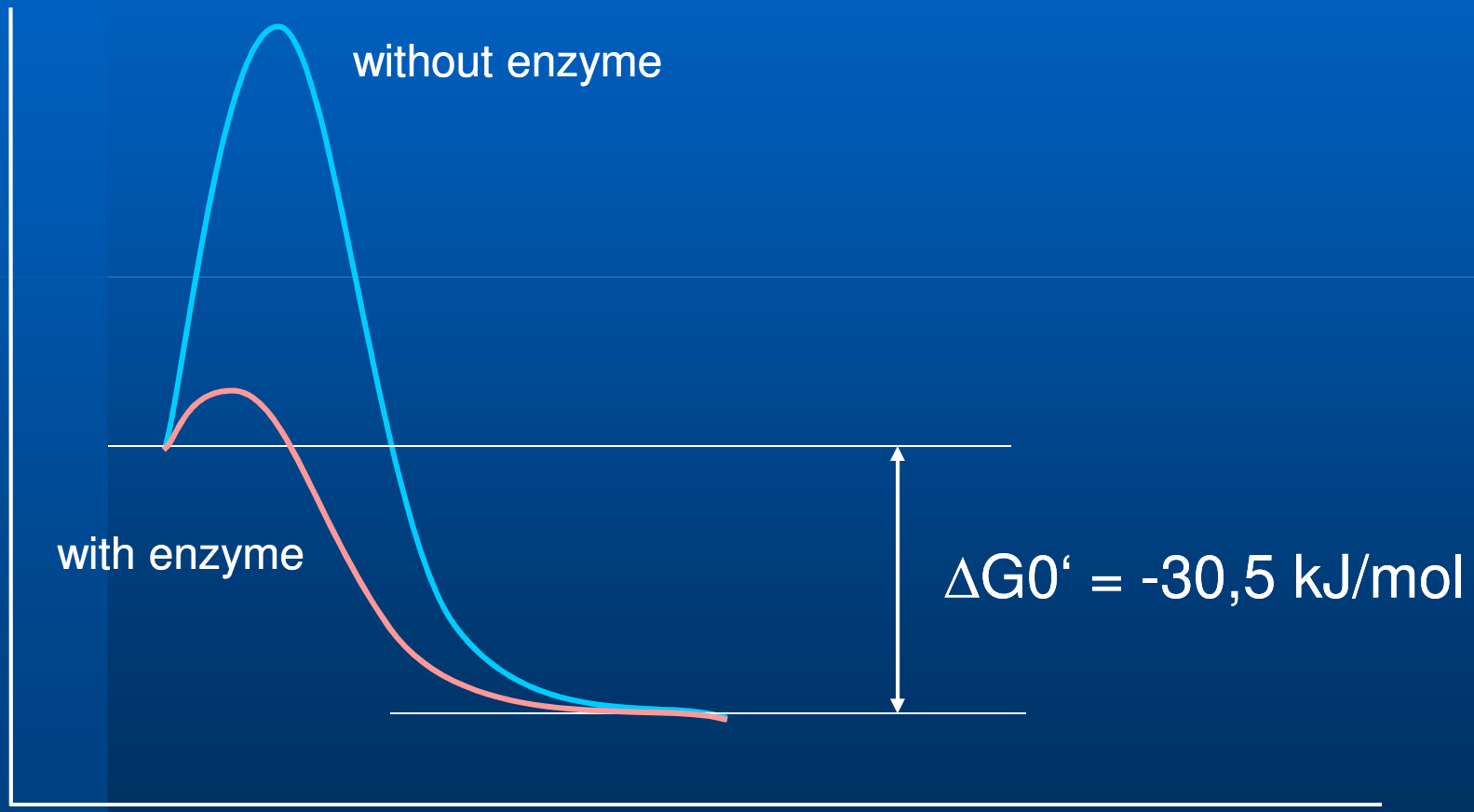
ATP

- **Hydrolysis of ATP is strongly exergonic**

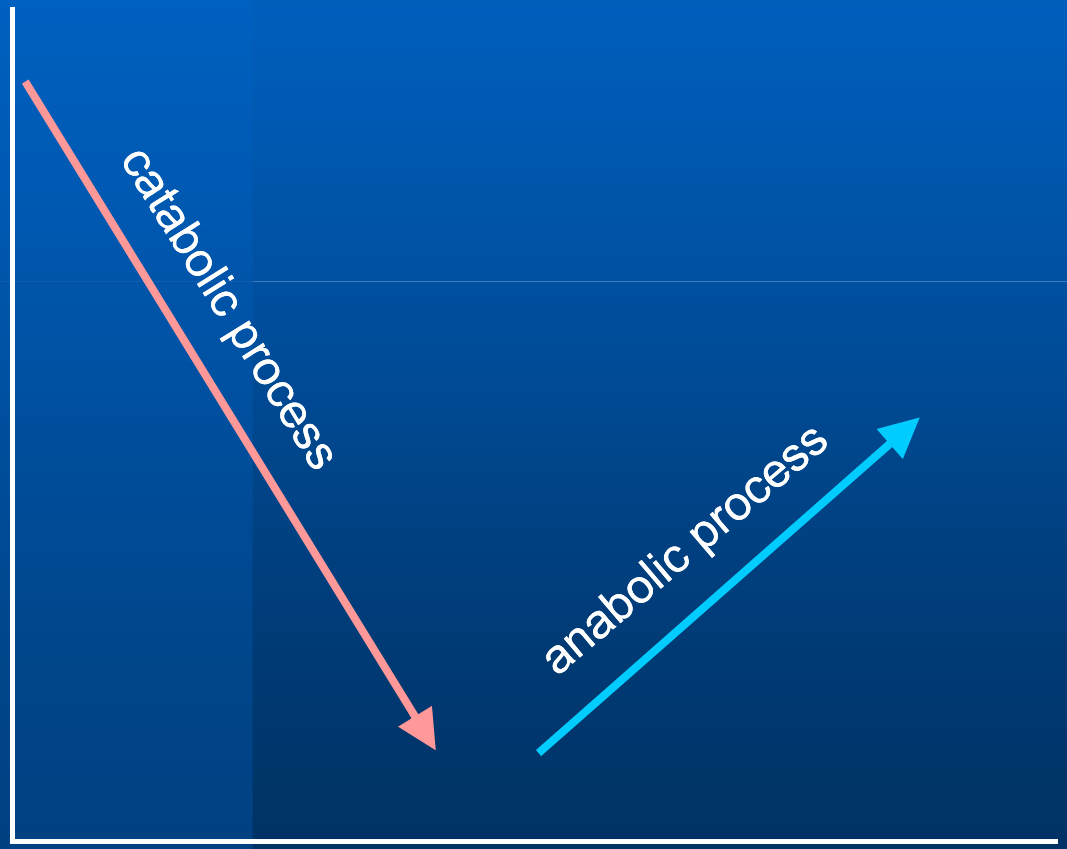
$ATP \rightarrow ADP + P_i$ $\quad \Delta G^{0'} = -30,5$ kJ/mol

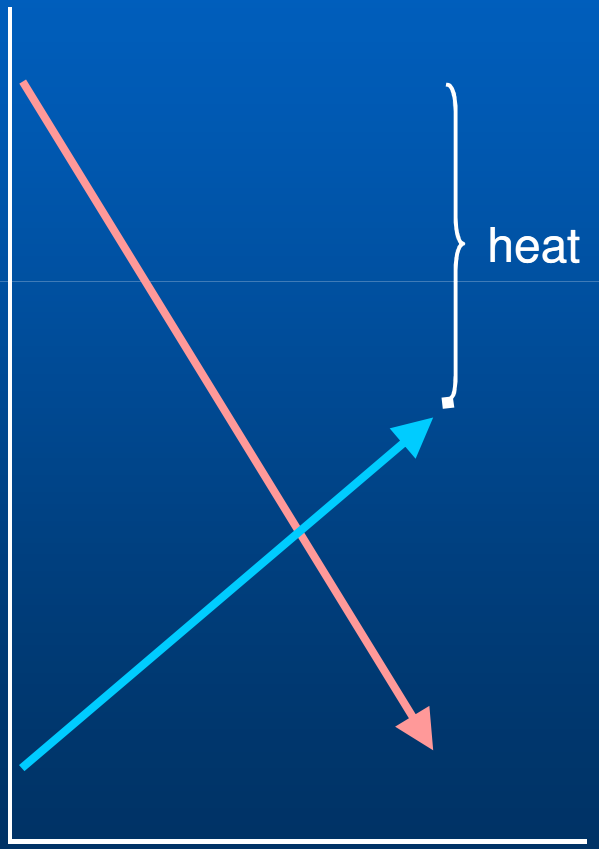
Thermodynamics: reaction may run spontaneously
Kinetics: reaction does NOT run spontaneously

Hydrolysis of ATP



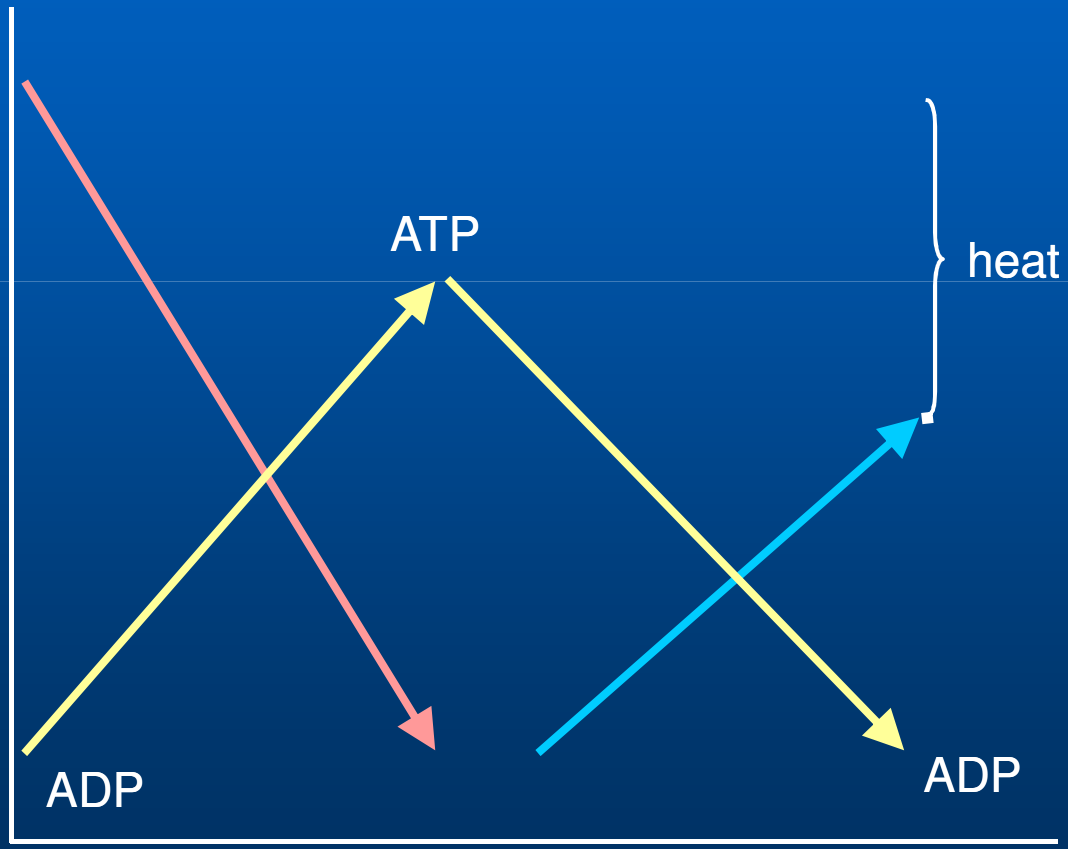
Coupling of reactions



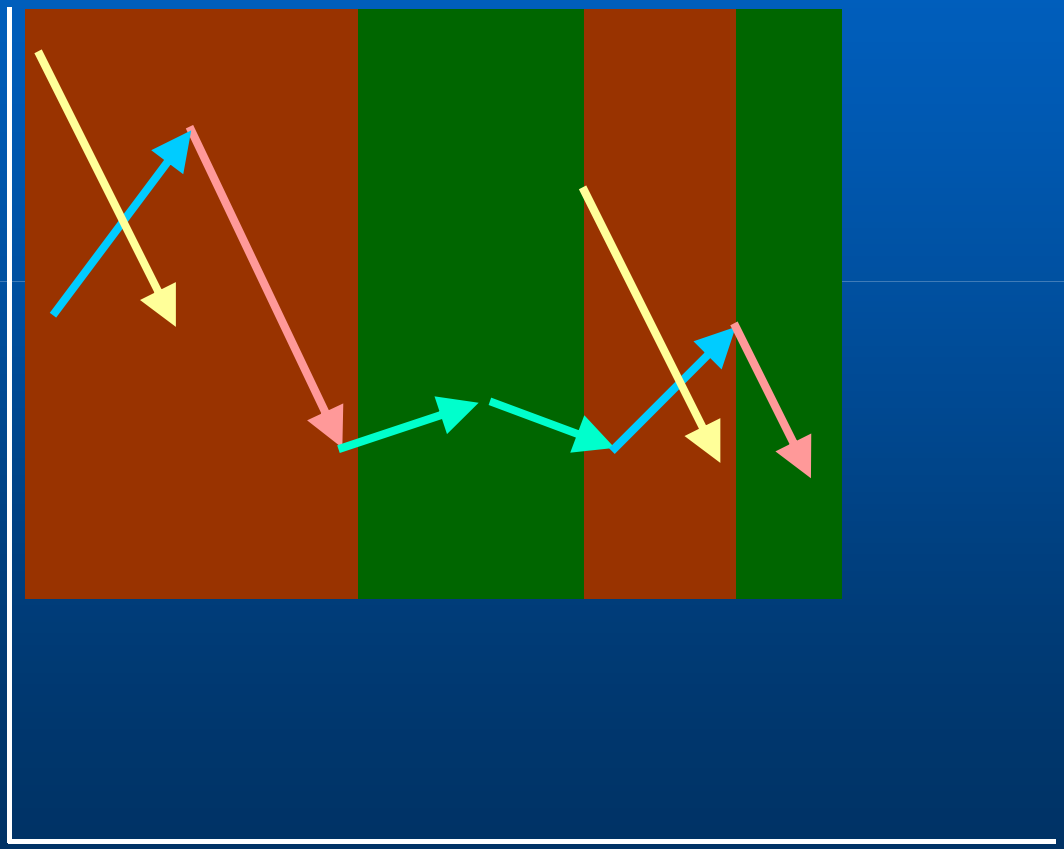


Modified from Murray et al.: Harper‘s Biochemistry

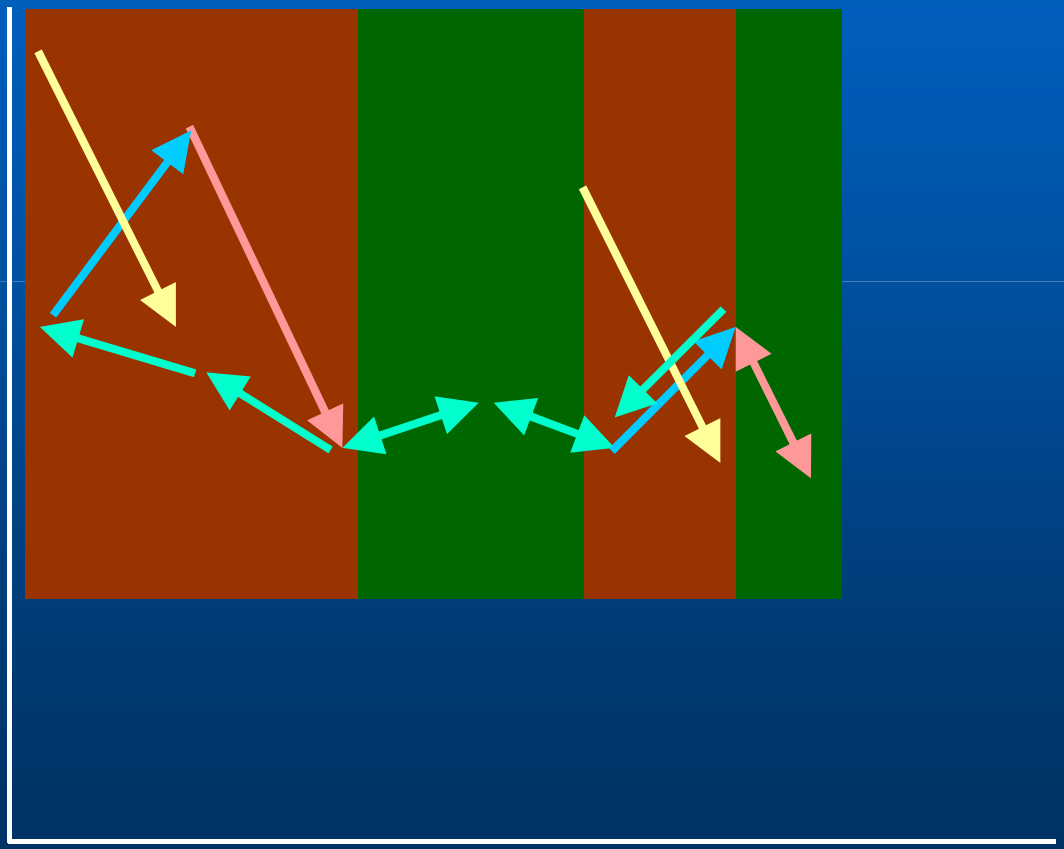
Coupling of reactions



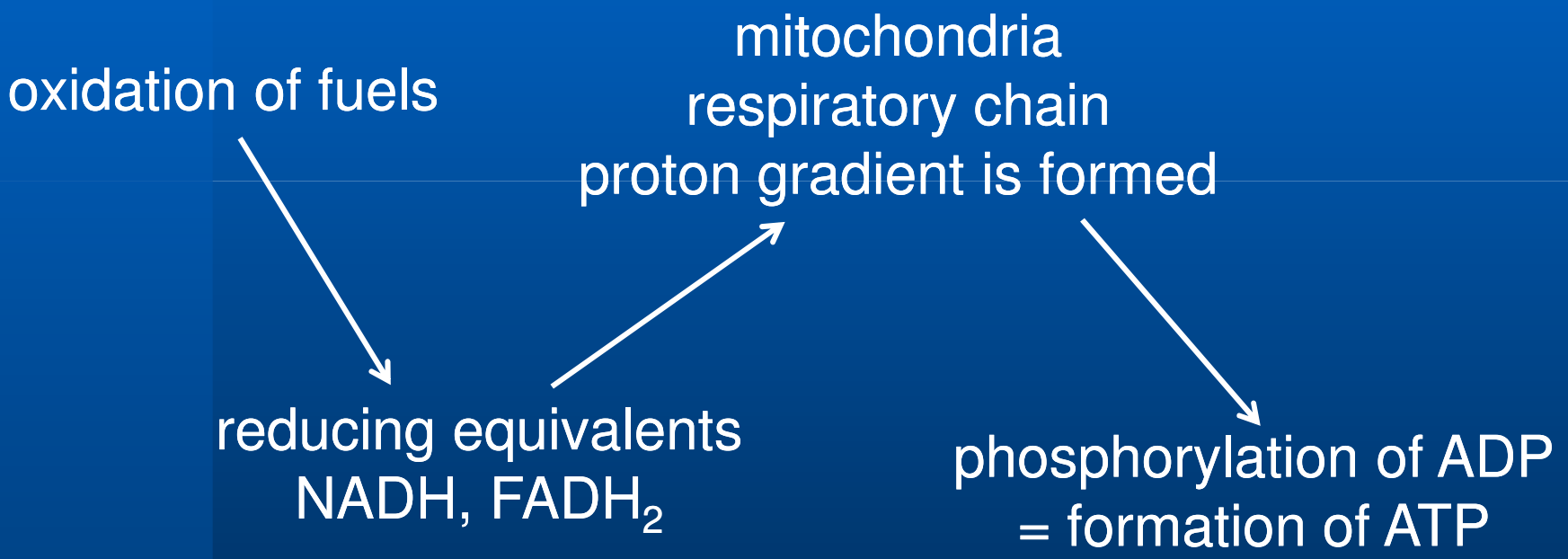
Irreversible reactions



Irreversible reactions



How to make ATP



Other macroeric compounds

Phosphoenolpyruvate
Carbamoylphosphate
Bisphosphoglycerate
Creatinphosphate

ATP

ADP
Pyrophosphate
Phosphorylated carbohydrates

Other:

thioesters (including acetylcoenzyme A)

esters of aminoacids

S-adenosylmethionin

phosphoribosyl pyrophosphate

…

Other properties of ATP

- **A complex with Mg^{2+} works**
  - **Mg is cofactor of all enzyme-catalysed reactions of ATP**

Some reactions of ATP

- **Adenylate kinase**
  ATP + AMP ↔ 2 ADP

- **Nucleoside kinases**
  ATP + GDP ↔ ADP + GTP