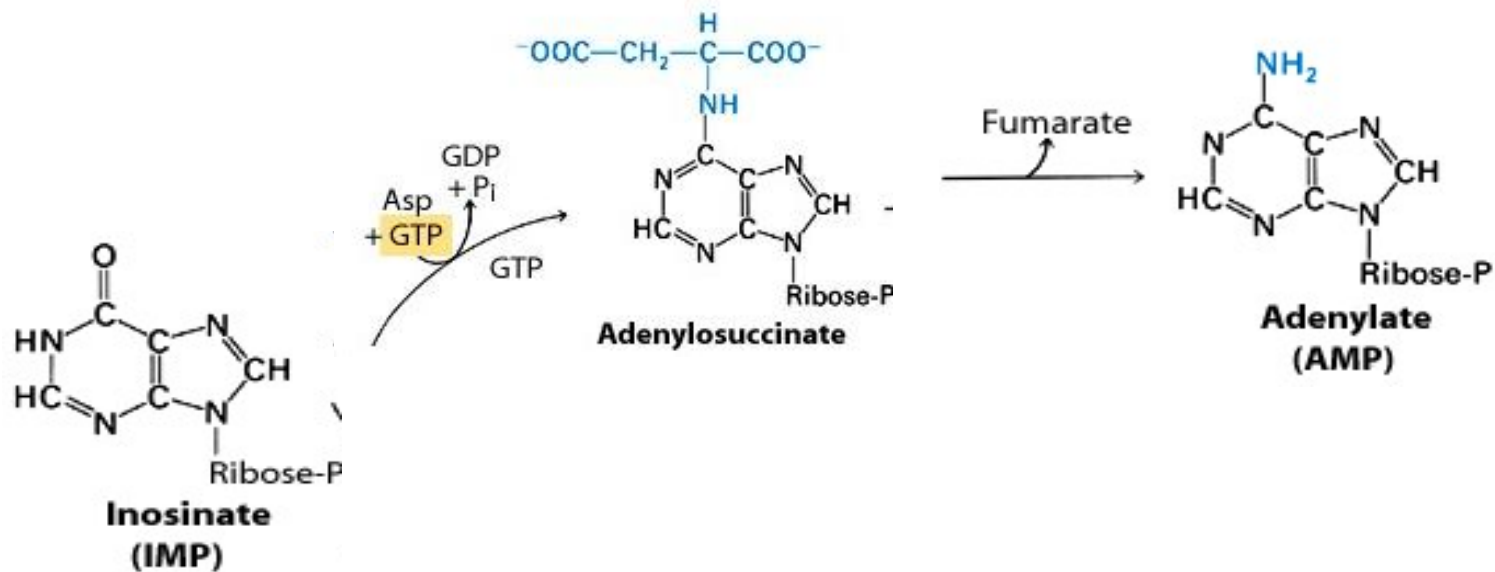


Additional Roles of Nucleotides

- **Activated precursors of nucleic acids (DNA, RNA)**
- **Universal carriers of chemical energy (e.g., ATP, GTP)**
- **Building blocks of co-factors (e.g., NAD, CoA etc.)**
 - **Substrates for covalent enzyme modification (e.g., phosphorylation, adenylylation)**
- **Second messengers in cellular communication (e.g., cAMP)**

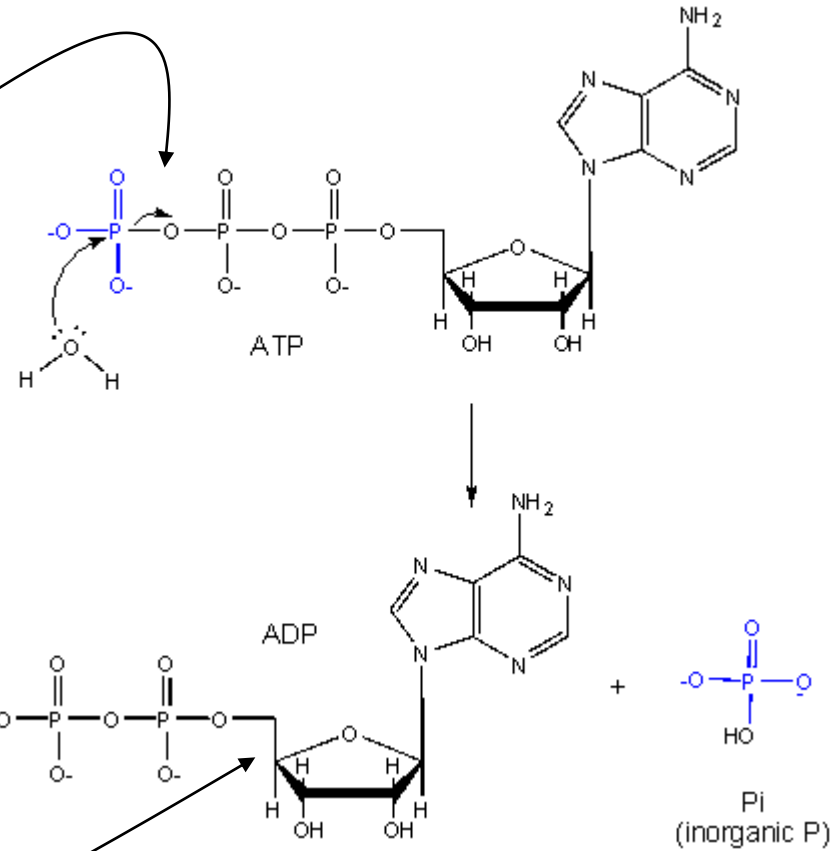
Universal carriers of chemical energy

- Nucleoside triphosphates are used to drive a wide variety of chemical reactions
 - ATP is most common
 - UTP, GTP and CTP are used in specific reactions (eg GTP: purine synthesis)



- Hydrolysis of NTP is an energy-yielding reaction due to the structure of the phosphates
 - Hydrolysis of ester link 14kJ/mol energy
 - Hydrolysis of an anhydride 30kJ/mol energy
- ATP hydrolysis drives less favorable reactions (i.e. those with a $\Delta G_0 > 0$)
- When coupled with a reaction the hydrolysis of ATP shifts the equilibrium of the reaction to favor product formation

ATP hydrolysis



**Two phosphoanhydride bonds
(connecting the 3 phosphates)
= 30kJ/mol x 2**

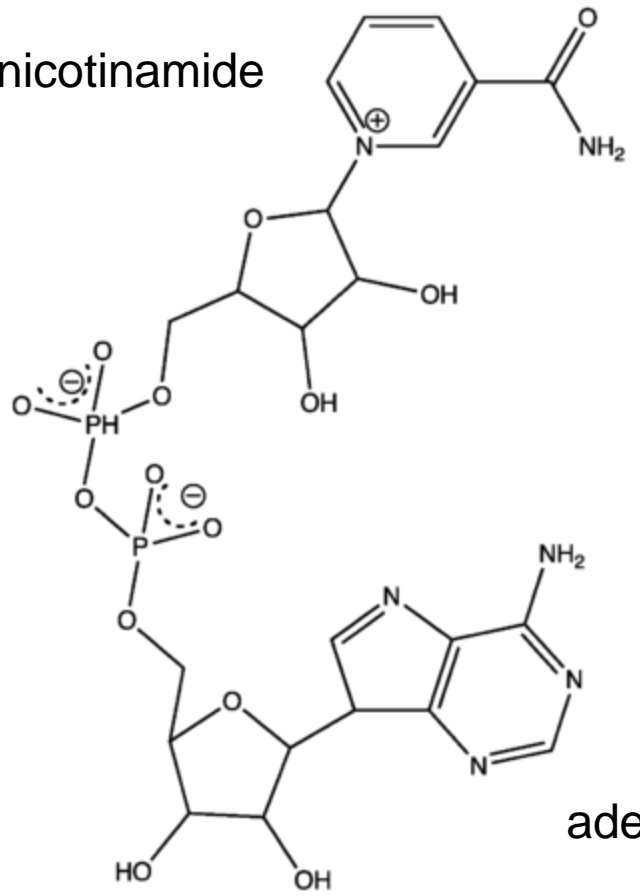
**One phosphoester bond (connecting
phosphate to ribose ring)
= 14kJ/mol**

Building blocks of co-factors (e.g., NAD, CoA etc.)

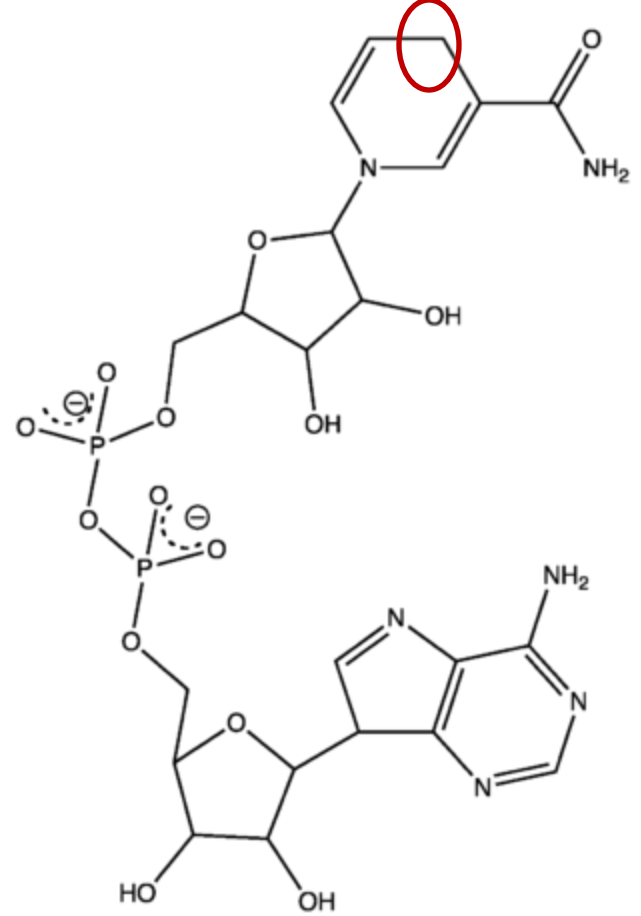
- Definition
 - Co-factor: an organic ion or co-enzyme required for enzyme activity
 - often contains a vitamin as a component

Coenzyme	Vitamin	Function
nicotinamide adenine dinucleotide (NAD ⁺)	niacin	oxidation or hydrogen transfer
flavin adenine dinucleotide (FAD)	riboflavin	oxidation or hydrogen transfer
coenzyme A (CoA)	pantothenic acid	Acetyl group carrier
coenzyme B-12	vitamin B-12	Methyl group transfer

nicotinamide

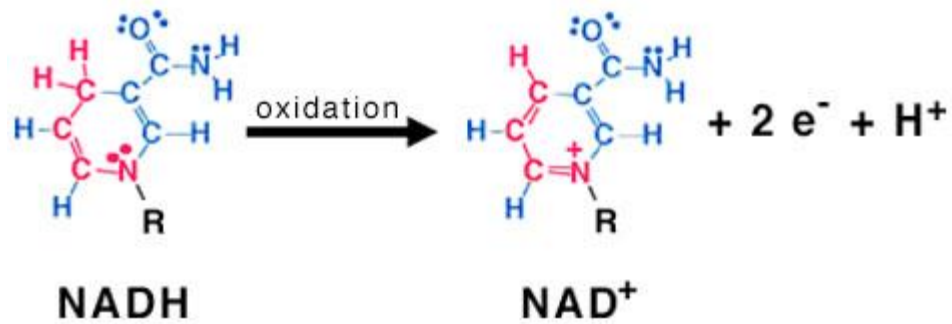


$2 e^- + 2 H^+$



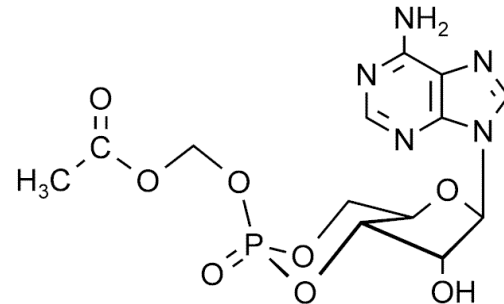
NAD+ (oxidized)

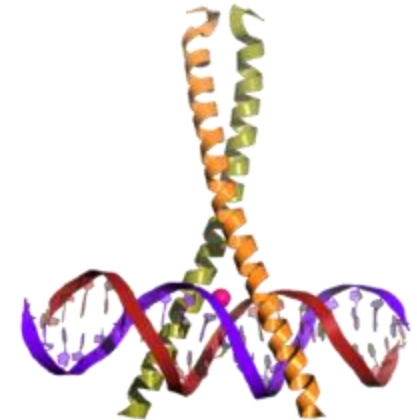
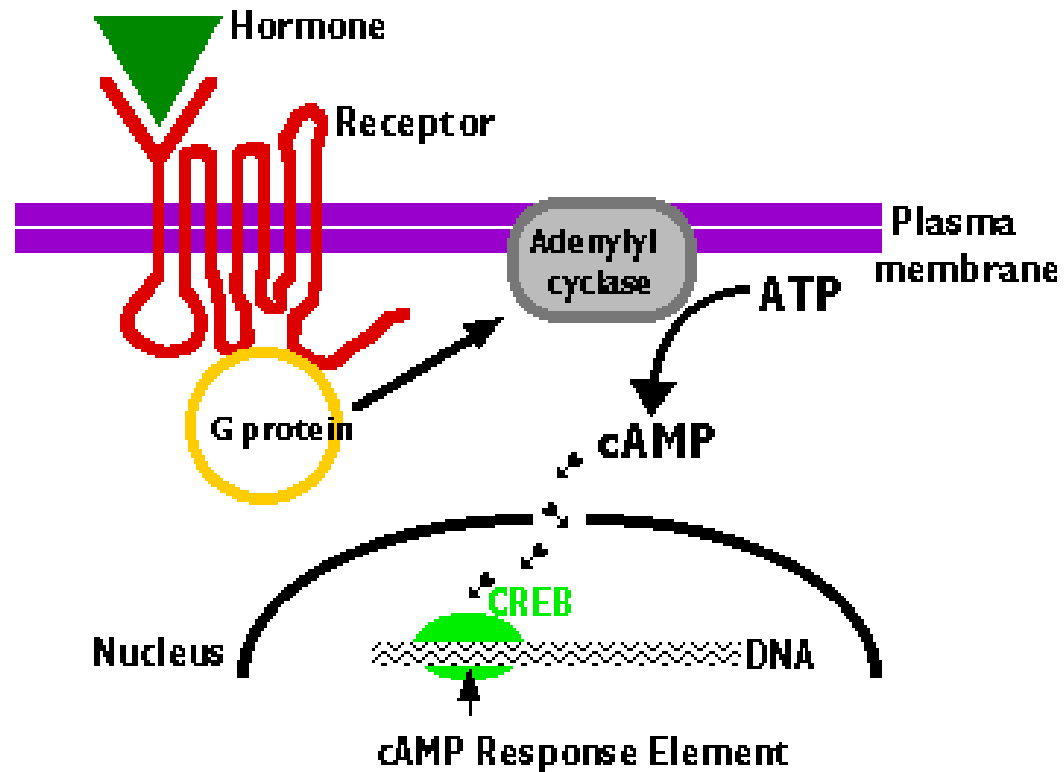
NADH (reduced)



Second messengers in cellular communication (e.g., cAMP)

- Cells respond to their environment by taking cues from hormones or other chemical signal in the surrounding medium
- cAMP (**Adenosine 3'5'cyclic monophosphate**; cyclic AMP) is one of the most common second messengers





CREB: cAMP response element-binding protein: nuclear factor

→ Activated in response to cAMP (via protein kinase): phosphorylation

→ Transcription factor

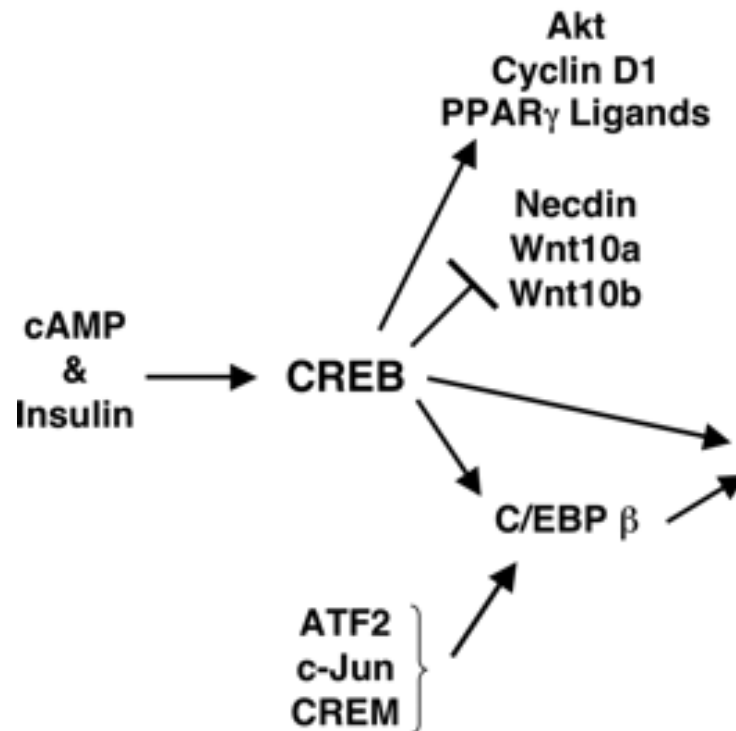
→ Once dimerised, it binds to sequences on DNA called cAMP response elements

→ CREB-binding protein (CRBBP) co-activates CREB

→ This changes the transcription of the affected gene

Stem cell differentiation into fat and muscle

Preadipocyte → Adipocyte



Myoblast → Myotube