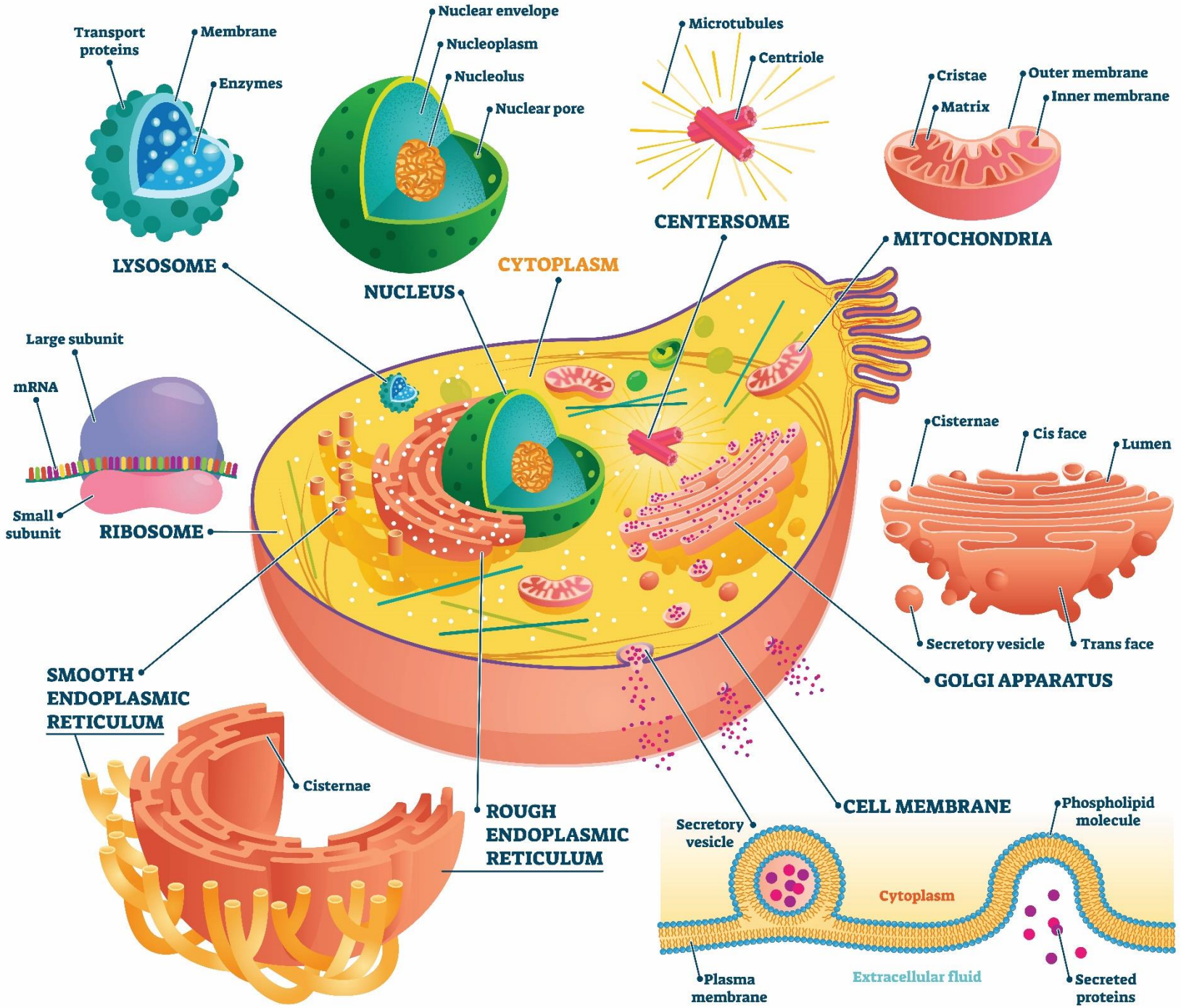
Cell structure and compartmentation of biochemical processes

1st week


Transport proteins
Membrane
Enzymes
LYSOSOME
Nuclear envelope
Nucleoplasm
Nucleolus
Nuclear pore
NUCLEUS
Microtubules
Centriole
CENTERSOME
Cristae
Outer membrane
Matrix
Inner membrane
MITOCHONDRIA
CYTOPLASM
Large subunit
mRNA
Small subunit
RIBOSOME
Cisternae
Cis face
Lumen
Secretory vesicle
Trans face
GOLGI APPARATUS
SMOOTH ENDOPLASMIC RETICULUM
Cisternae
ROUGH ENDOPLASMIC RETICULUM
CELL MEMBRANE
Secretory vesicle
Phospholipid molecule
Cytoplasm
Plasma membrane
Extracellular fluid
Secreted proteins

Biological oxidations

Types of oxidations

1. direct electron transfer :

$$\mathbf{Fe^{2+}} + Cu^{2+} \longrightarrow \mathbf{Fe^{3+}} + Cu^{+}$$

2. dehydrogenation

$$\mathbf{-}\ CH_2\ \mathbf{-}\ CH_2\ \mathbf{-} \xrightarrow{\mathbf{-\ 2H}} \mathbf{-}\ CH = CH\ \mathbf{-}$$

3. direct fusion with oxygen

$$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O$$

Enzymes of redox reactions

1. Oxidases

- take electrons from the substrate, which they transfer to an oxygen atom to form water

$$4\ e^- + O_2 + 4\ H^+ \longrightarrow 2\ H_2O$$

2. Dehydrogenases

- take 2 hydrogens from the substrate and transfer them to the dehydrogenase coenzyme, which is reduced in the process

$$AH_2 + \text{oxidated coenzyme} \rightleftharpoons A + \text{reduced coenzyme}$$

3. Hydroperoxidases

- degradation of hydrogen peroxide in cells

$$AH_2 + H_2O_2 \longrightarrow A + 2\ H_2O$$

$$H_2O_2 + H_2O_2 \longrightarrow 2\ H_2O + O_2$$

4. Oxygenases

- react with molecular oxygen, while 1 or 2 oxygen atoms are incorporated into the substrate molecule

A. Monooxygenases

- catalyze the hydroxylation of the substrate, requiring a hydrogen donor (reduced coenzyme)

$$AH + \text{reduced coenzyme} + O_2 \longrightarrow A\text{-}OH + H_2O + \text{oxidazed coenzyme}$$

B. Dioxygenaes

- catalyze the incorporation of the entire oxygen molecule into the substrate

$$A + O_2 \longrightarrow AO_2$$

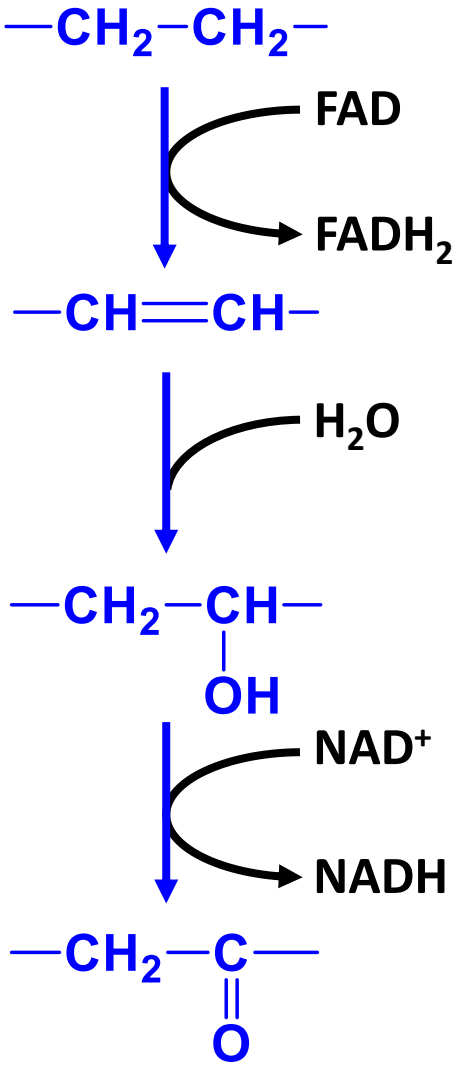
Coenzymes of redox processes

- nicotinamide: NAD^+ a $NADP^+$
- flavine: FAD a FMN
- oxidized coenzyme Q (ubiquinone)

- **by accepting 2 electrons, coenzymes change to their reduced forms :**

- NADH a NADPH
- FAD a $FADH_2$
- reduced coenzyme Q (ubiquinone)

Oxidation of hydrocarbon chain *in vivo*



dehydrogenation
(double bond formation)

hydration
(hydroxy-group formation)

dehydrogenation
(oxy-group formation)

Diferences between oxidations

	In vitro	*In vivo*
Conditions	high temperature	„physiological“ conditions
Speed	rapid reaction	slow reaction
Release of energy	release of energy at one stroke, most as heat	transformation to chemical energy – creation of energy rich bonds
Course of reaction	always end products $CO_2 + H_2O$	intermediates which can be used in other pathways
Mechanism of oxidation	$C + O_2 \rightarrow CO_2$	dehydrogenation $2H + ½O_2 \rightarrow H_2O$ CO_2 –decarboxylation

Macroergic compounds

Macroergic compounds

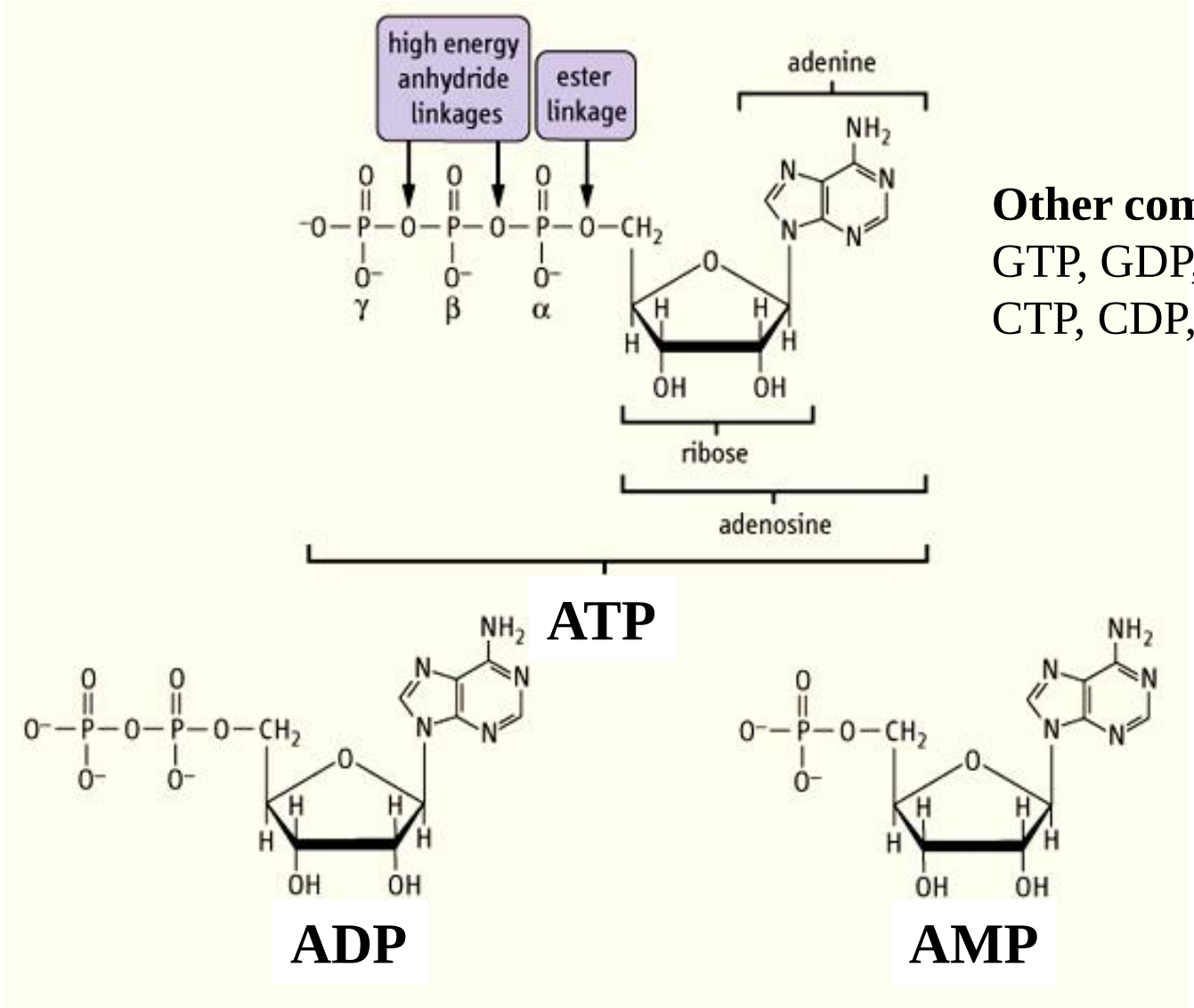
Energy rich compounds

1. **Endergonic metabolic processes** (synthesis of proteins, lipids, carbohydrates, nucleic acids)
2. **Transport processes** (active transport against the concentration gradient)
3. **Mechanical work –** muscles
4. **Nerve impulse transmission**

Types of macroergic bonds

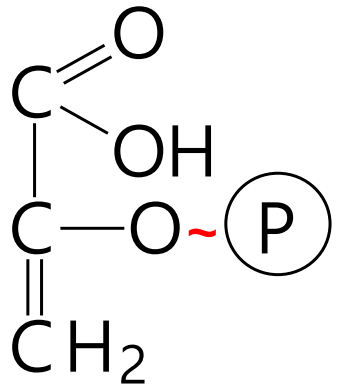
1. phosphoanhydride (diphosphate)
2. enolphosphate
3. acylphosphate (carboxyphosphate)
4. guanidine phosphate
5. thioester

1. Phosphoanhydride bond
(Diphosphate bond)



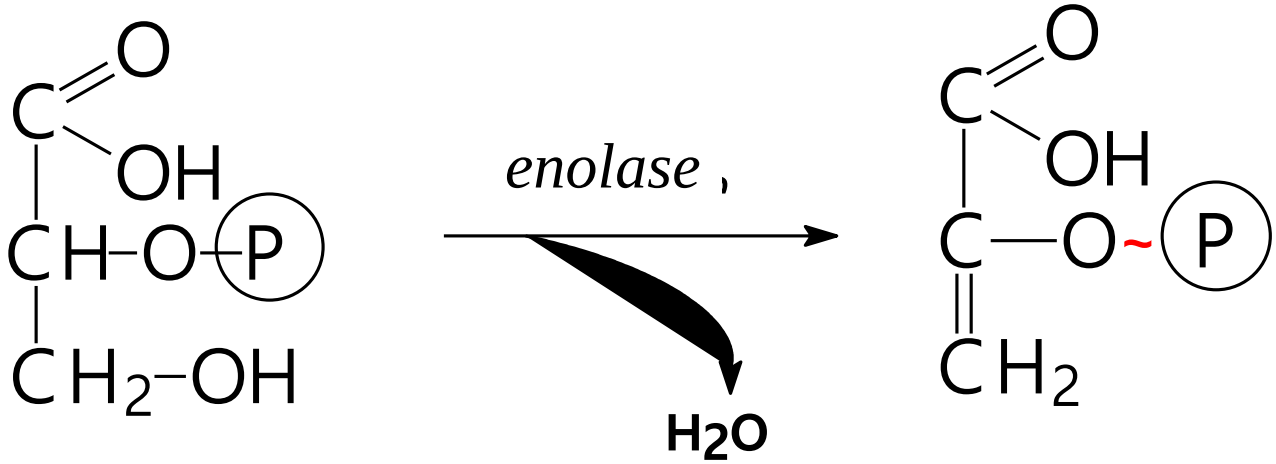
Other compounds:
GTP, GDP, UTP, UDP,
CTP, CDP, NAD^+, FAD, CoA

2. Enol phosphate bond



phosphoenolpyruvate (PEP)

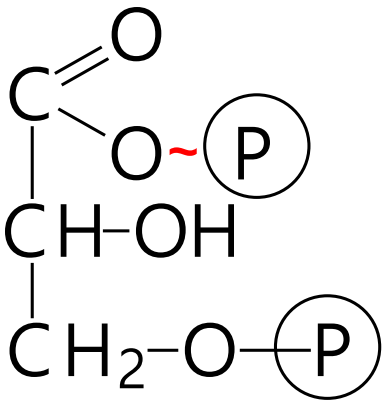
Production: in glycolysis by ***enolase***



2-phosphoglycerate

phosphoenolpyruvate (PEP)

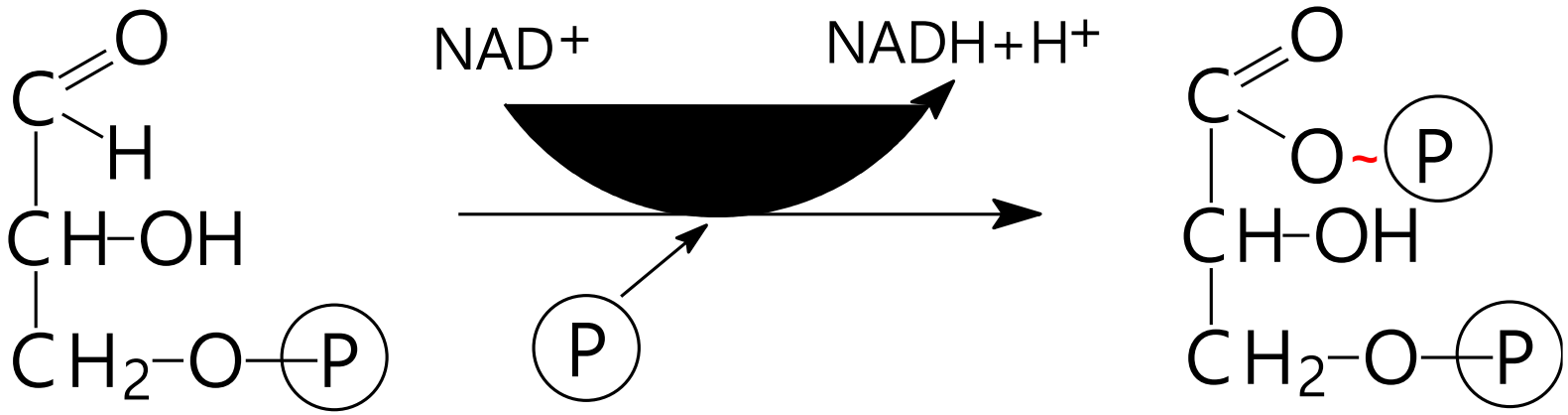
3. Acyl phosphate bond



1,3-bisphosphoglycerate (1,3-bPG)

Other compounds: some intermediates in metabolism (aminoacyladenylate..), carbamoylphosphate

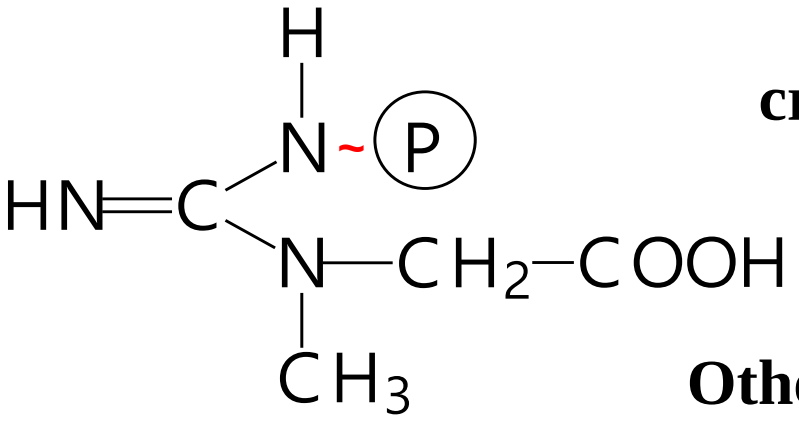
Production: in glycolysis by *glyceraldehyde dehydrogenase*



glyceraldehyde-3-P

1,3-bisphosphoglycerate (1,3-bPG)

4. Guanidine phosphate bond



creatine phosphate (Cr~P)

Other compound: arginine phosphate

Production: Cr + ATP → Cr~P + ADP

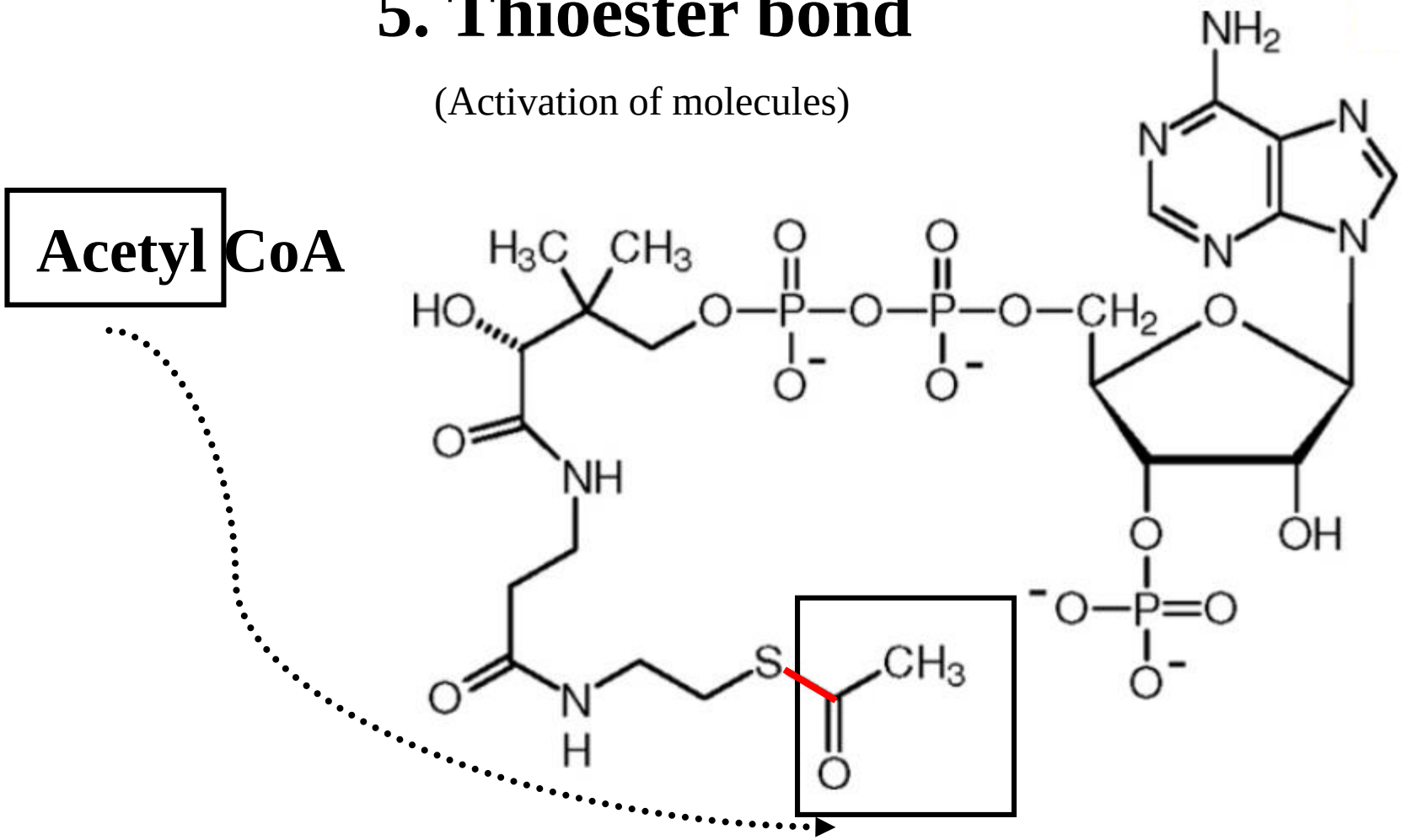
Utilization: storage form of energy, not a direct source!

Cr~P + ADP → Cr + **ATP**

direct source of energy

5. Thioester bond

(Activation of molecules)



Other compounds: acylCoA, some intermediates of metabolism – succinylCoA in Krebs cycle, intermediates of FA synthesis, S-acetyl lipoate in *pyruvate dehydrogenase* complex)

Aerobic / Anaerobic metabolism