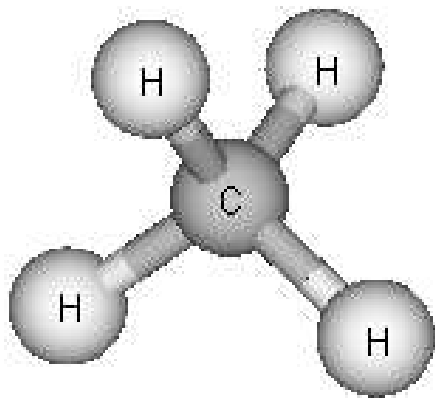
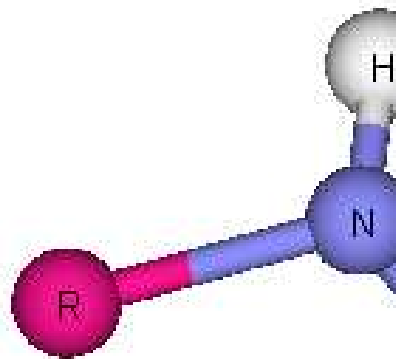


# Úvod do chemie organických sloučenin

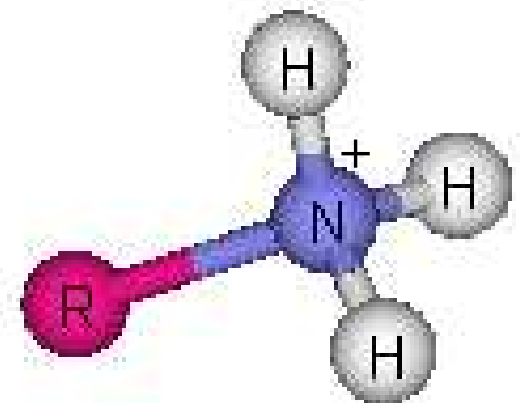
**Vaznost** – počet kovalentních vaz



*Methan*  $CH_4$



*alkylamin*  $R-\bar{N}H_2$



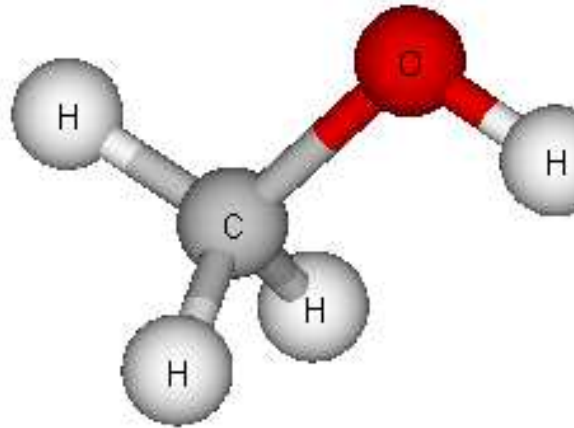
*alkylamonium*  $R-N^+H_3$

**Vodík (H) - 1**

**Uhlík (C) - 4**

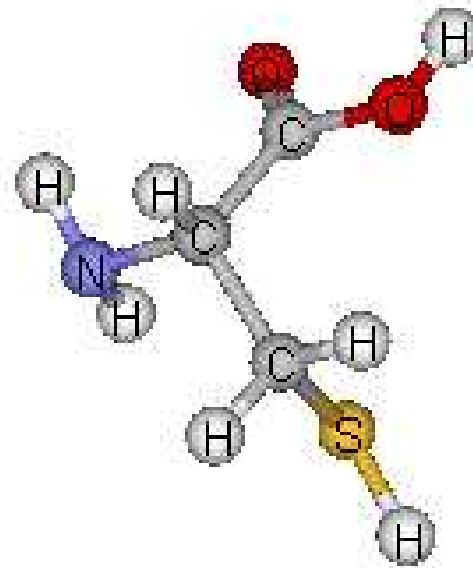
**Dusík (N)**

# Vznost prvku



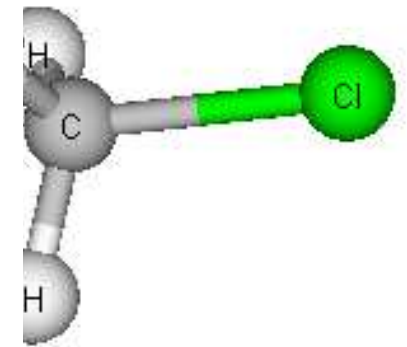
*methanol (CH<sub>3</sub>—O—H)*

**Kyslík (O) - 2**



*cystein*

**Síra (S) - 2**

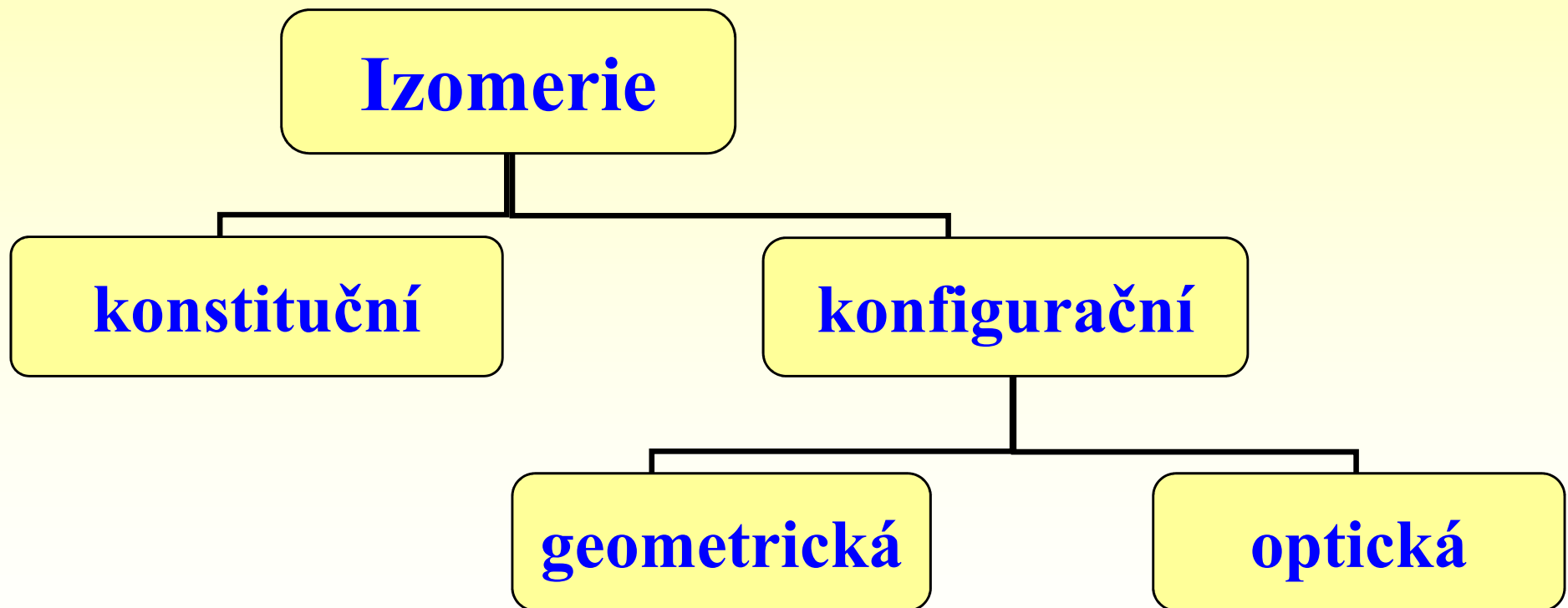


*methylchlorid*

**Chór (Cl) - 1**

# Izomerie

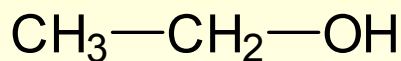
různé sloučeniny, ale stejný molekulový vzorec  
(např. pro glukosu  $C_6H_{12}O_6$ )



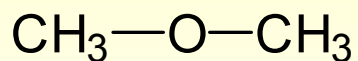
# Konstituční izomerie

**Konstituce** – druh *atomů* i *vazeb* v molekule,  
bez prostorového uspořádání

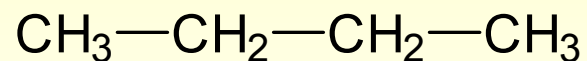
**Molekulový (sumární) vzorec:**



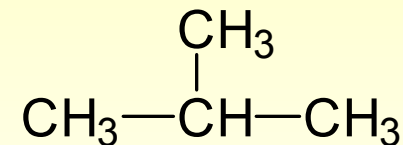
ethanol



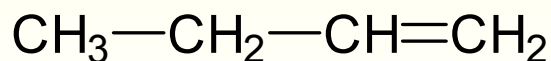
dimethylether



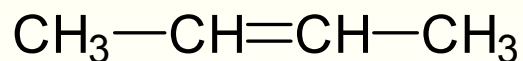
butan



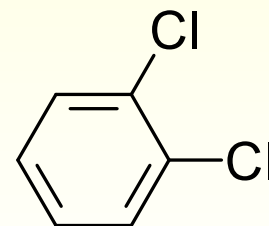
2-methylpropan



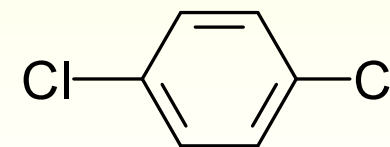
but-1-en



but-2-en



1,2-dichlorbenzen



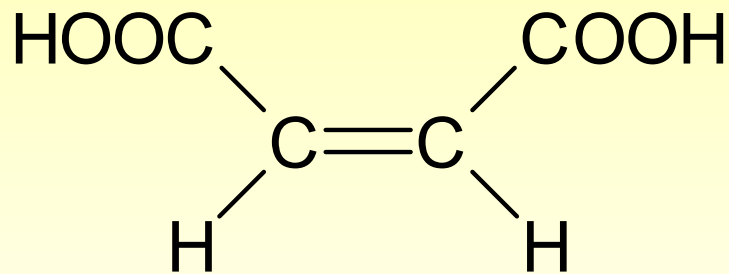
1,4-dichlorbenzen



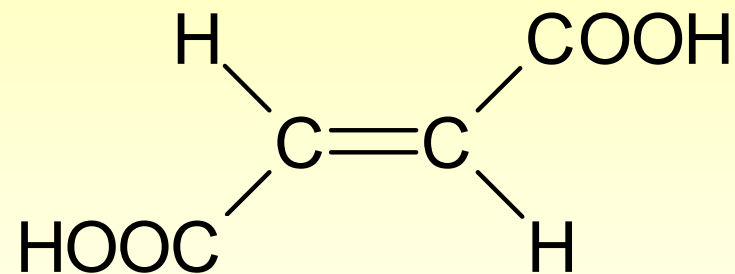
# Konfigurační izomerie

- **Konfigurace** – prostorové uspořádání všech atomů a vazeb bez ohledu na rotaci kolem jednoduchých vazeb
- **Konfigurační izomery** – mají stejnou konstituci, liší se však konfigurací
  - Geometrická izomerie (*cis/trans*)
  - Optická izomerie – (D/L)

# Geometrická (*cis/trans*) izomerie



*cis*-but-2-endiová kyselina  
(maleinová)



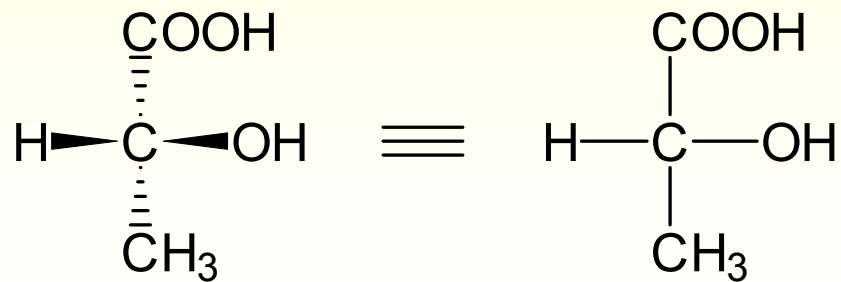
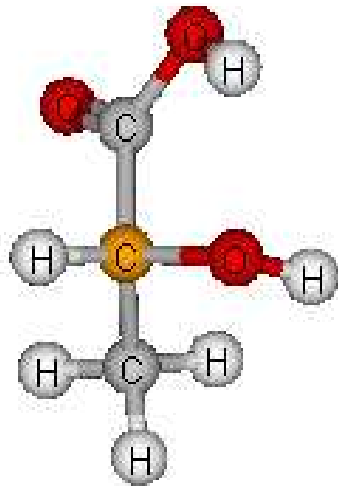
*trans*-but-2-endiová kyselina  
(fumarová)

meziprodukt citrátového cyklu

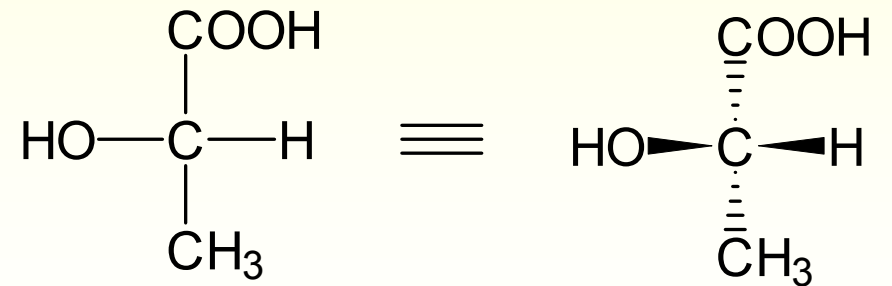
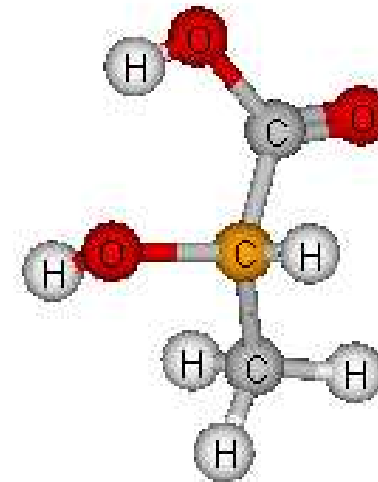
# Optická izomerie

Rovina

symetrie



D-mléčná kyselina

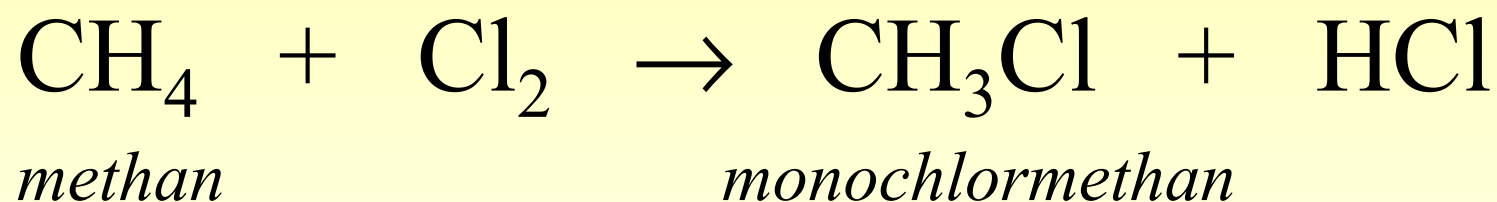


L-mléčná kyselina

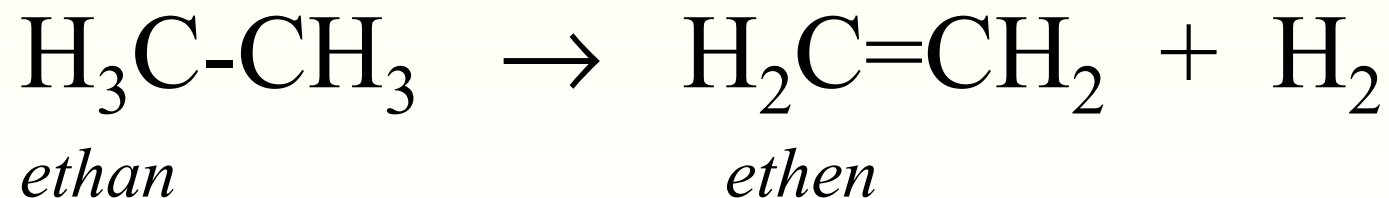
produkt glykolýzy za anaerobních podmínek <sup>7</sup>

# Typy reakcí

## 1. **Substituce** (nahrazování)



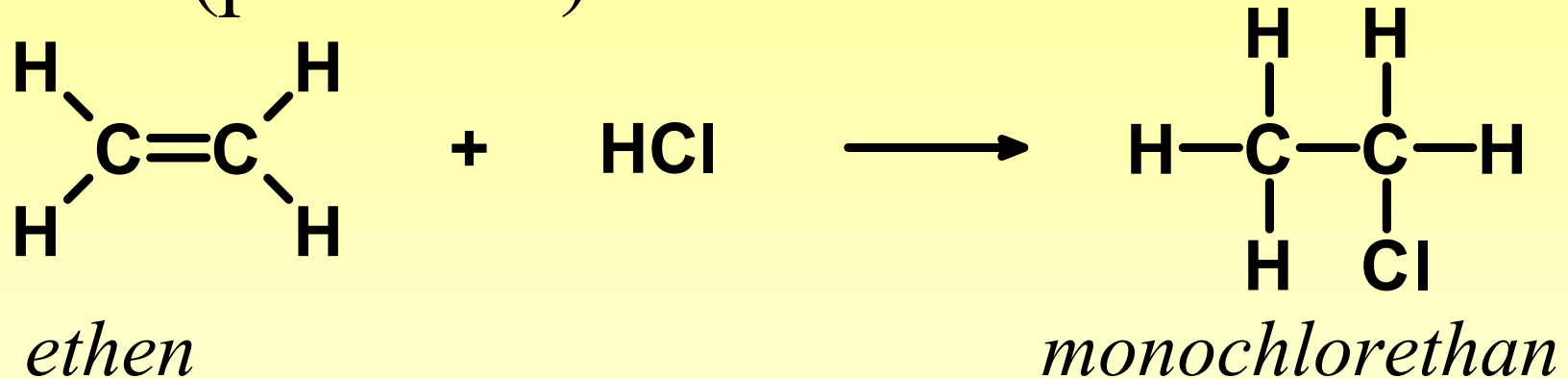
## 2. **Eliminace** (odebírání)



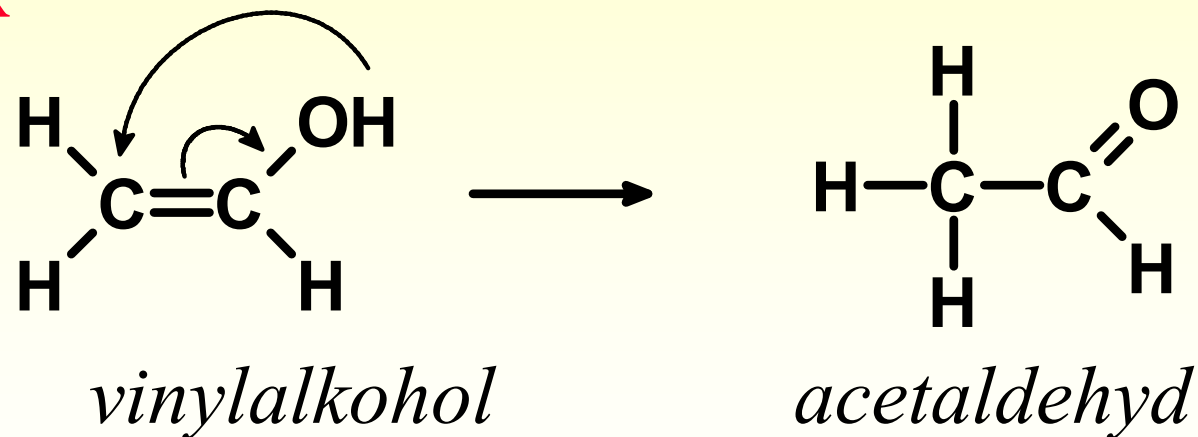


# Typy reakcí

## 3. **Adice** (přidávání)



## 4. **Přesmyk**



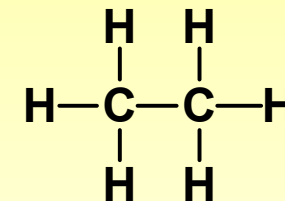
izomery (tautomery)

# Uhlovodíky

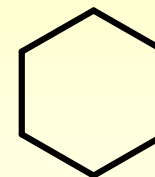
- obsahují pouze atomy C a H

## Typ uhlovodíku

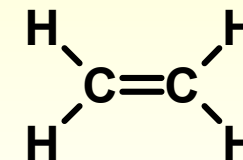
alkany (nasycené uhlovod.)



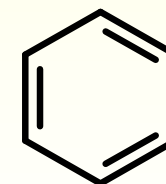
cykloalkany (cyklické a nasycené)



alkeny (dvojné vazby)

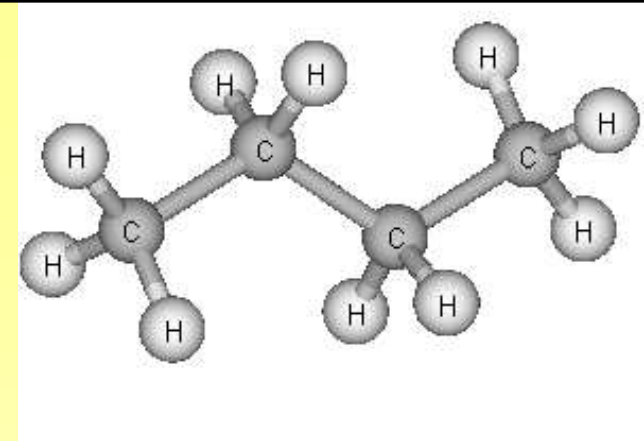


areny (aromatické uhlovod.)



## Příklad

# Alkany

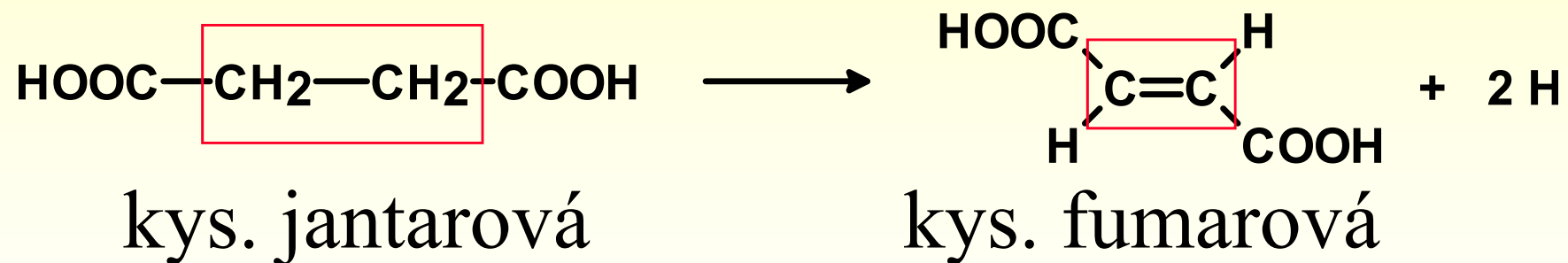


butan

- nepolární, nerozpustné ve vodě
- málo reaktivní

Reakce:

- **Eliminace**  $\text{H}_3\text{C}-\text{CH}_3 \rightarrow \text{H}_2\text{C}=\text{CH}_2 + \text{H}_2$

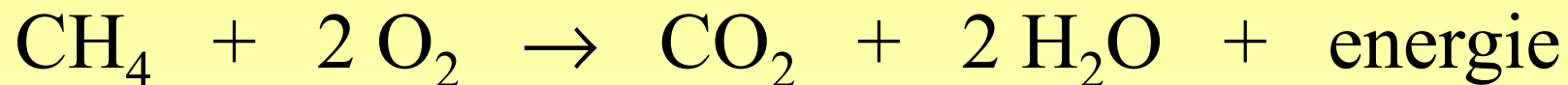


- **Substituce**



## • Oxidace

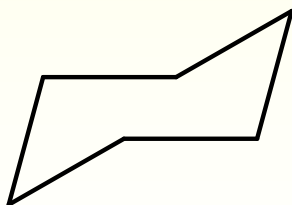
- hoření (např. spalování methanu, benzínů)



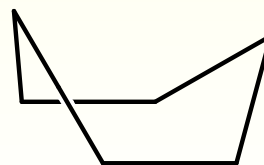
- částečná (produktem může být i CO)

## Cykloalkany

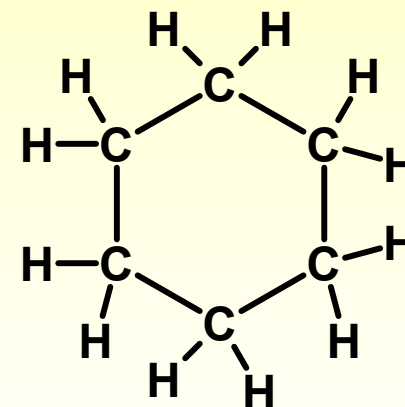
- nejstabilnější jsou s 5 a 6 C v cyklu
- židličková a vaničková konformace cyklohexanu



židlička

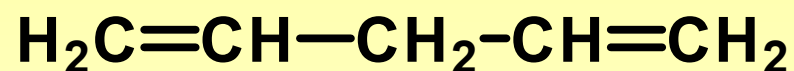


vanička

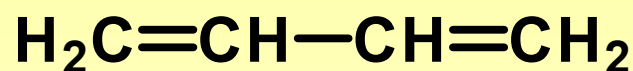


# Nenasycené uhlovodíky (alkeny)

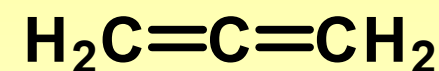
- alkeny obsahují dvojně vazby
- alkadieny - 2 dvojně vazby



izolované

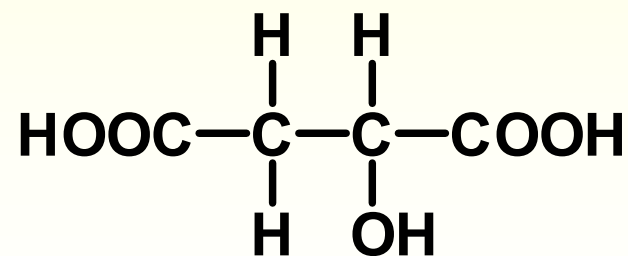
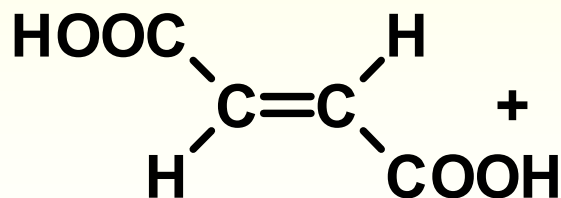
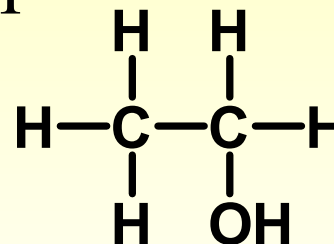
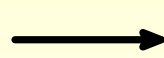
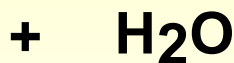
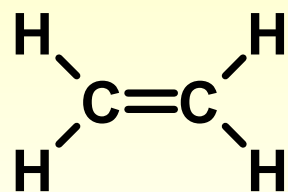


konjugované



kumulované

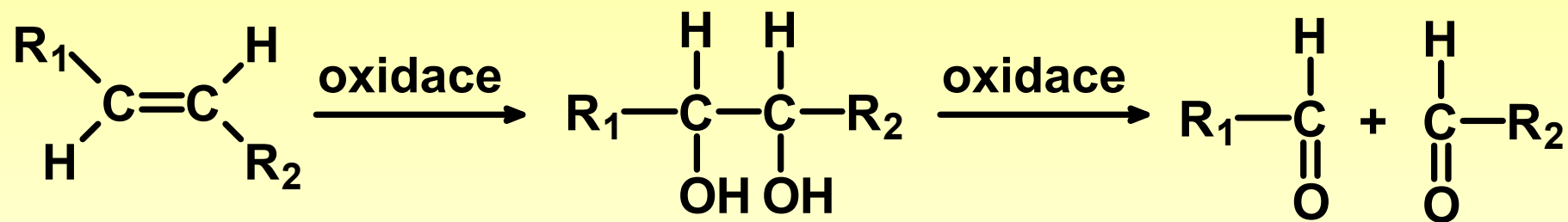
- jsou **reaktivnější než alkany**, typická reakce **adice**



kys. fumarová

kys. jablečná

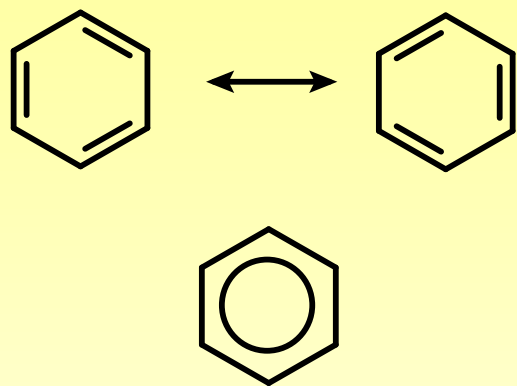
- oxidace (snadněji než u alkanů)



*vicinální diol*

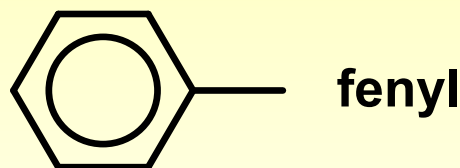
*aldehydy*

# Aromatické uhlovodíky (areny)

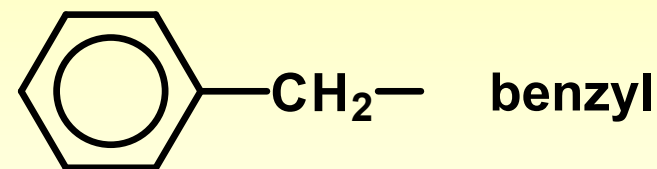


benzen

- atomy C a H leží v jedné rovině
- na C hybridizace  $sp^2$
- vazby C-C jsou rovnocenné
- dokonalá delokalizace  $\pi$ -elektronů



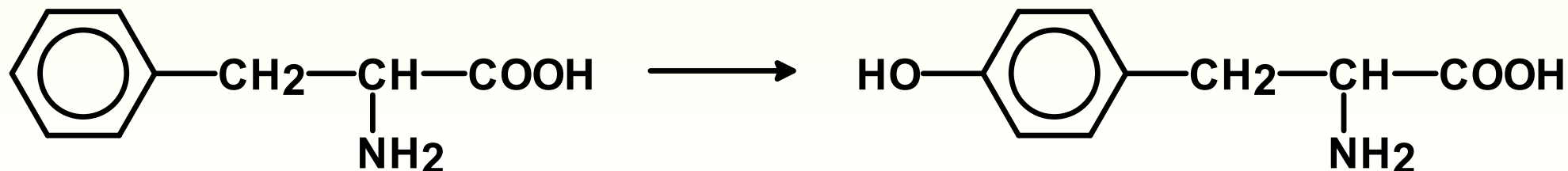
fenyl



benzyl

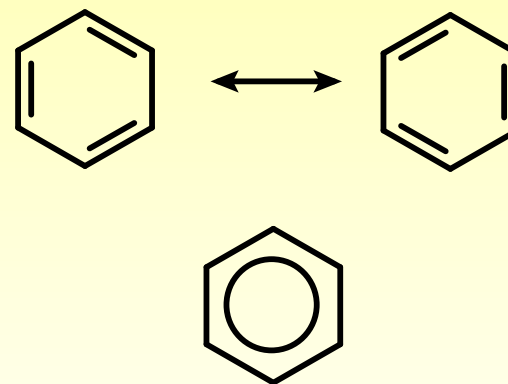
- typická reakce **substituce**, adice (oxidace) nesnadno

Př. hydroxylace



# Benzen

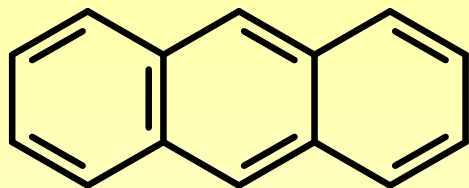
- Atomy C –  
hybridizace  $sp^2$
- Všechny atomy  
uhlíku a vodíku  
leží v jedné  
rovině



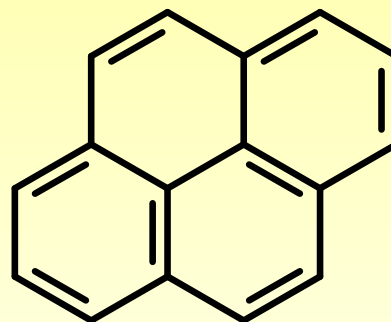
benzen



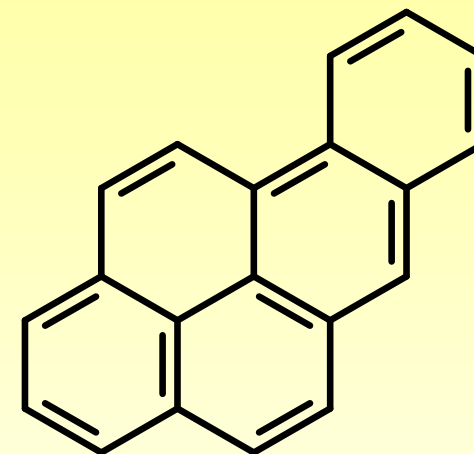
# Polykondenzované aromatické uhlovodíky (PAH)



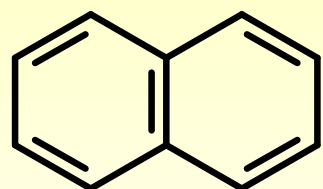
anthracen



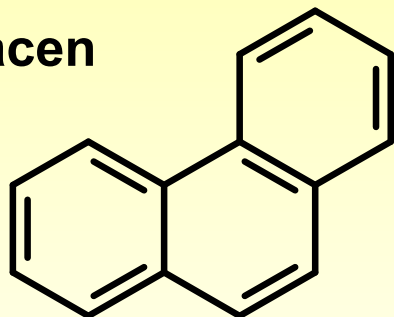
pyren



benzo[a]pyren



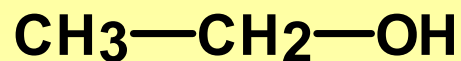
naftalen



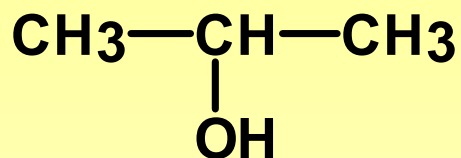
fenanthren

- jsou **kancerogenní (=karcinogenní)**
- cigaretový kouř, výfukové plyny, dehet, saze a smažené, uzené, připálené potraviny

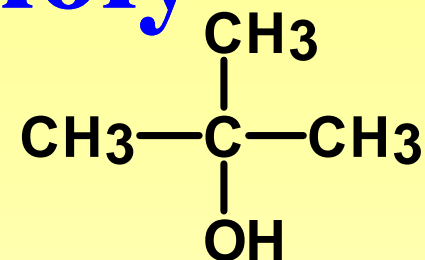
# Alkoholy a fenoly



ethanol  
(primární alk.)



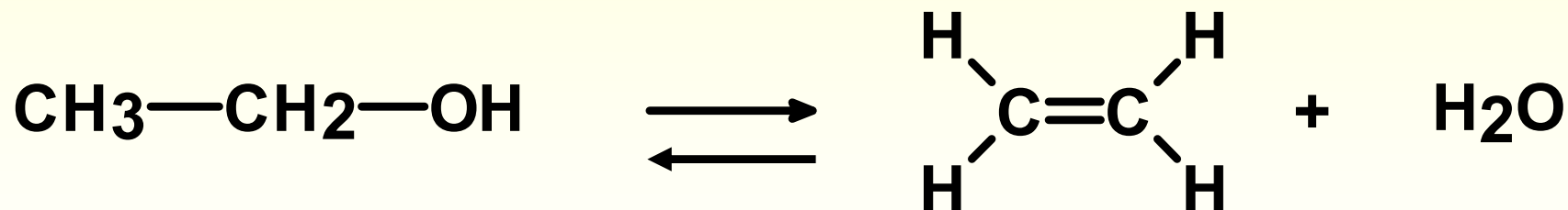
2-propanol  
(sekundární alk.)



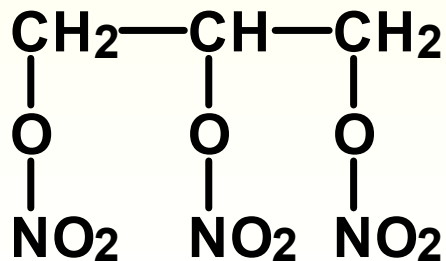
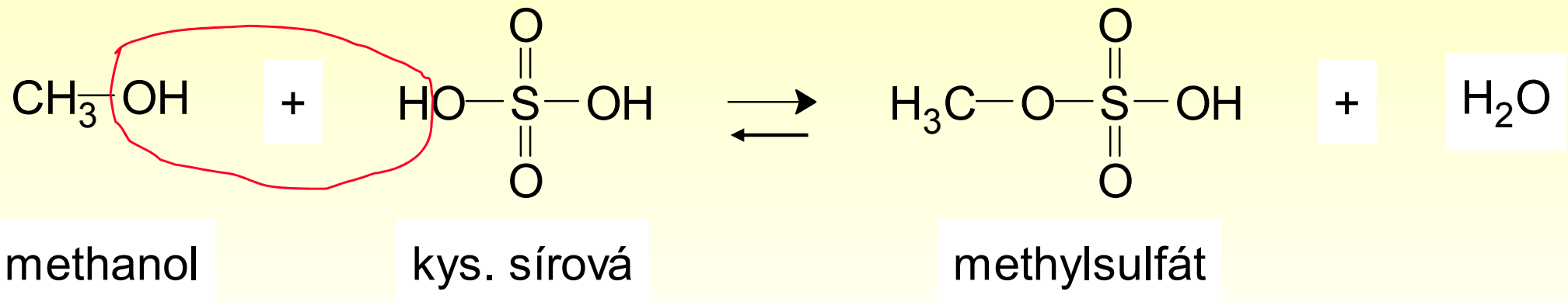
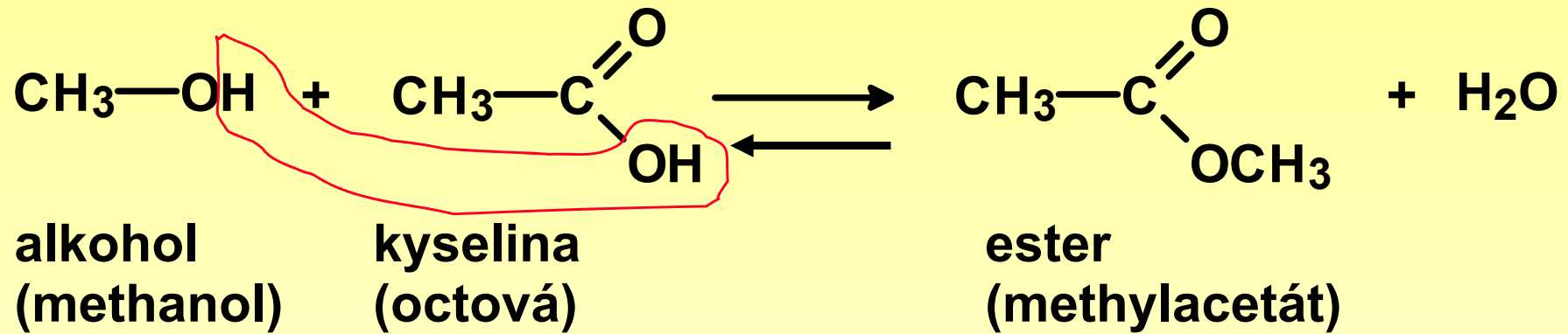
2-methyl-2-propanol  
(terciární alkohol)

## Reakce:

- Dehydratace

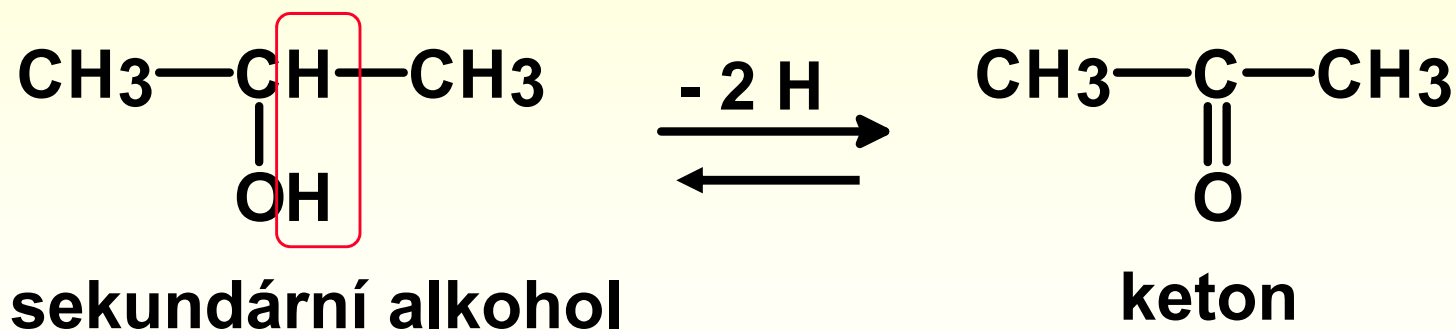
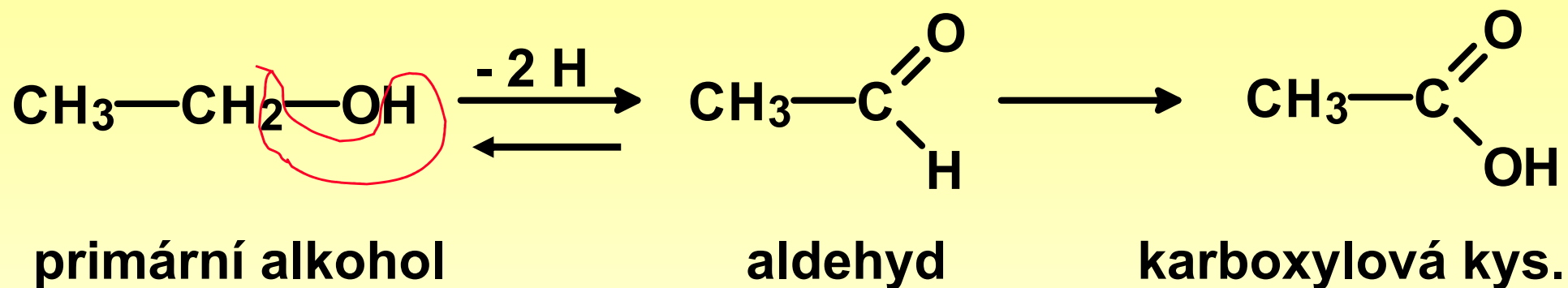


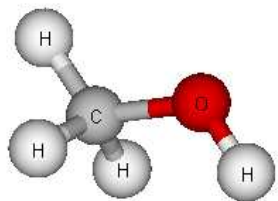
# • Esterifikace



Glyceroltrinitrát - vazodilatans  
účinek prostřednictvím NO

- Oxidace (dehydrogenace)**

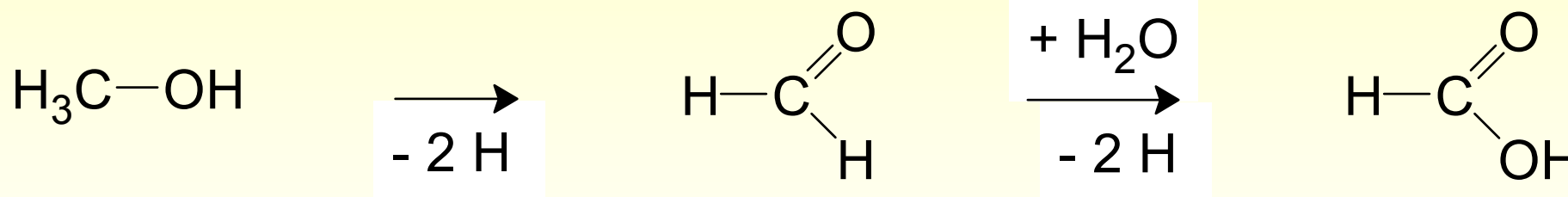




# Methanol (CH<sub>3</sub>OH)



- kapalina alkoholové vůně a chuti, mísitelná s vodou – průmyslové rozpouštědlo
- oxiduje se na formaldehyd a mravenčí kyselinu



- **značně neurotoxický**, poškození zrakového nervu
- antidotum ethanol (přednostně se oxiduje v organismu)

# Ethanol (CH<sub>3</sub>CH<sub>2</sub>OH)

- obsažen v alkoholických nápojích
- oxiduje se na acetaldehyd a octovou kyselinu
- **alkohol v krvi:** (‰) =  $m / (h * f)$

m hmotnost ethanolu v g

h tělesná hmotnost v kg

f 0,67 muži, 0,55 ženy

pokles:

0,15 ‰ / hod

## Koncentrace alkoholu v krvi

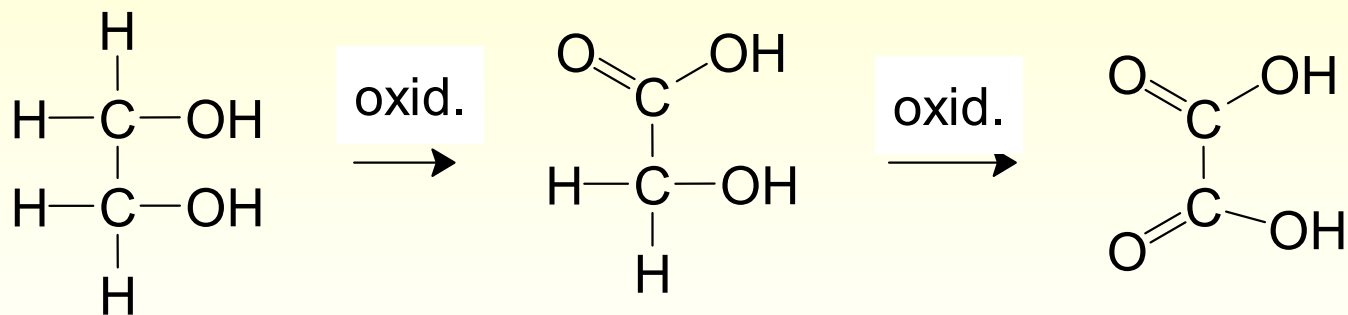
> 0,3 ‰ - vždy znamená požití alkoholu

0,5 - 1,5 ‰ - lehká opilost, 2 - 3 ‰ - těžká opilost,

3 - 4 ‰ - bezvědomí, smrtelná dávka **150 -250 g**

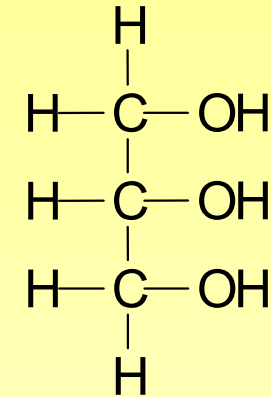
# Ethylenglykol (HO-CH<sub>2</sub>-CH<sub>2</sub>-OH)

- nasládlá viskózní kapalina
- přísada do nemrznoucích směsí - „FRIDEX“
- oxiduje se na šťavelovou kyselinu

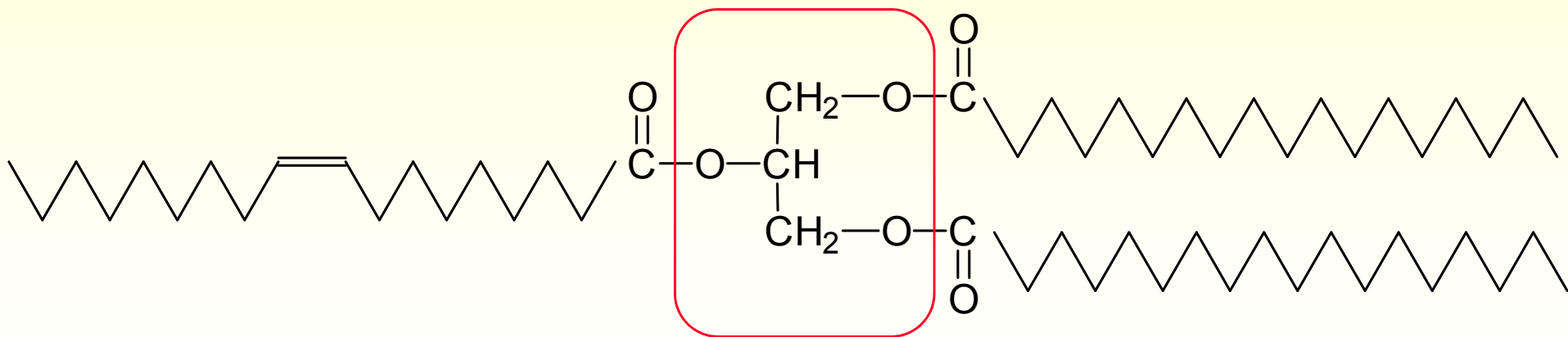


- způsobuje **těžkou acidózu a selhání ledvin** (Ca-oxalát)
- antidotum ethanol

# Glycerol



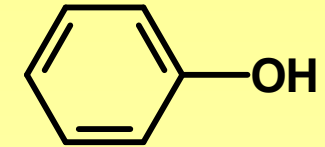
- Sirupovitá nasládlá kapalina
- **Součást triacylglycerolů a glycerolfosfolipidů**
- **Je hygroskopický** – kosmetika, glycerinové čípky



triacylglycerol

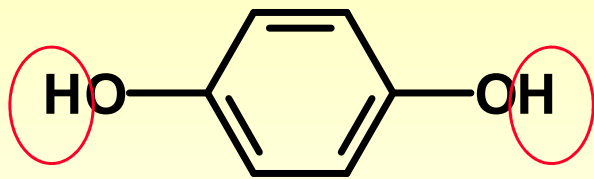


# Fenoly

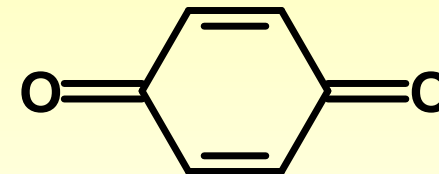
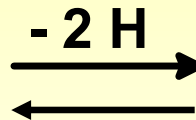


fenol

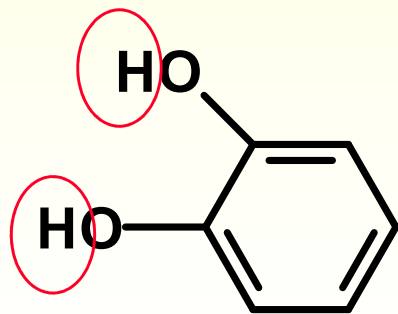
- na rozdíl od alkoholů jsou velmi slabé kyseliny
- dávají podobné reakce jako alkoholy
- **oxidace**



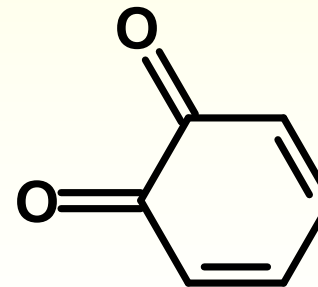
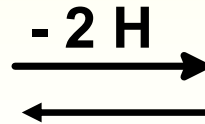
1,4-benzendiol



1,4-benzochinon

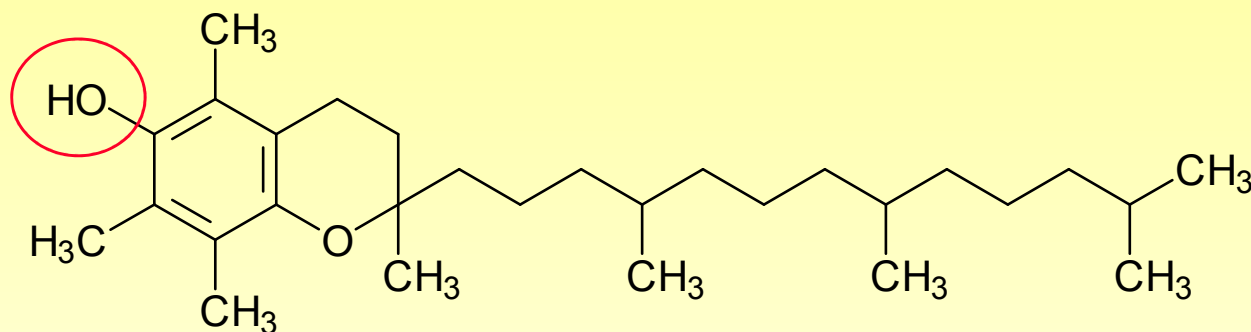


1,2-benzendiol

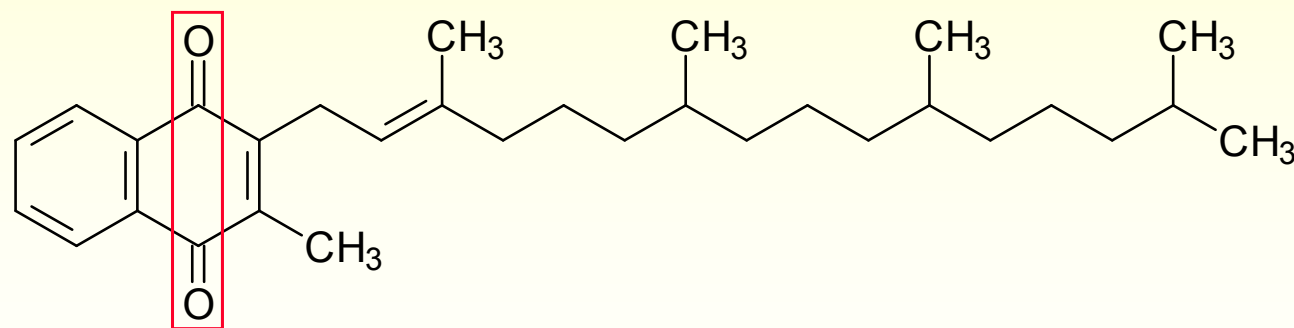


1,2-benzochinon

# Biogenní fenoly a chinony

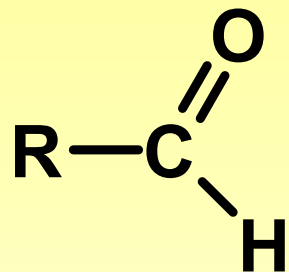


Tokoferol - vitamin E

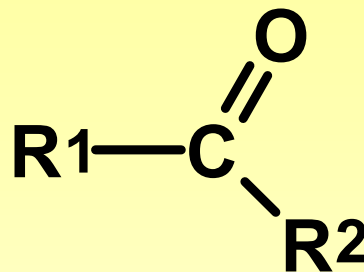


Fylochinon - vitamin K

# Aldehydy a ketony



aldehyd

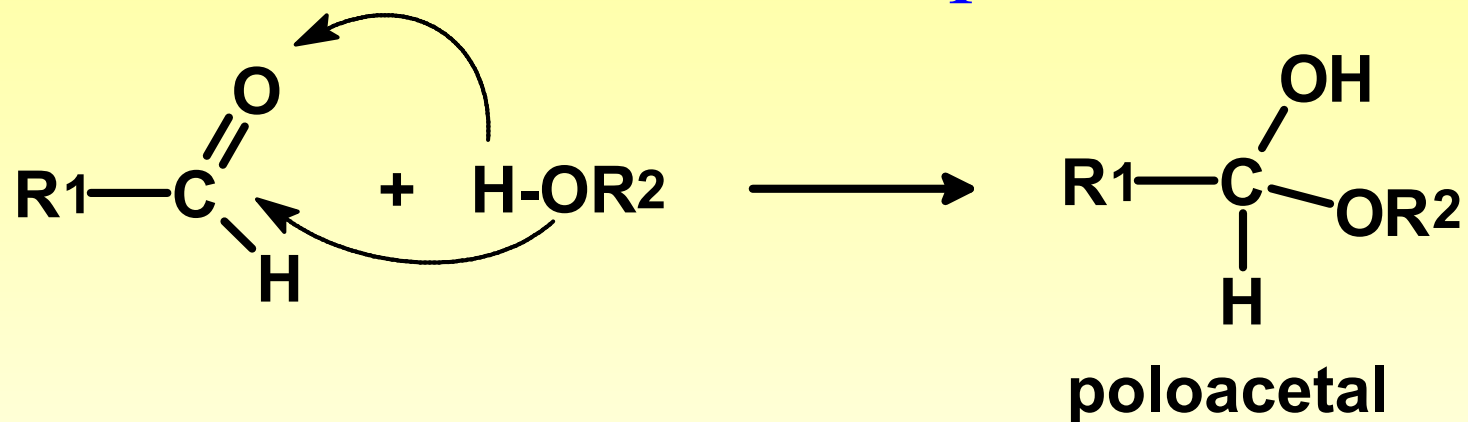


keton

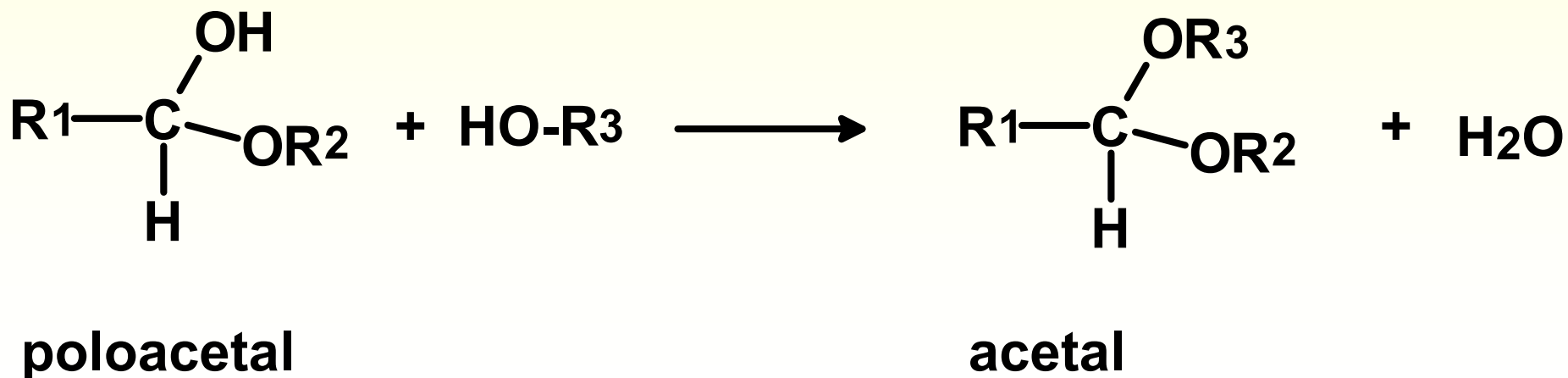
- Jsou reaktivnější než alkoholy
- typická je **adice na polární vazbu C=O**
- aldehydy se oxidují na karboxylové kyseliny

# Reakce aldehydů a ketonů

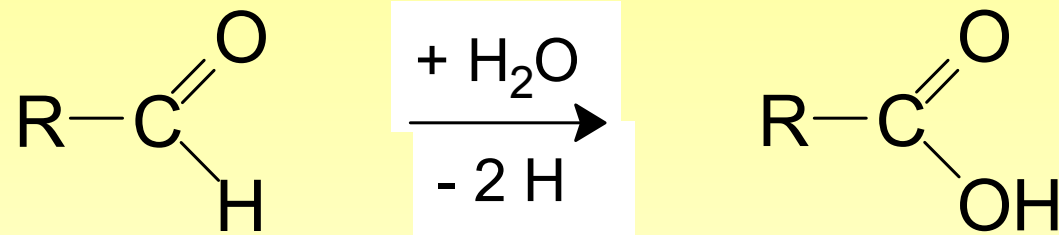
- Adice alkoholů za vzniku poloacetalu



- přeměna poloacetalu na acetal - substituce

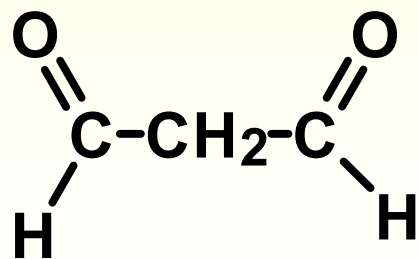


- Aldehydy se snadno oxidují na karboxyl. kyseliny



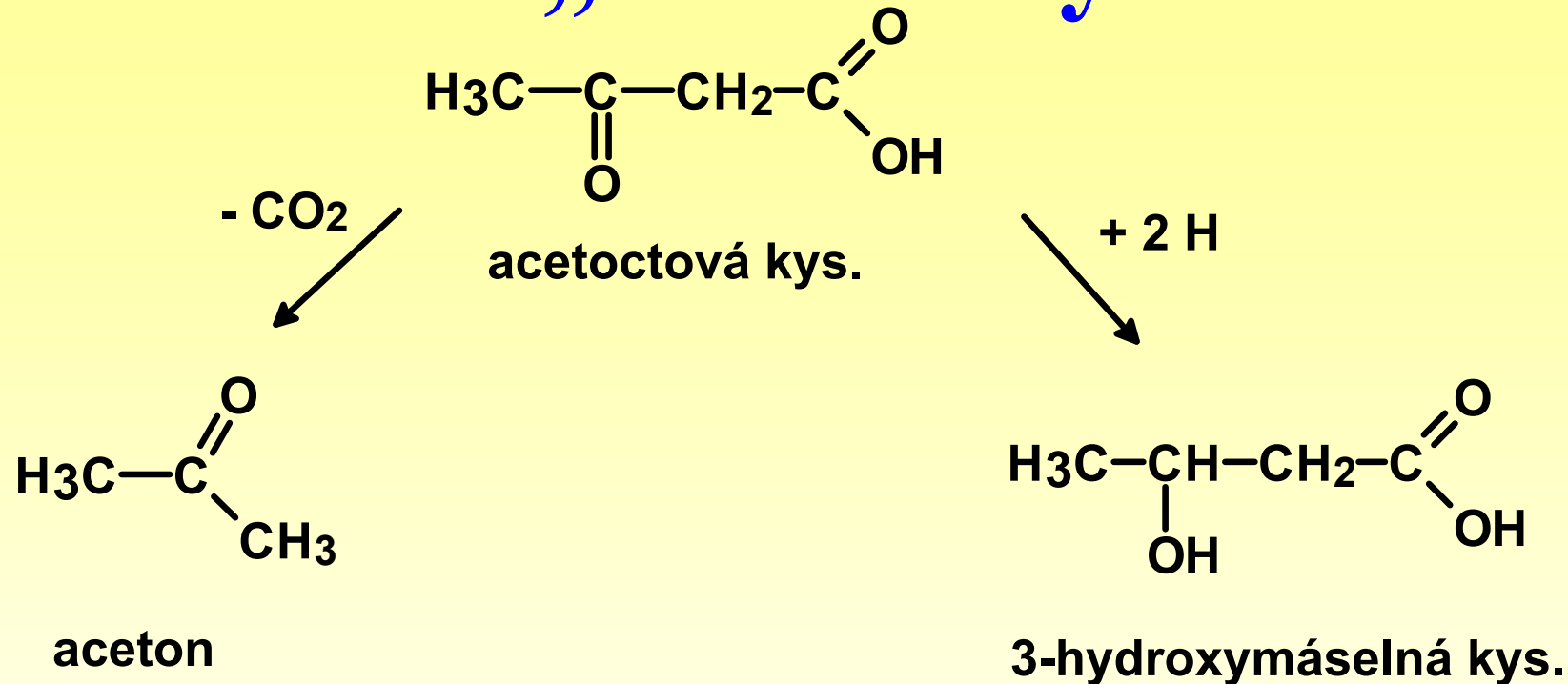
- Ketony se oxidují nesnadno

## Malondialdehyd (dialdehyd kys. malonové)



- reaktivní **produkt peroxidace** (oxidace) lipidů
- vzniká z nenasycených mastných kys.

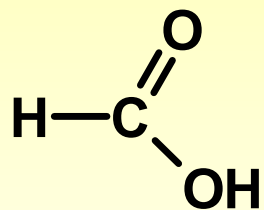
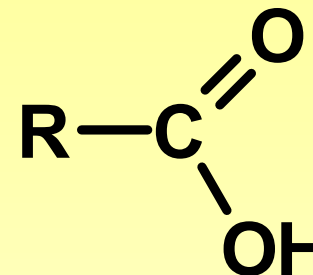
# „Ketolátky“



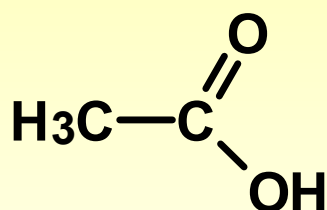
- vznikají při odbourávání tuků (mastných kyselin)
- vznikají jen v nepatrném množství v játrech
- ve zvýšené míře při zvýšeném odbourávání tuků (např. **nekompenzovaná cukrovka, hladovění**) ketoacidóza
- vylučují se močí, potem a dechem
- stanovují se v moči testem s nitroprusidem sodným

# Karboxylové kyseliny

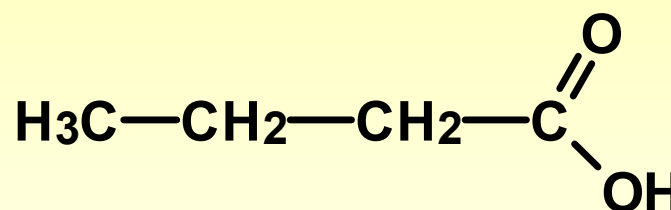
- Karboxylová skupina je polární
- jsou slabé kyseliny



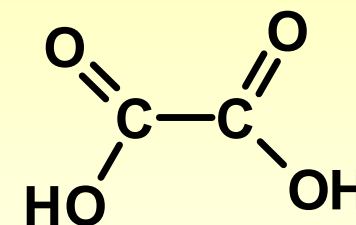
kys. mravenčí



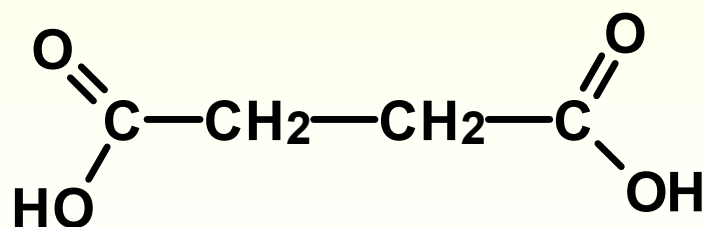
kys. octová



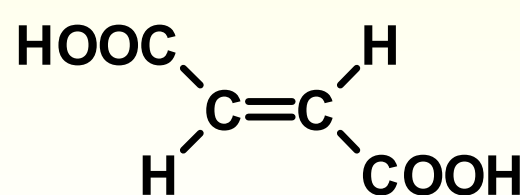
kys. máselná



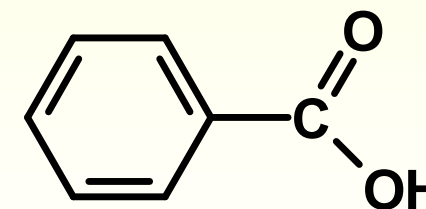
kys. šťavelová



kys. jantarová

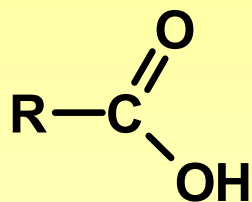


kys. fumarová

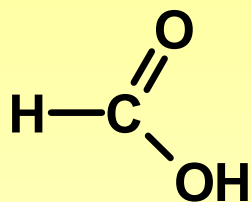


kys. benzoová

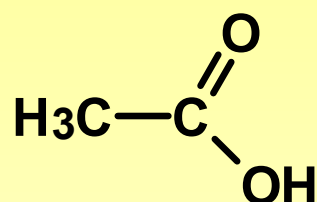
# Názvy acylů karboxylových kyselin



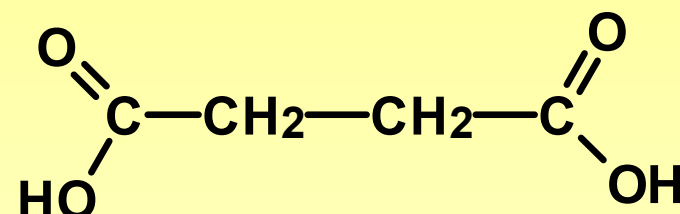
karboxylová kys.



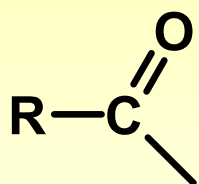
kys. mravenčí



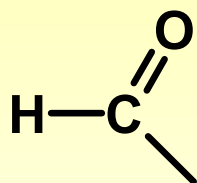
kys. octová



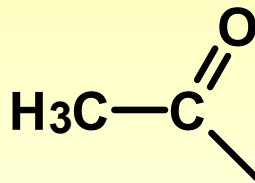
kys. jantarová



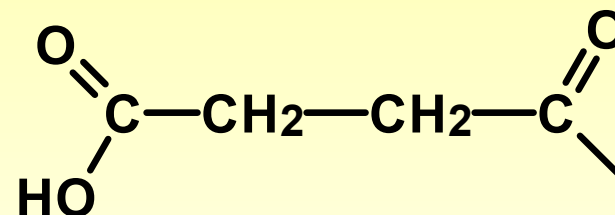
acyl



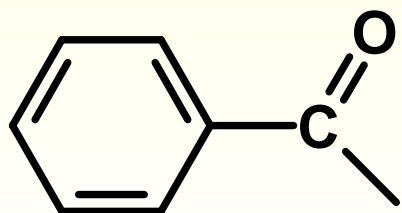
formyl



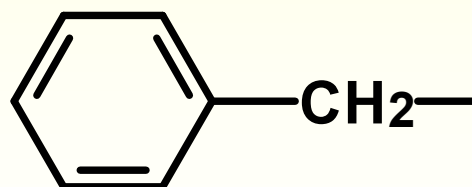
acetyl



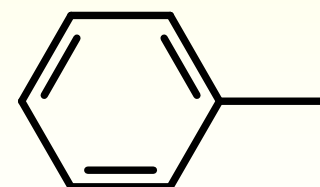
sukcinyl



benzoyl



benzyl

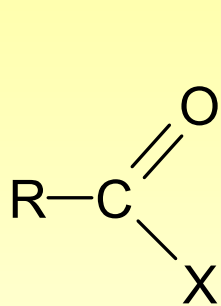


fenyl

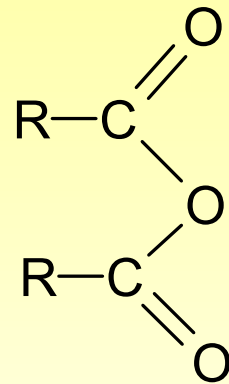


# Funkční deriváty karboxylových kyselin

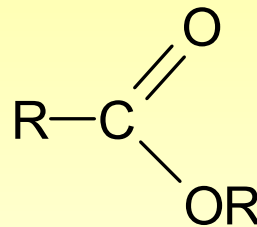
- nejsou kyselé, mohou se hydrolyzovat na karboxyl. kys.



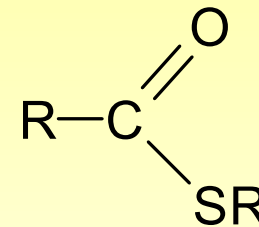
acylhalogenid



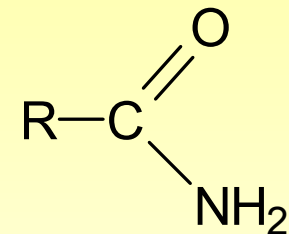
anhydrid



ester

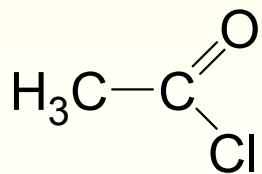


thioester

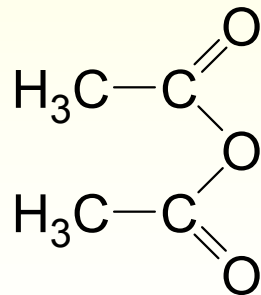


amid

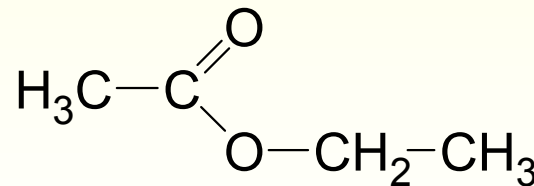
## Příklady



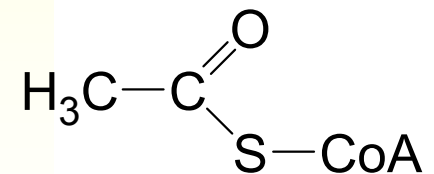
acetylchlorid



acetanhydrid

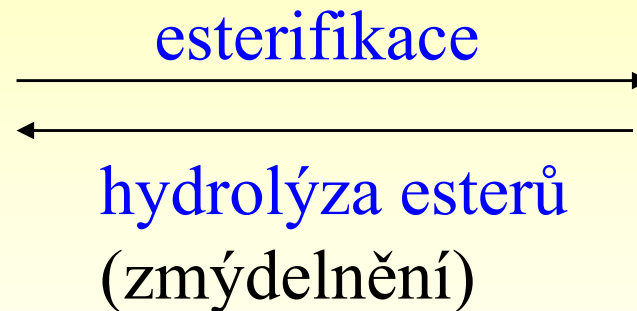
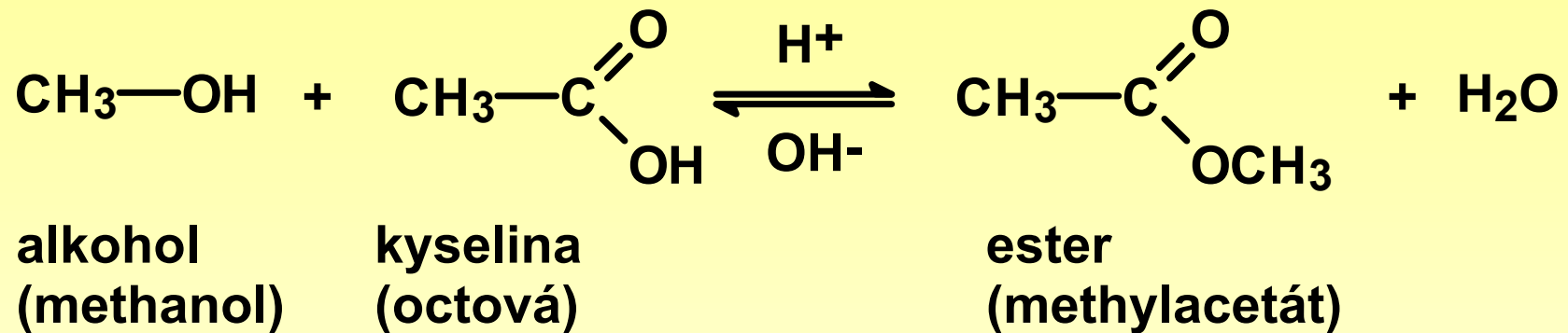


ethyl-acetát



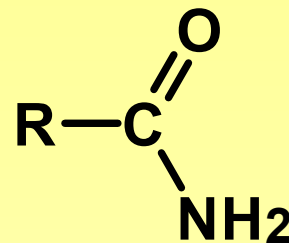
acetylkoenzym A

# Estery

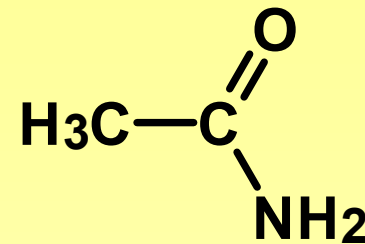


- estery jsou těkavé kapaliny většinou příjemné vůně
- **tuky** - estery glycerolu a vyšších mastných kyselin

# Amidy



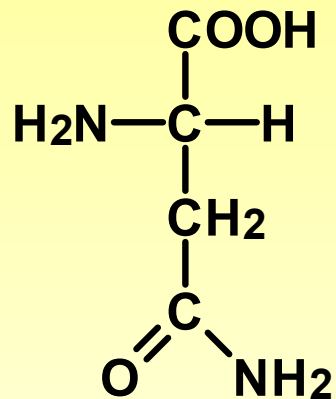
amid



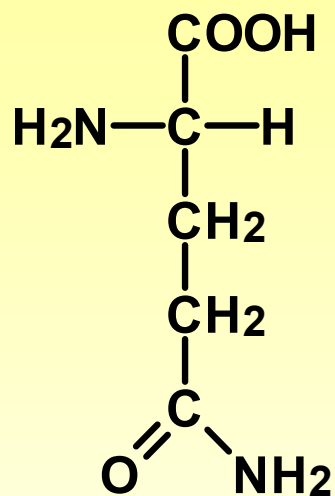
acetamid

- na rozdíl od aminů ( $\text{R}-\text{NH}_2$ ) **nejsou bazické**
- odolnější vůči alkalické hydrolýze na rozdíl od esterů
- mezi amidy patří aminokyseliny: **asparagin** a **glutamin**
- mezi amidy patří **peptidy a bílkoviny**

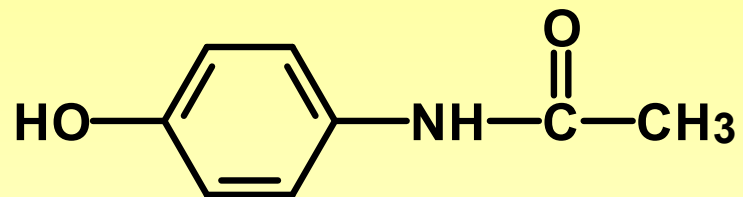
# Významné amidy



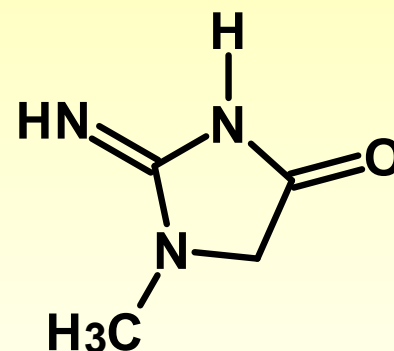
asparagin



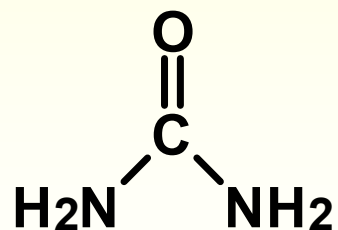
glutamin



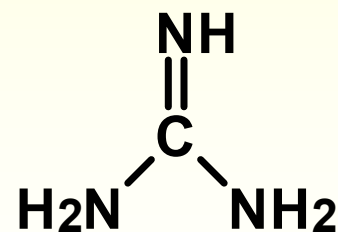
paracetamol



kreatinin  
(laktam)  
(intramolekulární amid)

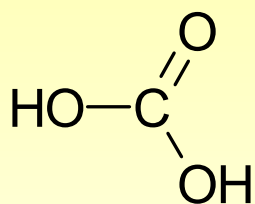


močovina  
(polární)

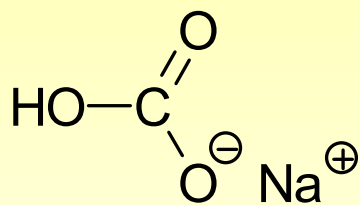


guanidin  
(silná báze)

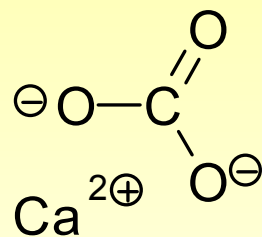
# Deriváty kyseliny uhličité



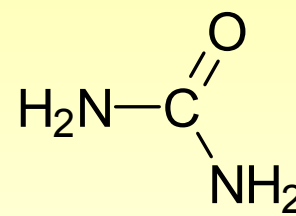
kyselina uhličitá



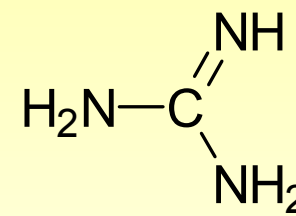
hydrogenuhličitan  
sodný ( $\text{NaHCO}_3$ )



uhličitan vápenatý  
( $\text{CaCO}_3$ )



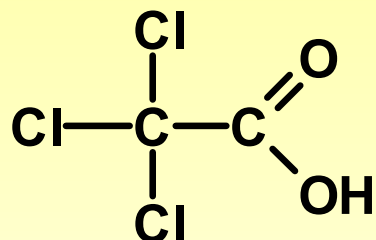
močovina



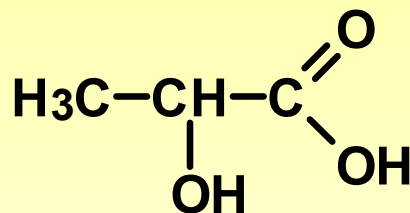
guanidin

# Substituční deriváty karboxylových kyselin

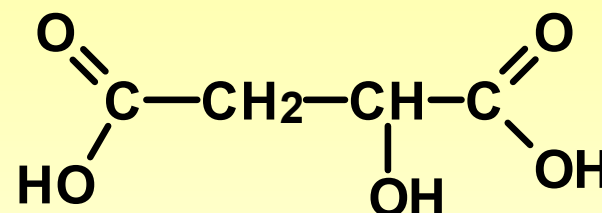
## Halogenkyseliny, hydroxykyseliny



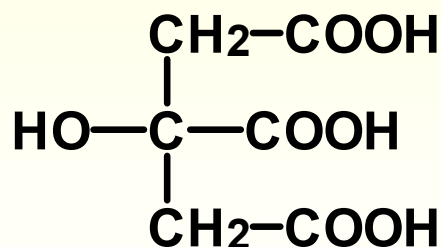
trichloroctová kys.  
(př. halogenkyseliny)



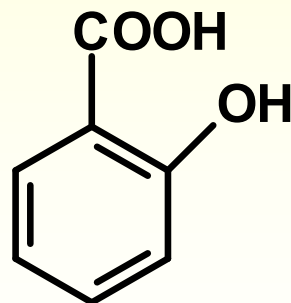
kys. mléčná  
(sůl laktát)



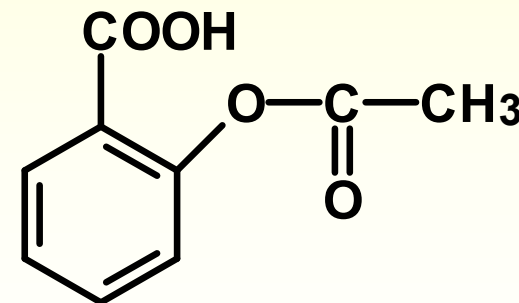
kys. jablečná  
(sůl malát)



kys. citronová  
(sůl citrát)

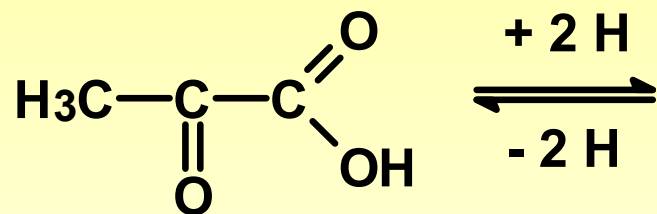


kys. salicylová  
(sůl salicylát)

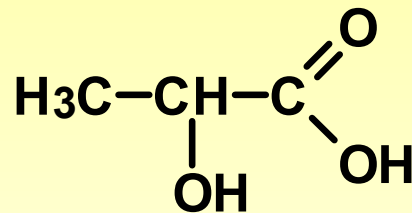
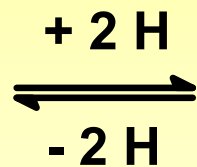


kys. acetylsalicylová

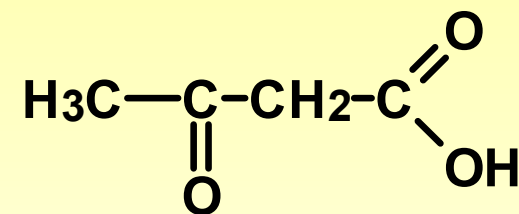
# Oxokyseliny



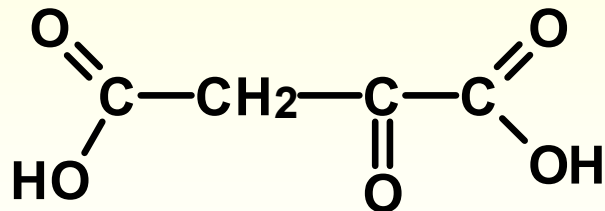
kys. pyrohroznová  
(sůl pyruvát)



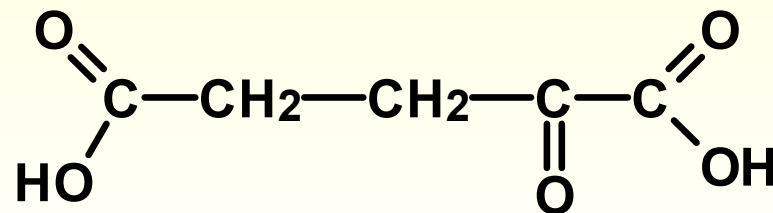
kys. mléčná



kys. acetoctová

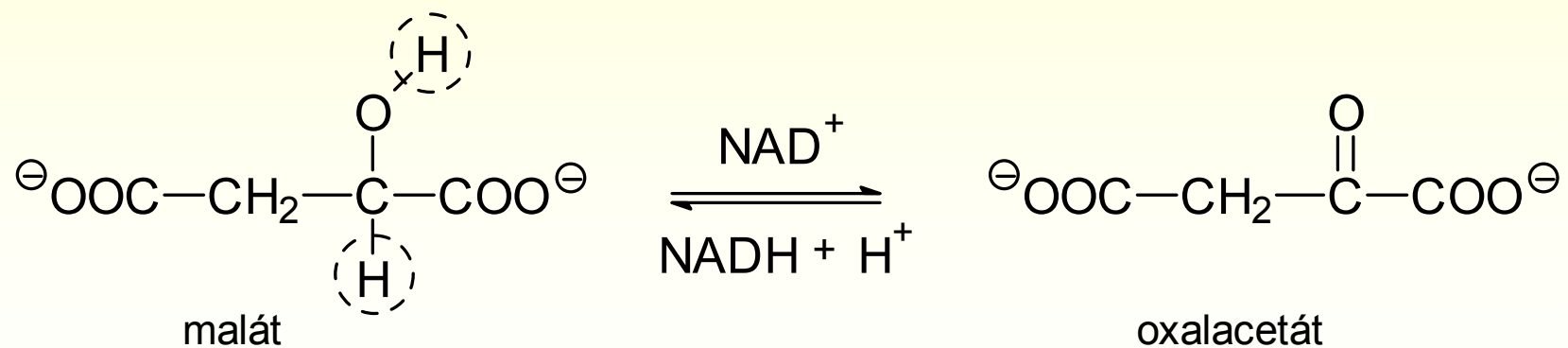
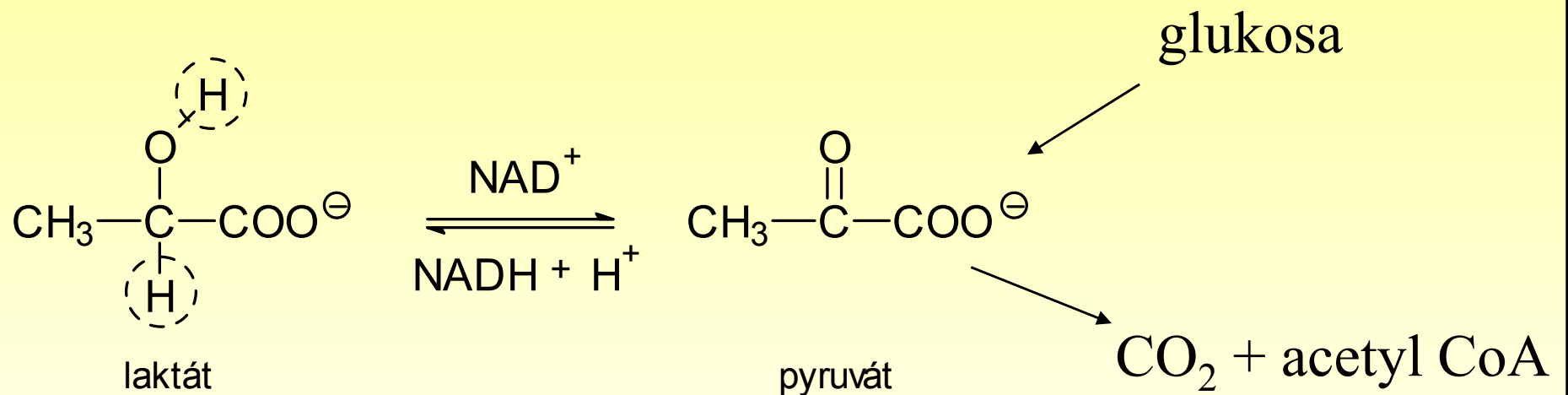


kys. oxaloctová



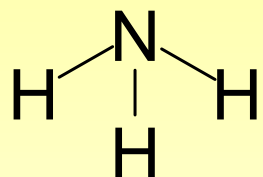
kys. 2-oxoglutarová

# Přeměny hydroxykyselin a oxokyselin

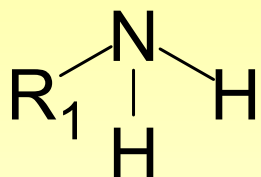




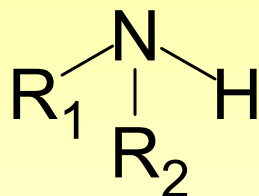
# Aminy



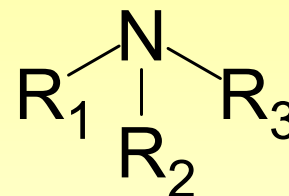
amoniak



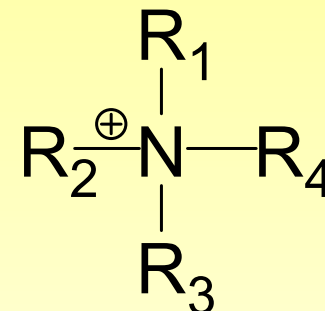
primární  
amin



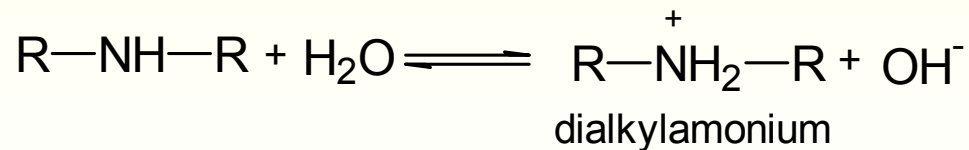
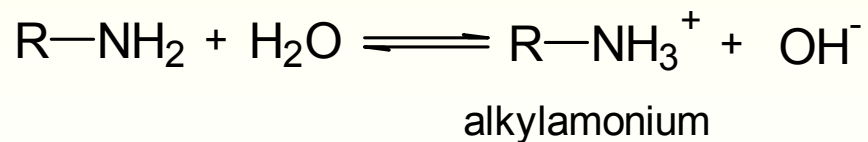
sekundární  
amin



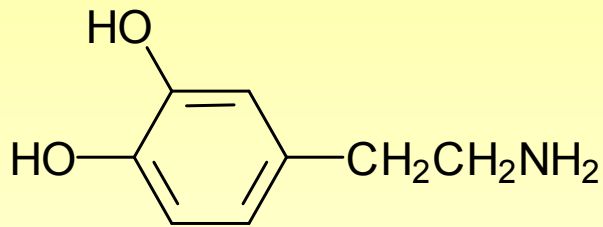
terciární  
amin



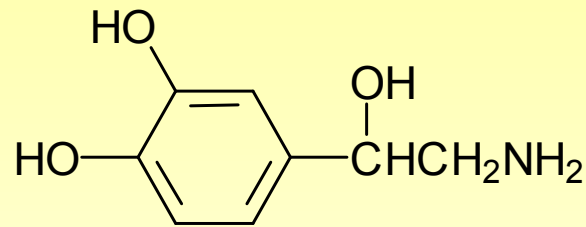
kvarterní  
amonná sůl



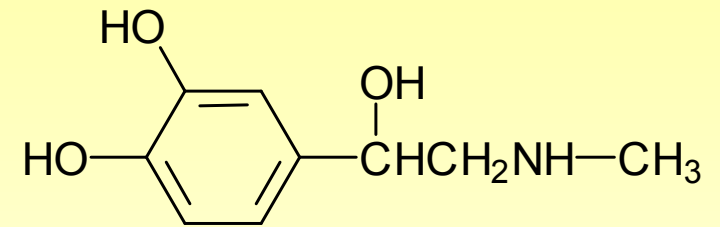
# Biogenní aminy



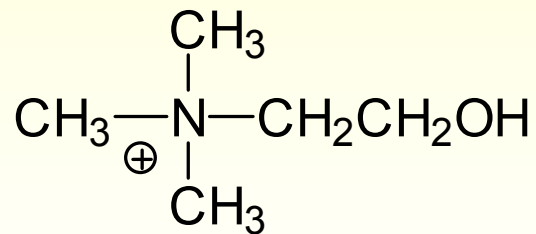
dopamin



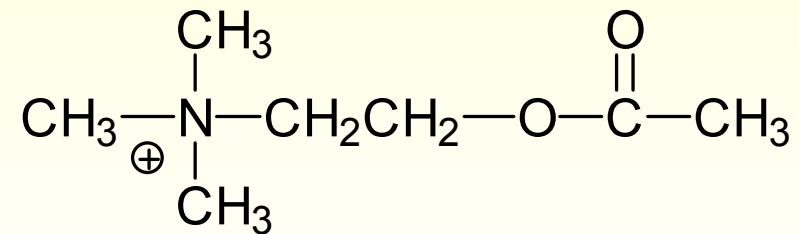
noradrenalin



adrenalin

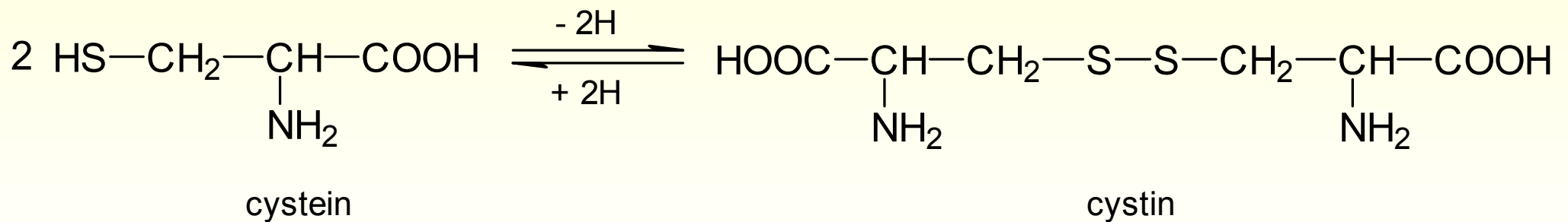
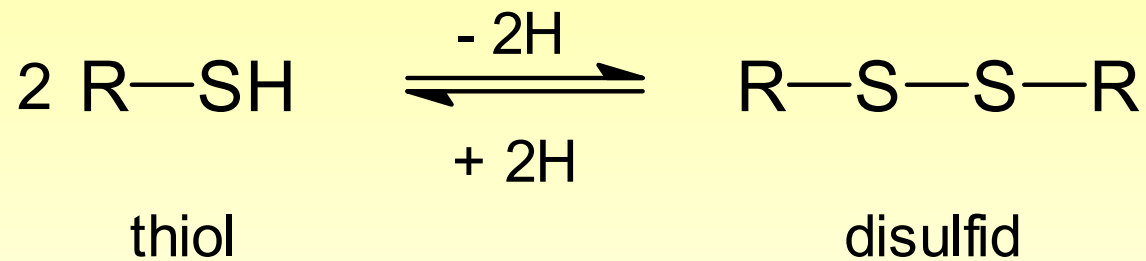


cholin



acetylcholin

# Thioly

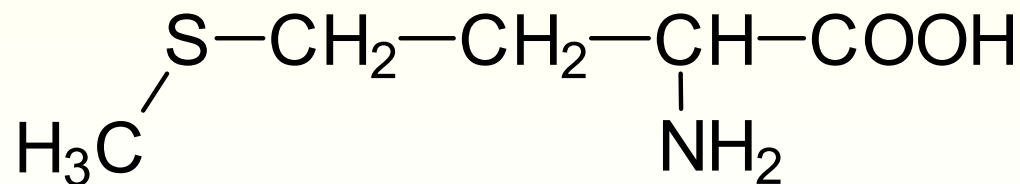
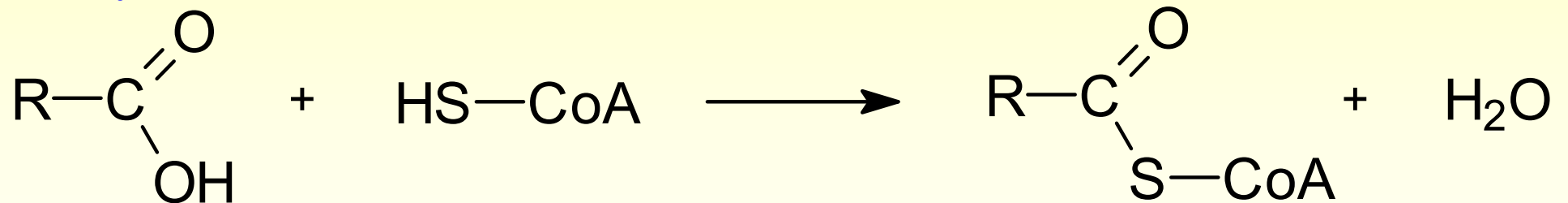


# Významné thioly

glutathioperoxidasa

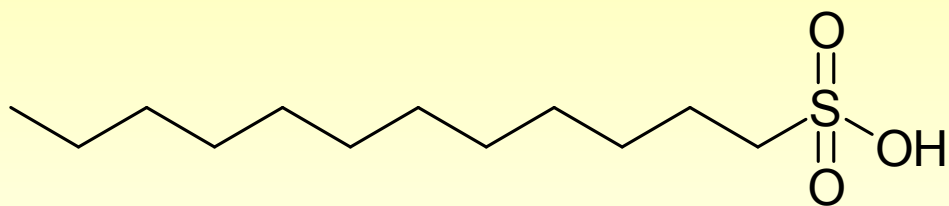


**Koenzym A:**

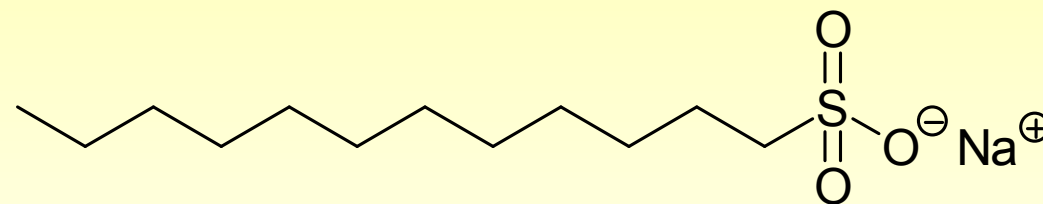


methionin

# Sulfonové kyseliny



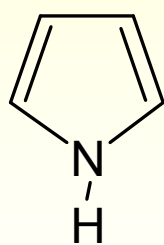
dodekansulfonová kyselina



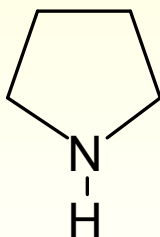
natrium-dodekansulfonát

# Heterocyklické sloučeniny

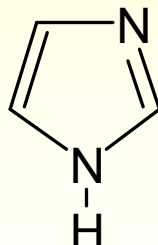
- Cyklické sloučeniny s jiným atomem než C v kruhu
- Nejstabilnější 5ti a 6ti členné heterocykly
- Přednost mají triviální názvy



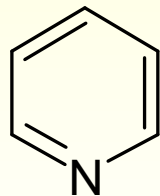
pyrrol



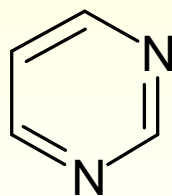
pyrrolidin



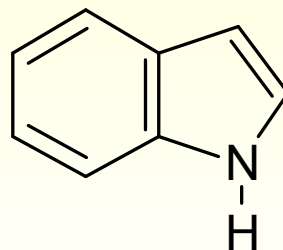
imidazol



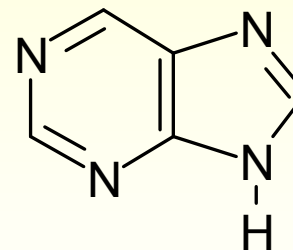
pyridin



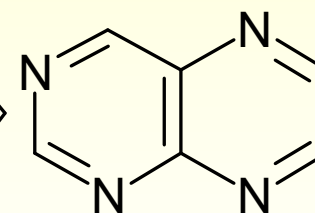
pyrimidin



indol

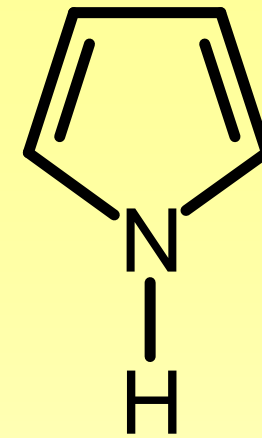


purin

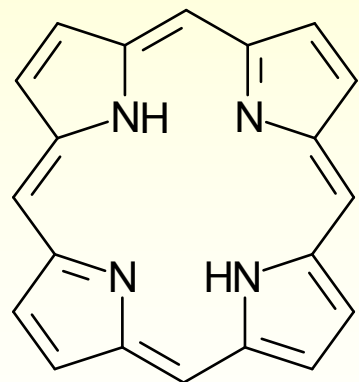


pteridin

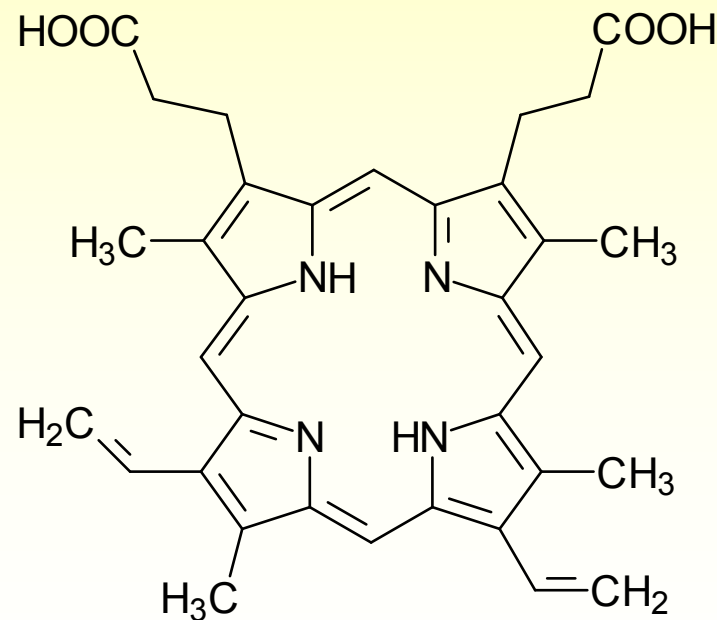
# Pyrrol



- Cyklické tetrapyrroly (př. hem, kyanokobalamin)



porfin

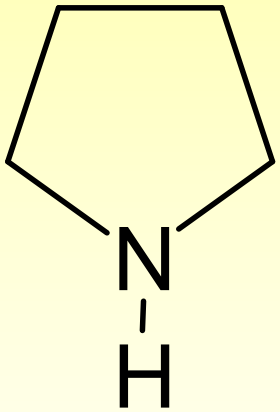


protoporfyryn IX

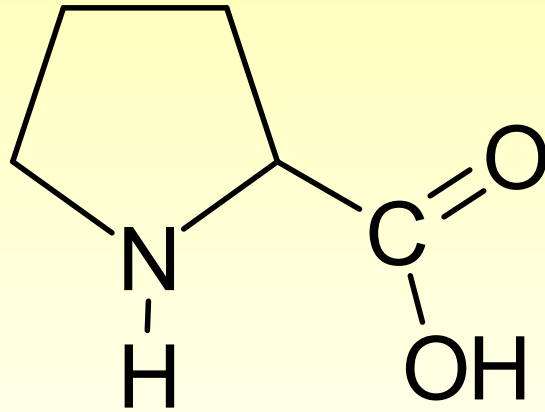
Hem:

- hemoglobin
- myoglobin
- cytochromy
- katalasa

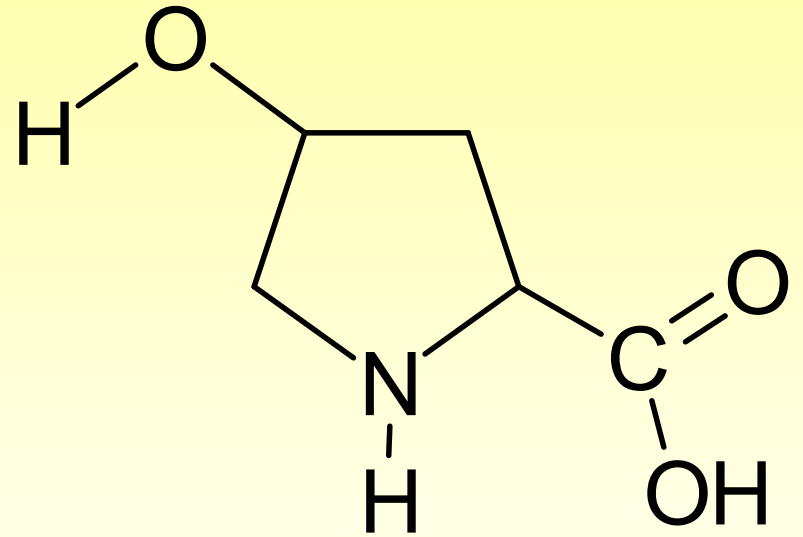
# Pyrrolidin



pyrrolidin



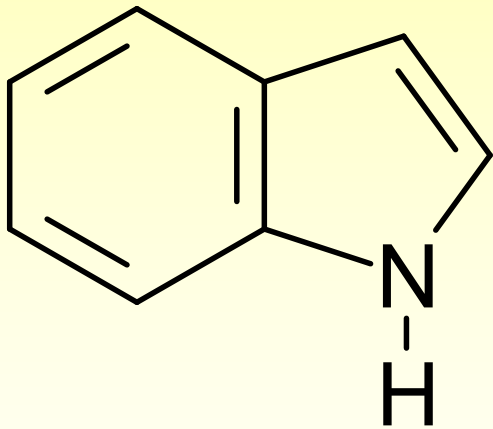
prolin



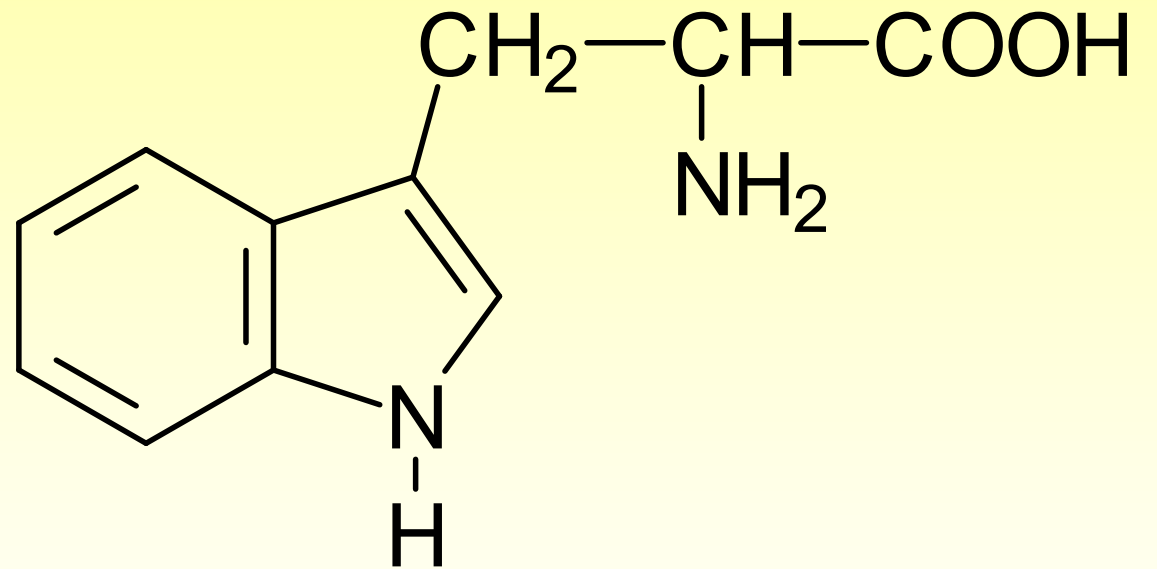
4-hydroxyprolin



# Indol

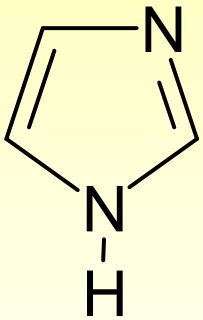


indol

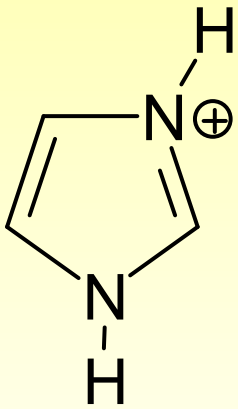


tryptofan

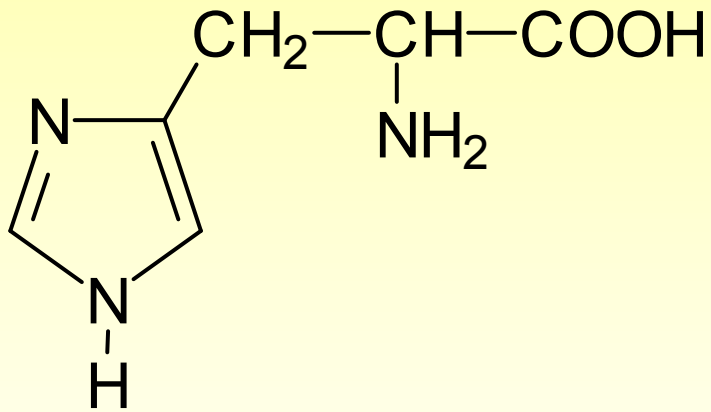
# Imidazol



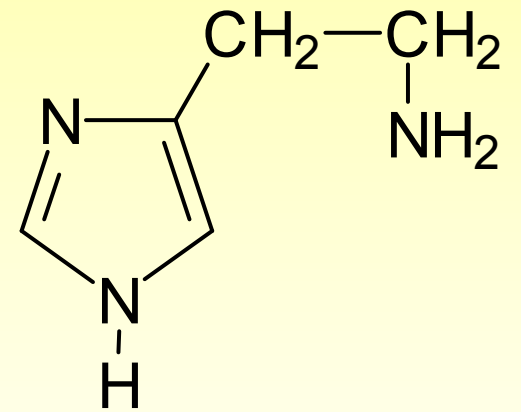
imidazol



imidazolium

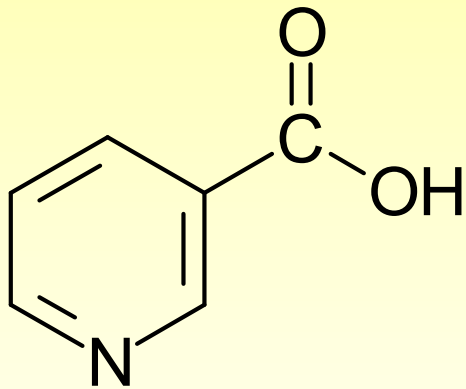


histidin

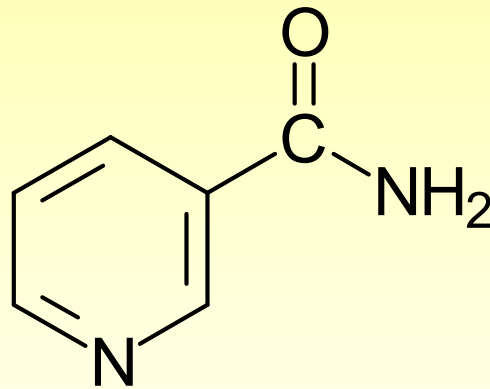


histamin

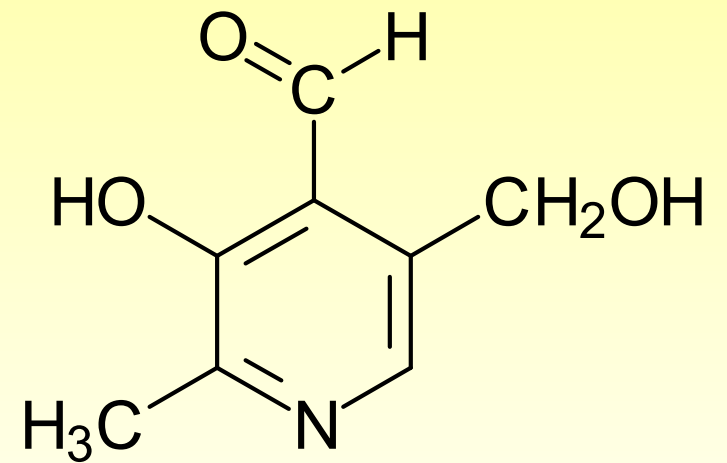
# Pyridin



nikotinová kyselina

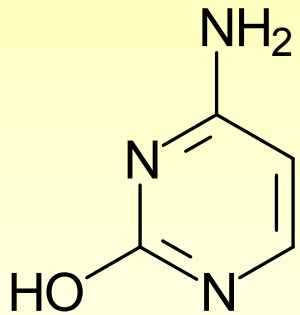


nikotinamid

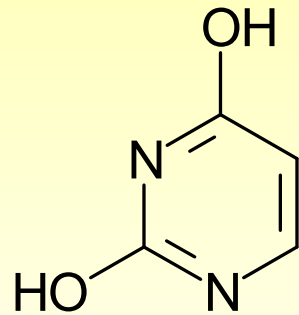


pyridoxal

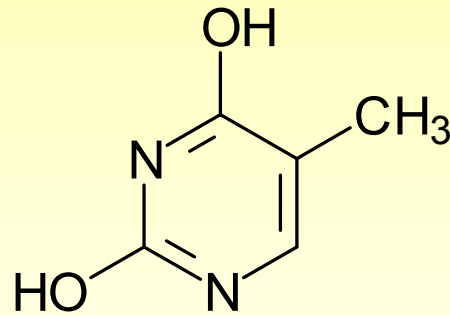
# Pyrimidin



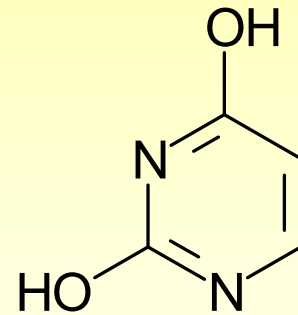
cytosin



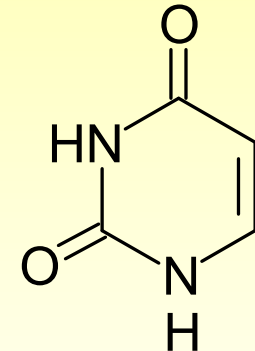
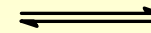
uracil



thymin



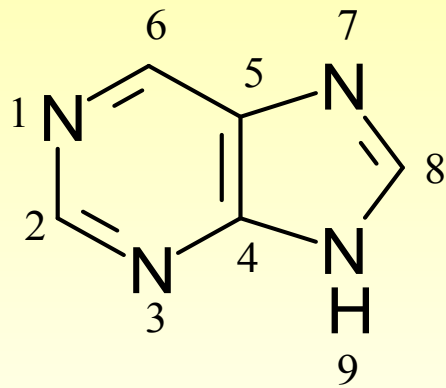
laktim uracilu



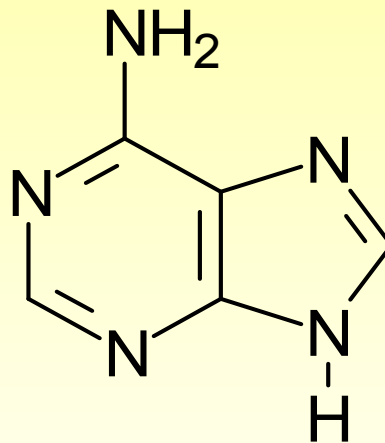
laktam uracilu

## Pyrimidinové báze

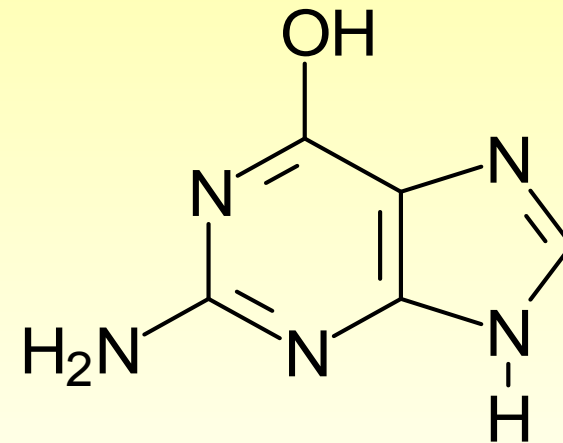
# Purin



purin



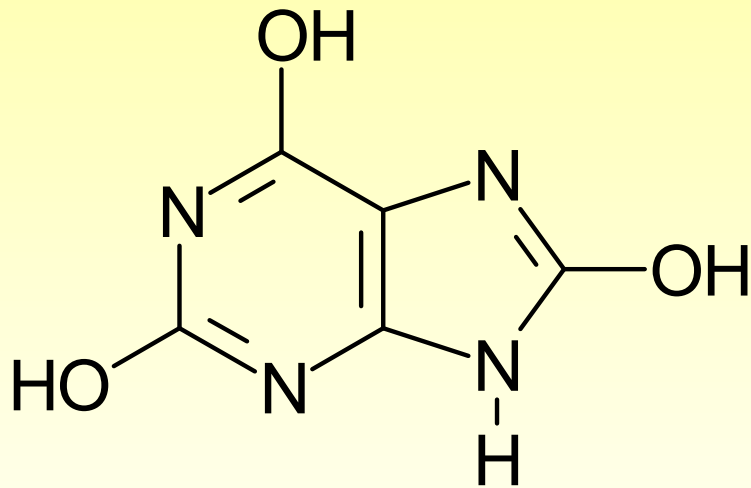
adenin



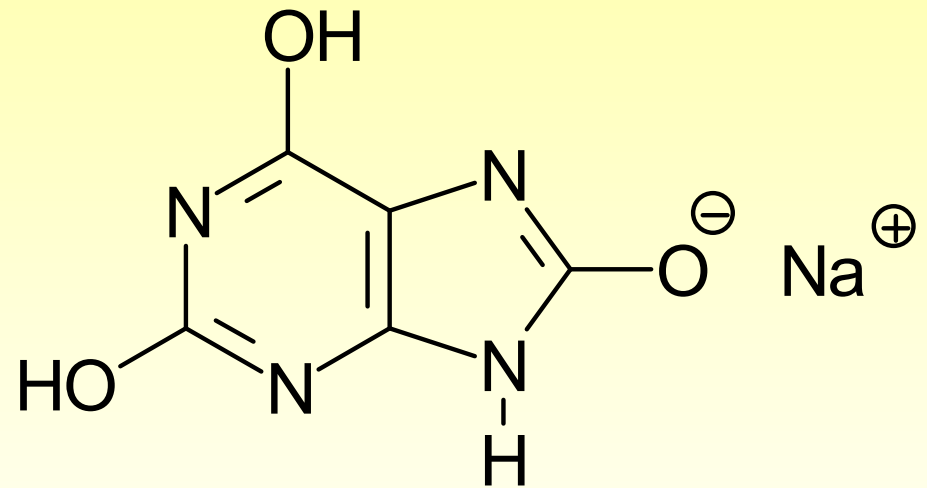
guanin

## Purinové báze

# Močová kyselina



močová kyselina



hydrogenurát sodný