

# C3181

# Biochemie I

01c-Aminokyseliny

FRVŠ **1647/2012**

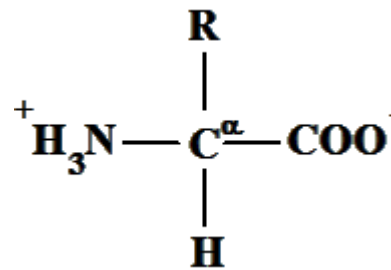
# Obsah

- Aminokyseliny jako stavební kameny bílkovin
- Obecná struktura, popis
- Významné vlastnosti
  - Chiralita
  - Acidobazicitá
  - Polarita
  - Reaktivita

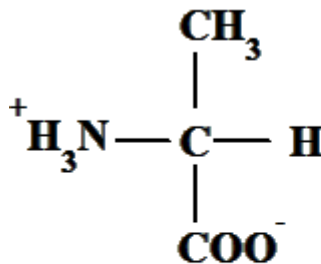
# Obecná struktura aminokyselin

- $\alpha$ -aminokyseliny  
(2-aminokyseliny)

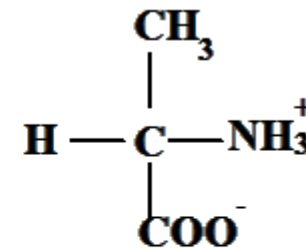
R – specifický zbytek  
jednotlivých AK



- L-aminokyseliny  
typické pro většinu  
biomolekul (D-vzácně)



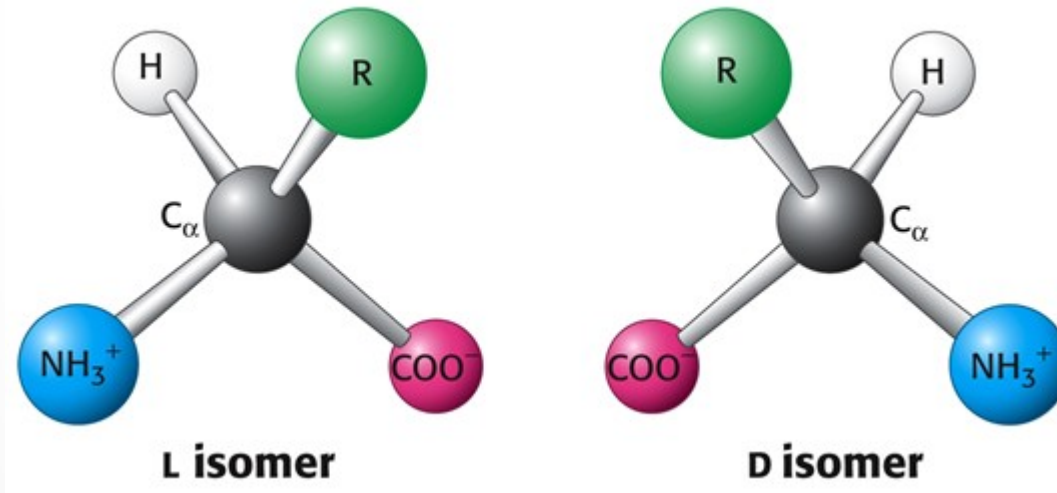
**L -alanin**



**D-alanin**

# Chiralita aminokyselin

- Nejméně 1 asymetrický C (mimo Gly)



# Chiralita aminokyselin

## Absolutní konfigurace

Gly (G) není chirální

Cys (C) je v absolutní konfiguraci *R*

Ile (I) a Thr (T) mají dvě chirální centra.

L-Ile ( $2S,3S$ ) a L-Thr ( $2S,3R$ )

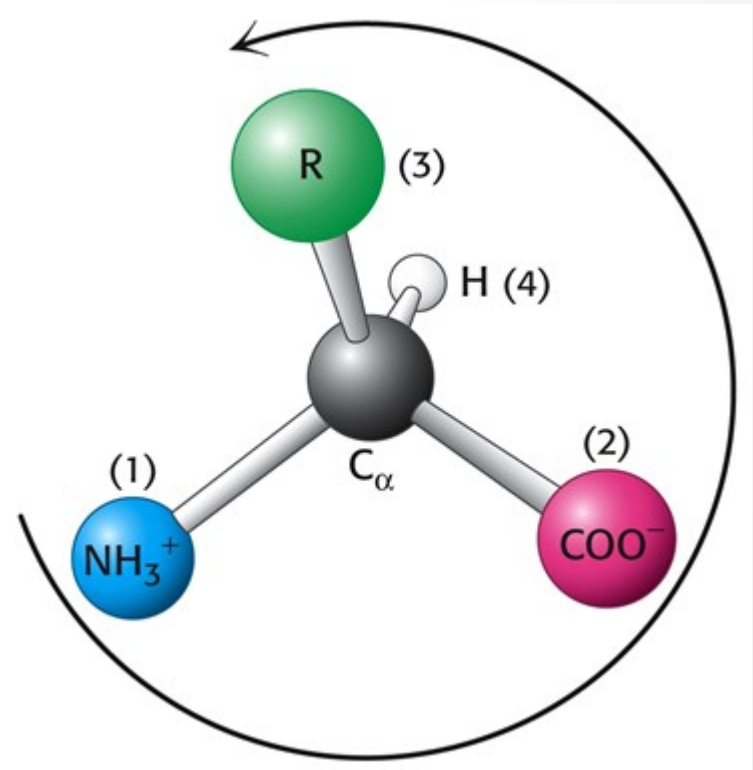
mají dva enantiomery

diastereoizomerní

k alloisoleucinu ( $2R,3S$ )

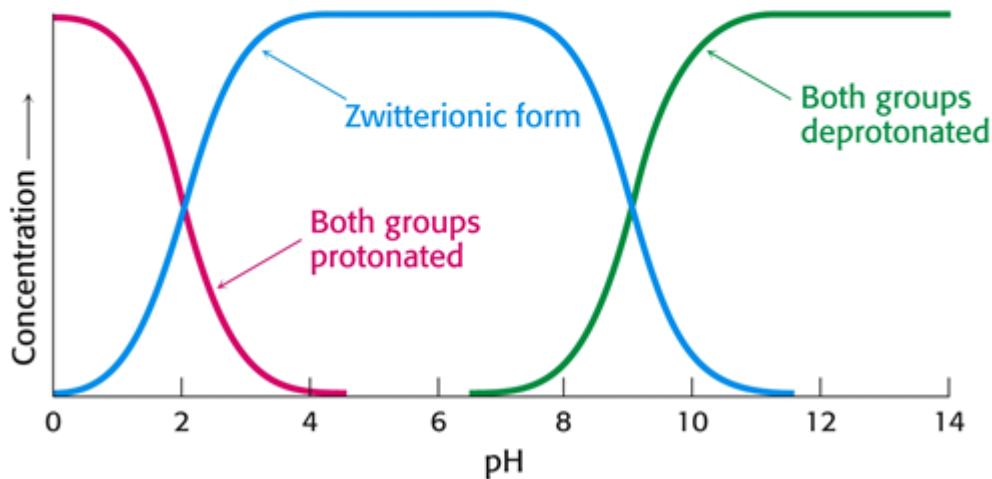
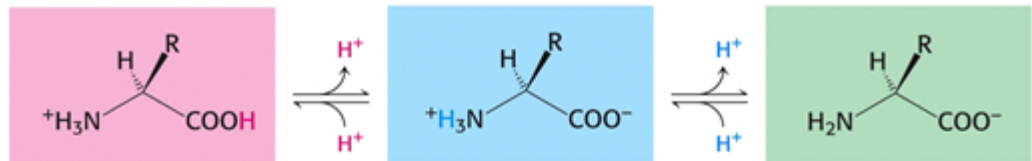
resp. k allothreoninu ( $2R,3R$ ).

**Všechny ostatní L-aminokyseliny jsou *S* !!**



# Acidobazické vlastnosti

- Obojetné ionty x zjednodušené vzorce
- Rozpustnost =  $f(Q)$ , soli x neutrální



# Acidobazické vlastnosti

- Disociace AK
- Jednoduchá struktura
- Více disociabilních skupin – složitější křivka
- Pojem pI

$$pI = \frac{pK_{COOH} + pK_{NH_2}}{2}$$

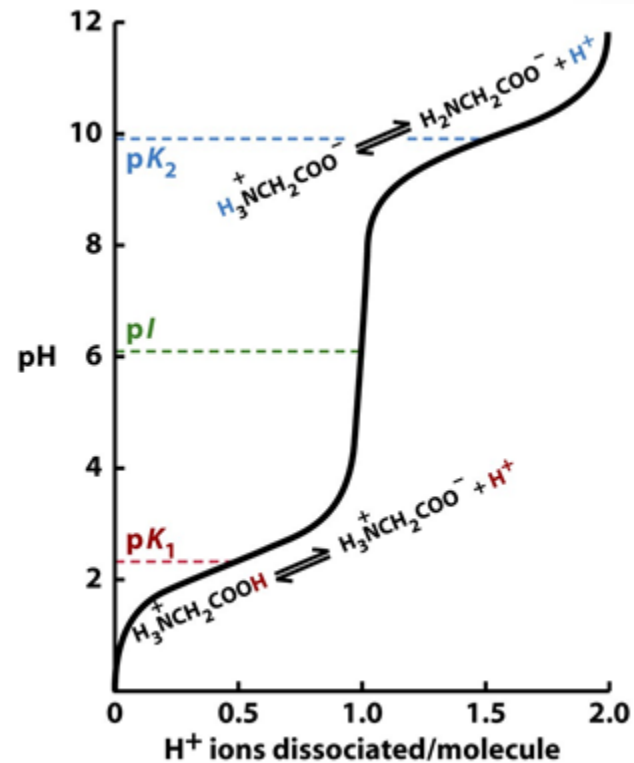


Figure 4-8 Fundamentals of Biochemistry, 2/e  
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# Acidobazické vlastnosti

TABLE 3.1 Typical pK<sub>a</sub> values of ionizable groups in proteins

Group	Acid	⇌	Base	Typical pK <sub>a</sub> *
Terminal α-carboxyl group				3.1
Aspartic acid Glutamic acid				4.1
Histidine				6.0
Terminal α-amino group				8.0
Cysteine				8.3
Tyrosine				10.9
Lysine				10.8
Arginine				12.5

\*pK<sub>a</sub> values depend on temperature, ionic strength, and the microenvironment of the ionizable group.

Více disociabilních skupin

$$pI = (pK_m + pK_n)/2$$

kde pK<sub>m</sub> a pK<sub>n</sub> ohraničují neutrální formu

Výpočet je informativní (vliv molekuly na disociaci)

Platí i pro jiné amfoionty

Skupina	pK	Skupina	pK	Skupina	pK
α COOH	1.8 - 2.5	β COOH	3.9	γ COOH	4.1
α NH <sub>2</sub>	9 - 10	ε NH <sub>2</sub>	10.8	guanidin	12.5
imidazol	6.0	SH	8.3	OH	10.1



# Polarita

- Asymetrie elektronových hustot – nábojů
- Závisí na R
- Hydropatický index
  - $\Delta G$  transportu z o do i fáze
  - Oktanol – voda
  - Jiná vyjádření

**TABLE 3.1** Hydropathy scale for amino acid residues

Amino acid	Free-energy change for transfer ( $\text{kJ mol}^{-1}$ )
Isoleucine	3.1
Phenylalanine	2.5
Valine	2.3
Leucine	2.2
Methionine	1.1
Tryptophan	1.5 <sup>b</sup>
Alanine	1.0
Glycine	0.67
Cysteine	0.17
Tyrosine	0.08
Proline	-0.29
Threonine	-0.75
Serine	-1.1
Histidine	-1.7
Glutamate	-2.6
Asparagine	-2.7
Glutamine	-2.9
Aspartate	-3.0
Lysine	-4.6
Arginine	-7.5

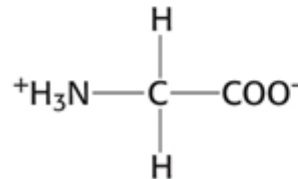
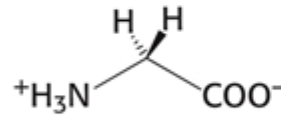
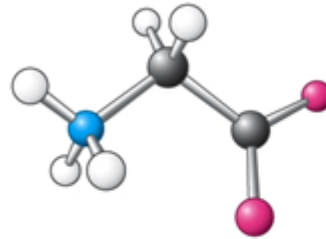
# Přehled aminokyselin

- 20 + 1 + v bílkovinách, proteinogenní, kódované
  - Derivatizované – posttranslační modifikace
- Volné AK a deriváty, složky jiných biomolekul
- Dělení podle struktury – významných vlastností
  - Nepolární – neutrální – alifatické
  - Polární nedisociované (zbytky R)
  - Disociované (zbytky R)
    - Kyselé
    - Bazické
- Jiné dělení, prolínání skupin
  - Aromatické
  - Sírné
  - Heterocyklické apod.

# Nepolární

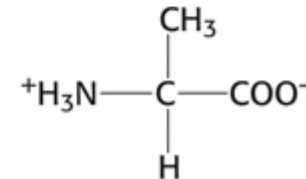
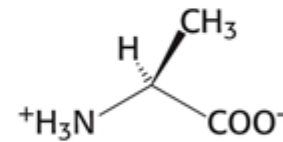
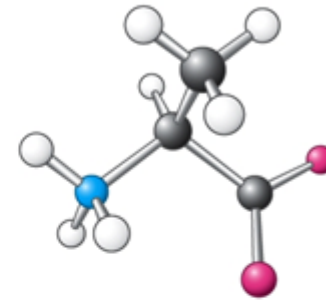
- Alifatické

Glycine  
(Gly, G)



Glycine  
(Gly, G)

Alanine  
(Ala, A)

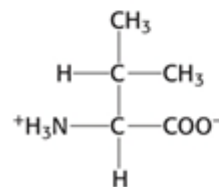
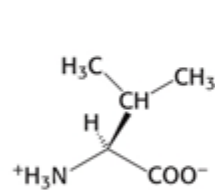
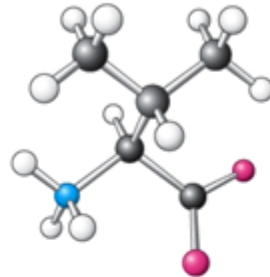


Alanine  
(Ala, A)

# Nepolární

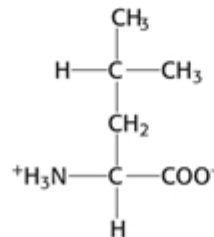
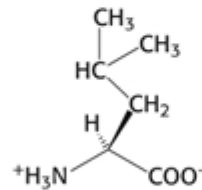
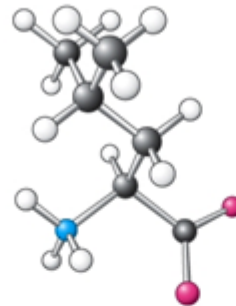
- Alifatické větvené
- Met sirná

**Valine**  
(Val, V)



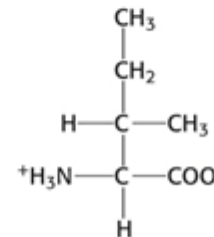
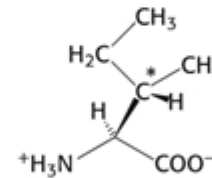
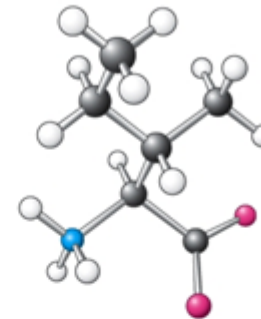
**Valine**  
(Val, V)

**Leucine**  
(Leu, L)



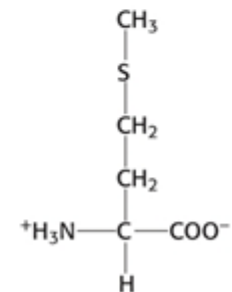
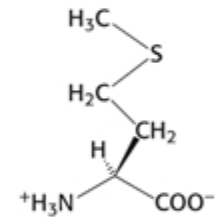
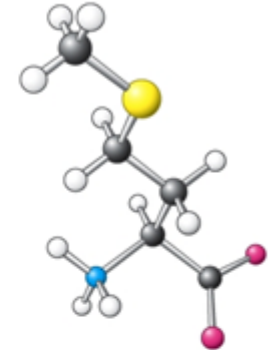
**Leucine**  
(Leu, L)

**Isoleucine**  
(Ile, I)



**Isoleucine**  
(Ile, I)

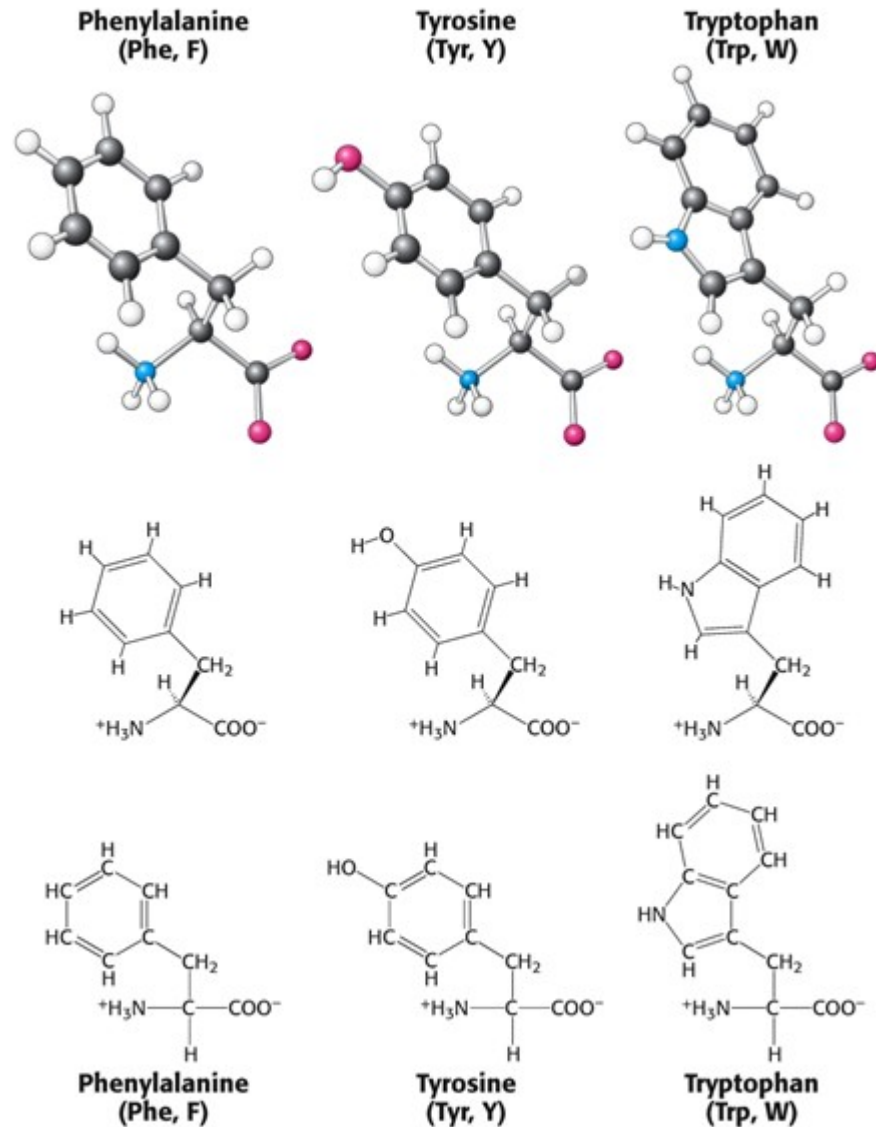
**Methionine**  
(Met, M)



**Methionine**  
(Met, M)

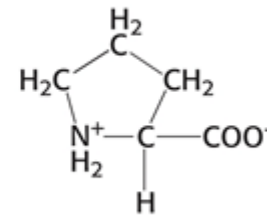
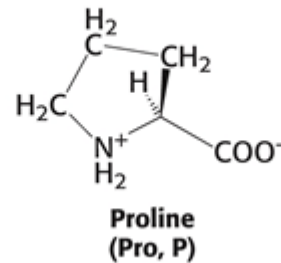
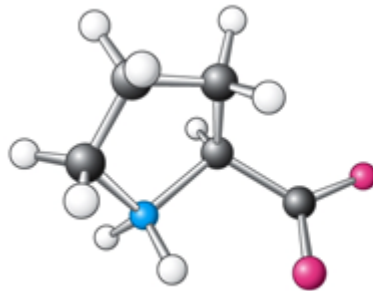
# Nepolární

- Aromatické



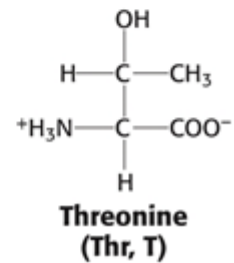
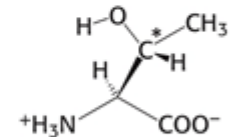
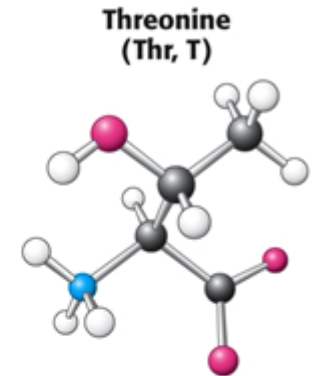
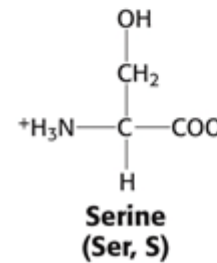
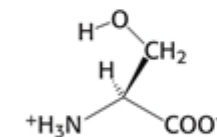
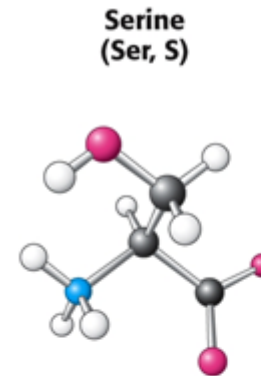
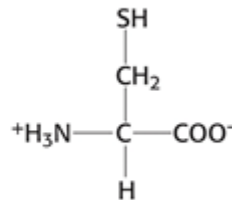
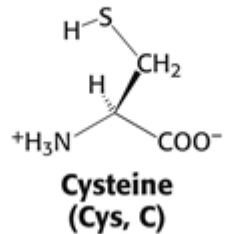
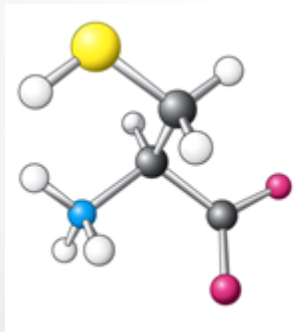
# Nepolární

- Výjimečná struktura
  - Zvláštní dopad na strukturu polymeru – bílkoviny
- Heterocyklická



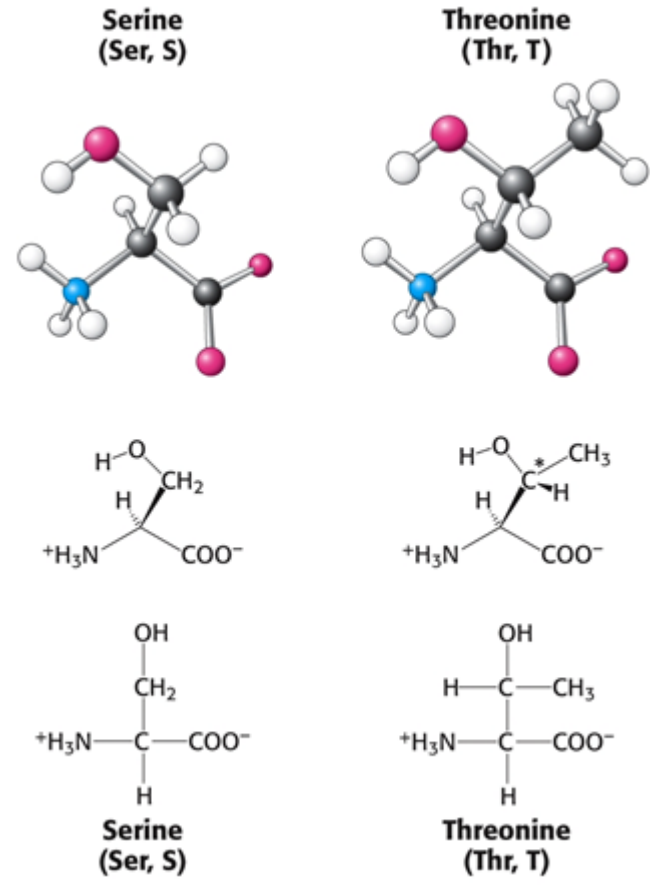
# Polární nedisociované

- Hydroxy AK
- Sirná – Cys  
(sl. kyselá)



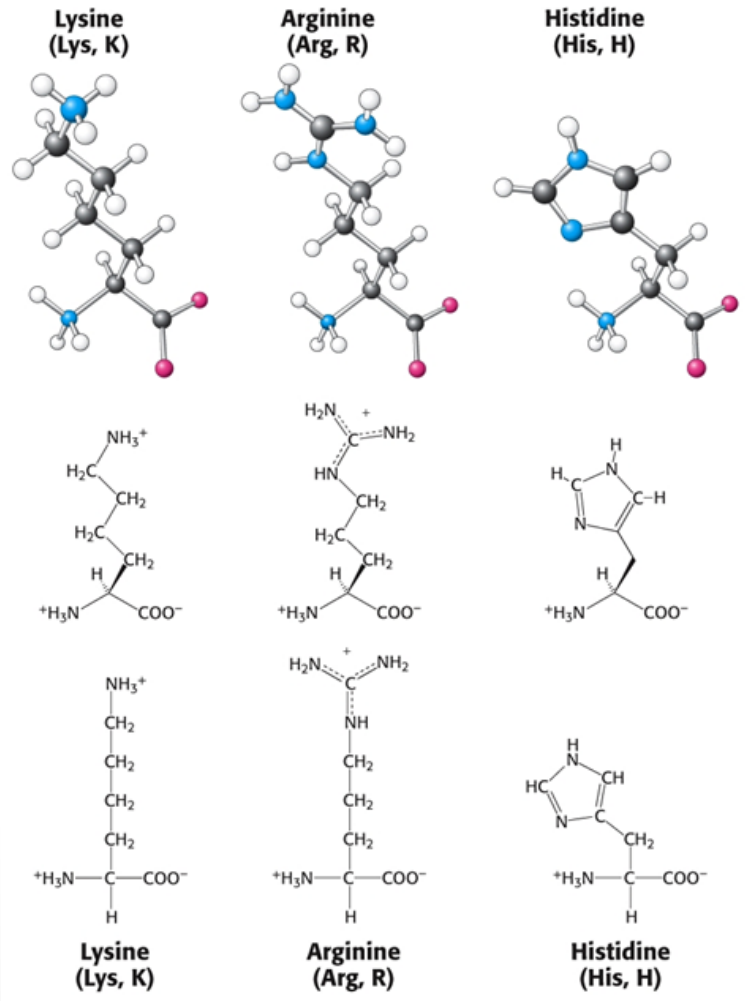
# Polární nedisociované

- Hydroxy AK



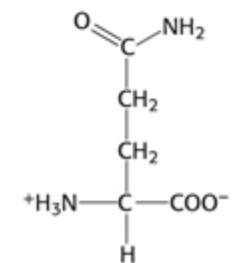
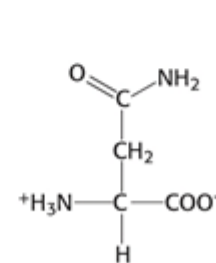
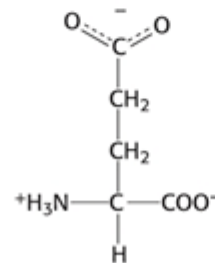
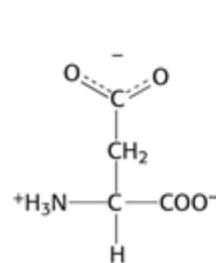
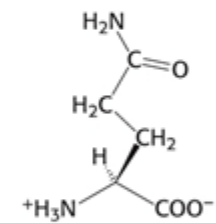
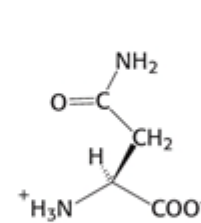
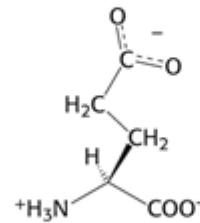
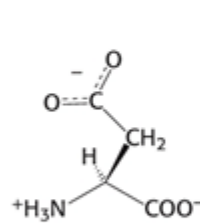
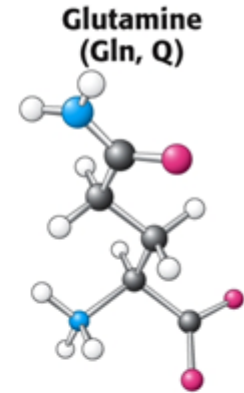
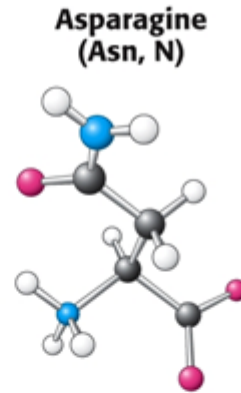
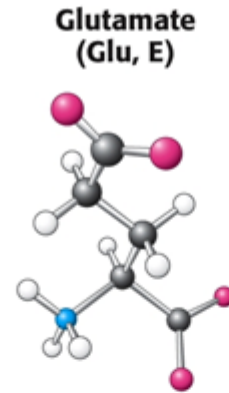
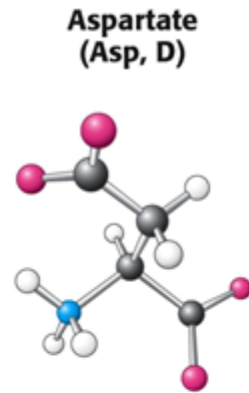


# Disociované - bazické



# Disociované - kyselé

- Asn a Gln nedisociované, nejsou aminy!



**Aspartate (Asp, D)**

**Glutamate (Glu, E)**

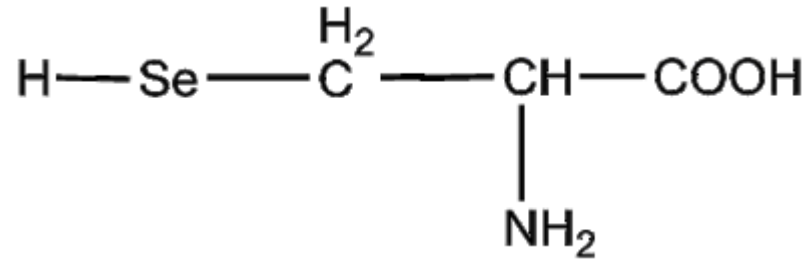
**Asparagine (Asn, N)**

**Glutamine (Gln, Q)**

# Speciální

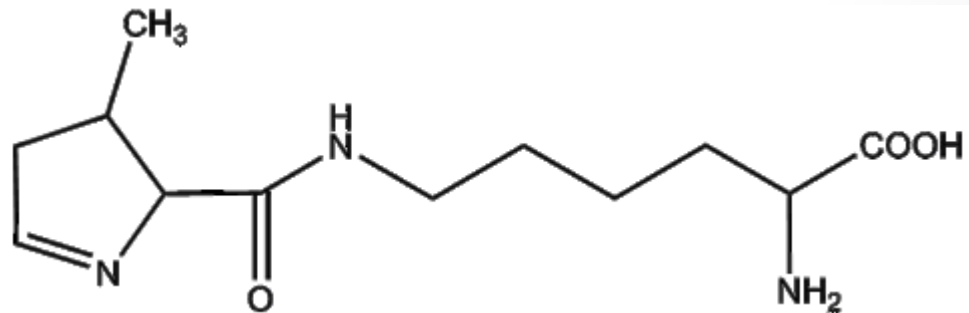
- Výskyt omezen na několik bílkovin či mikroorganismů
- Selenocystein

  - GSH peroxidáza aj.
  - Antioxidační



- Pyrolyzin

  - Archea



# Názvy a zkratky

- Troj- a jednopísmenkové

AMK	Symboly		AMK	Symboly	
glycin	Gly	G	methionin	Met	M
alanin	Ala	A	glutamová k.	Glu	E
valin	Val	V	asparagin	Asn	N
leucin	Leu	L	glutamin	Gln	Q
izoleucin	Ile	I	lysin	Lys	K
serin	Ser	S	arginin	Arg	R
threonin	Thr	T	tyrosin	Tyr	Y
cystein	Cys	C	fenylalanin	Phe	F
histidin	His	H	tryptofan	Trp	W
prolin	Pro	P	asparagová k.	Asp	D

- Se-Cys = U

# Názvy a zkratky

- Troj- a jednopísmenkové

**TABLE 3.2** Abbreviations for amino acids

Amino acid	Three-letter abbreviation	One-letter abbreviation	Amino acid	Three-letter abbreviation	One-letter abbreviation
Alanine	Ala	A	Methionine	Met	M
Arginine	Arg	R	Phenylalanine	Phe	F
Asparagine	Asn	N	Proline	Pro	P
Aspartic Acid	Asp	D	Serine	Ser	S
Cysteine	Cys	C	Threonine	Thr	T
Glutamine	Gln	Q	Tryptophan	Trp	W
Glutamic Acid	Glu	E	Tyrosine	Tyr	Y
Glycine	Gly	G	Valine	Val	V
Histidine	His	H	Asparagine or aspartic acid	Asx	B
Isoleucine	Ile	I	Glutamine or glutamic acid	Glx	Z
Leucine	Leu	L			
Lysine	Lys	K			

- Se-Cys = U

# Chemická reaktivita

- Reakce karboxylu
  - Tvorba solí (disociace – viz výše)
  - Tvorba esterů
  - Tvorba anhydridů
  - **Tvorba amidů – vazba –CO-NH-**
- Reakce aminoskupin
  - Tvorba solí (disociace – viz výše)
  - **Acylace – vazba –CO-NH-**
  - Diazotace –  $R-CH(NH_2).COOH + HNO_2 = R-CH(OH).COOH + N_2$  – van Slyke
- Reakce skupin bočního řetězce
  - Speciální, podle druhu AK
  - Význam metabolický – struktura, funkce (oxidace –SH aj.)
  - Analytické využití

# Volné aminokyseliny a deriváty

- Součásti jiných biomolekul –  $\beta$ -alanin

- Funkce v metabolismu

– výše uvedené + další

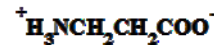
- ornitin a citrulin + Asp a Arg

- Nervové mediátory a hormony

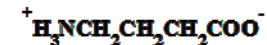
- $\gamma$  aminomáselná
- DOPA, dopamin, adrenalin
- thyroxin, trijodthyronin

- Antibiotika

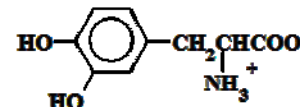
- azaserin, cykloserin, chloramfenikol



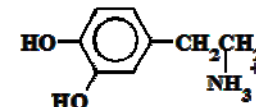
$\beta$  alanin



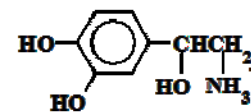
$\gamma$  aminomáselná kyselina



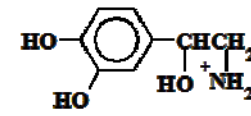
DOPA



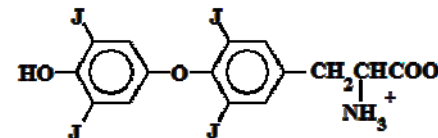
dopamin



noradrenalin



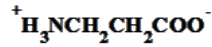
adrenalin



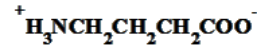
tyroxin

(3,5,3',5'-tetrajodthyronin)

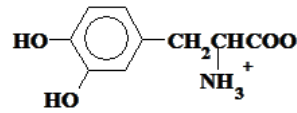
# Volné aminokyseliny a deriváty



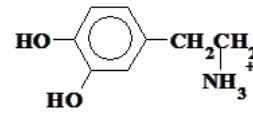
β alanin



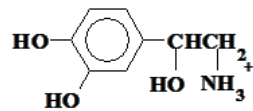
γ aminomáselná kyselina



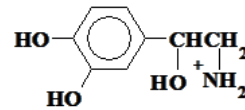
DOPA



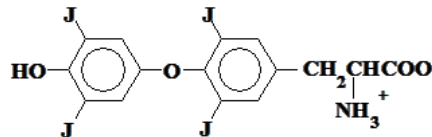
dopamin



noradrenalin



adrenalin



tyroxin

(3,5,3',5'-tetrajodthyronin)