

# Amino Acids and Peptides

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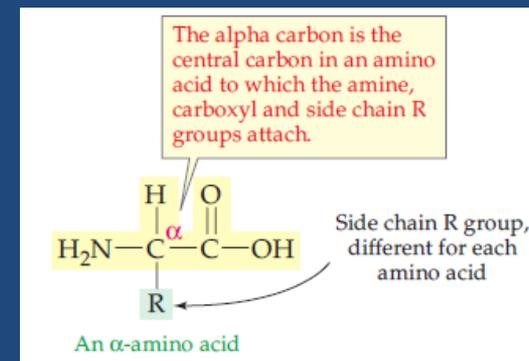
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# Protein structure and function

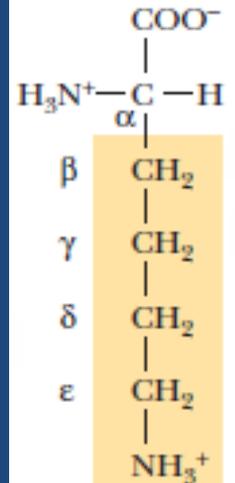
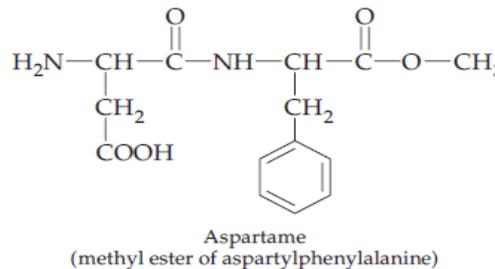
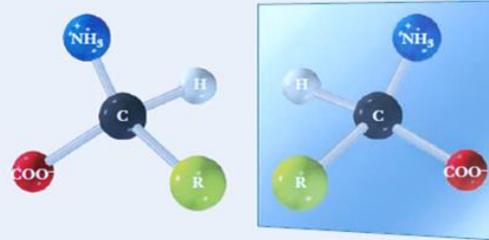
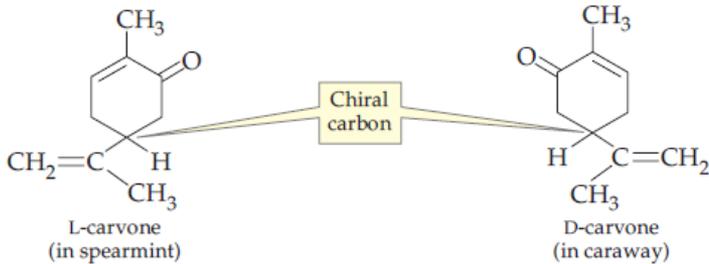
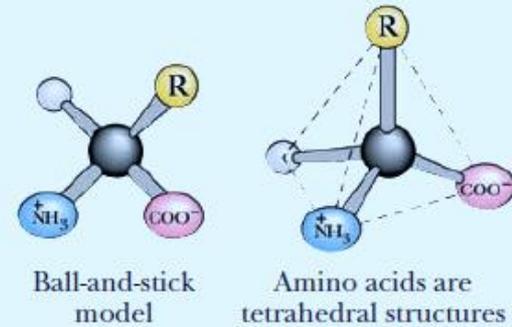
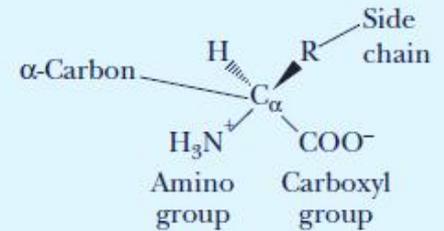
- Greek: proteios, primary (importance)
- 50 % of body's dry weight is protein
- Wide range of different functions
- Polymers of amino acids
- Structure of the amino acids

TYPE	FUNCTION	EXAMPLE
Enzymes	Catalysts	<i>Amylase</i> —begins digestion of carbohydrates by hydrolysis
Hormones	Regulate body functions by carrying messages to receptors	<i>Insulin</i> —facilitates use of glucose for energy generation
Storage proteins	Make essential substances available when needed	<i>Myoglobin</i> —stores oxygen in muscles
Transport proteins	Carry substances through body fluids	<i>Serum albumin</i> —carries fatty acids in blood
Structural proteins	Provide mechanical shape and support	<i>Collagen</i> —provides structure to tendons and cartilage
Protective proteins	Defend the body against foreign matter	<i>Immunoglobulin</i> —aids in destruction of invading bacteria
Contractile proteins	Do mechanical work	<i>Myosin and actin</i> —govern muscle movement



# What should not be forgotten for good?

- There are a lot of amino acids in life.
- There are 20 encoded by the genetic code.
- Their general structure (amino, carboxyl, H, R), the basis of their classification.
- Two vs. 3-dimensional (handedness, chirality, chiral vs. achiral, left vs. right, L vs. D).



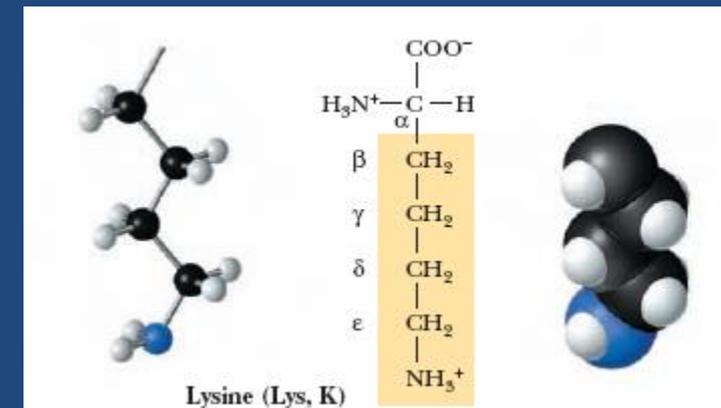
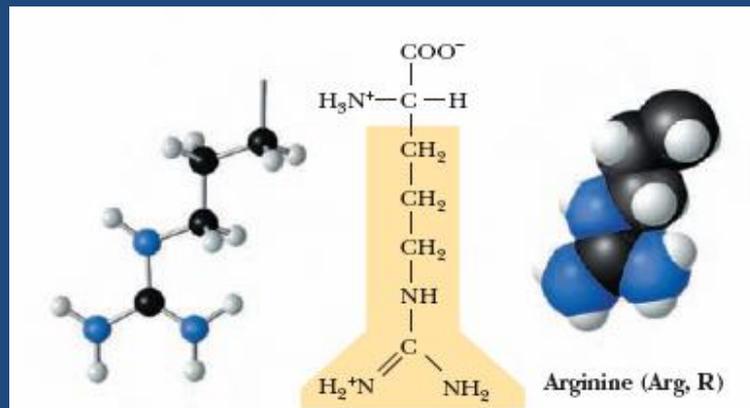
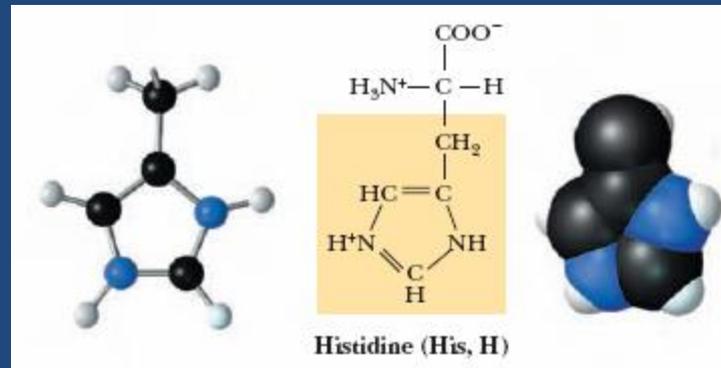
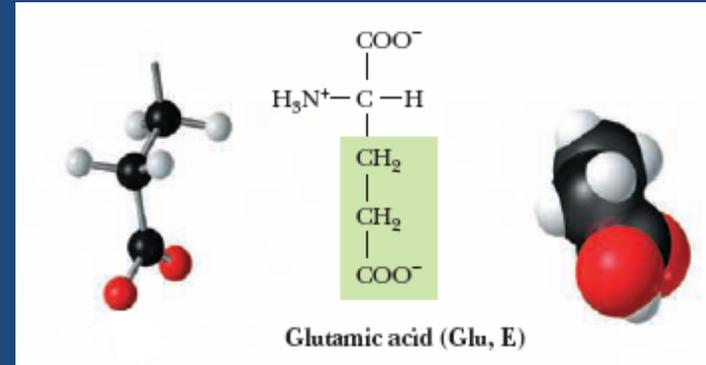
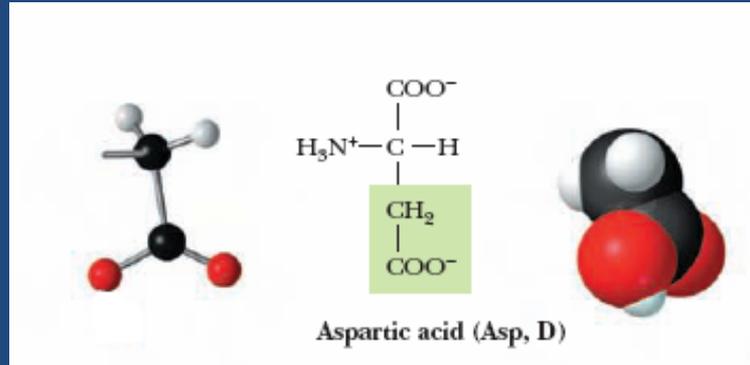
$\omega$ -carbon



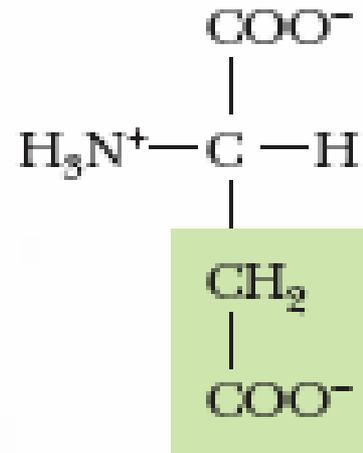
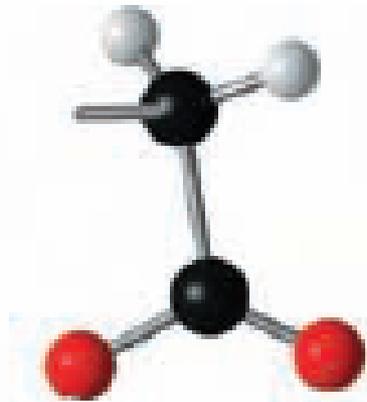
# Names and codes

Amino Acid	3-letter code	1-letter code	Amino Acid	3-letter code	1-letter code
Alanine	Ala	A	Leucine	Leu	L
Arginine	Arg	R	Lysine	Lys	K
Asparagine	Asn	N	Methionine	Met	M
Aspartic acid	Asp	D	Phenylalanine	Phe	F
Cysteine	Cys	C	Proline	Pro	P
Glutamic acid	Glu	E	Serine	Ser	S
Glutamine	Gln	Q	Threonine	Thr	T
Glycine	Gly	G	Tryptophan	Trp	W
Histidine	His	H	Tyrosine	Tyr	Y
Isoleucine	Ile	I	Valine	Val	V

# Charged

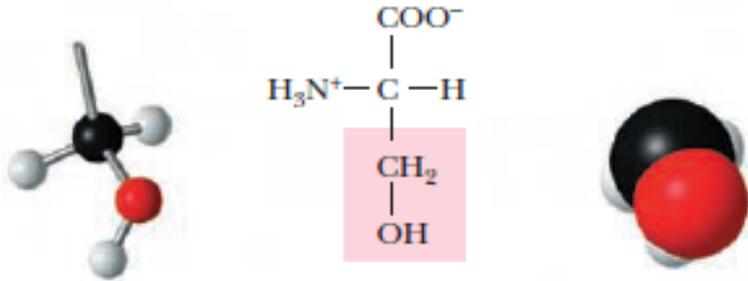


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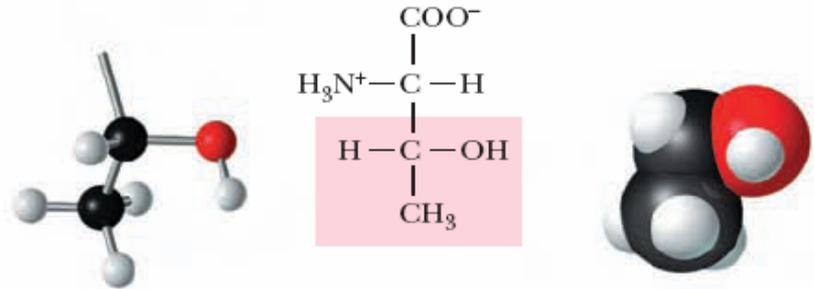


Aspartic acid (Asp, D)

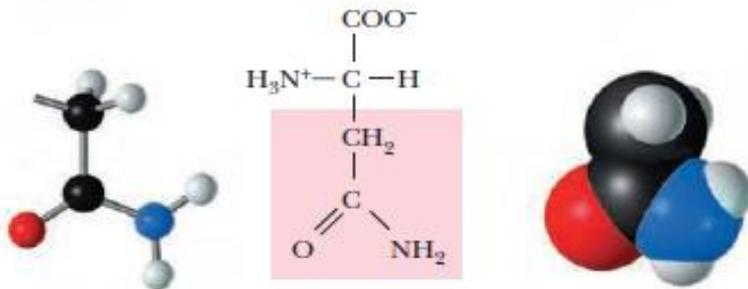
# Polar, Uncharged



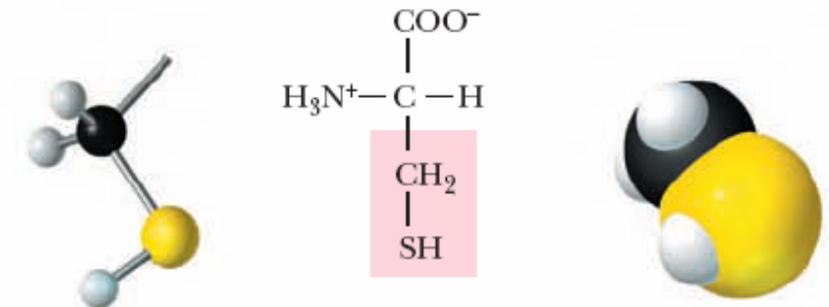
Serine (Ser, S)



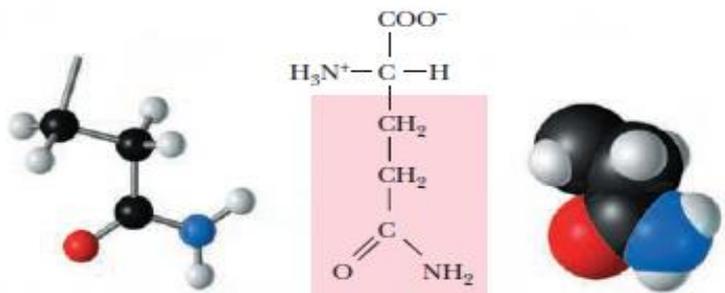
Threonine (Thr, T)



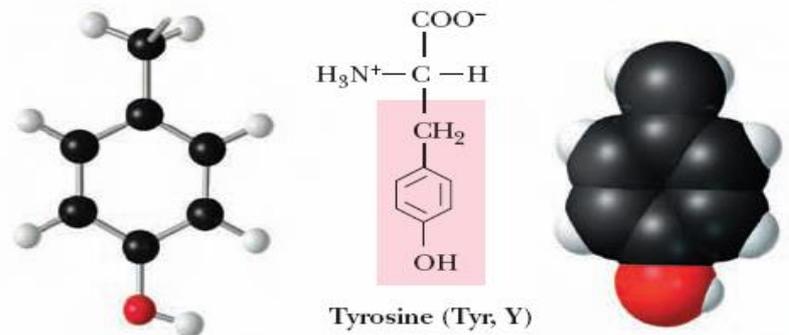
Asparagine (Asn, N)



(-S-S-) Cysteine (Cys, C)

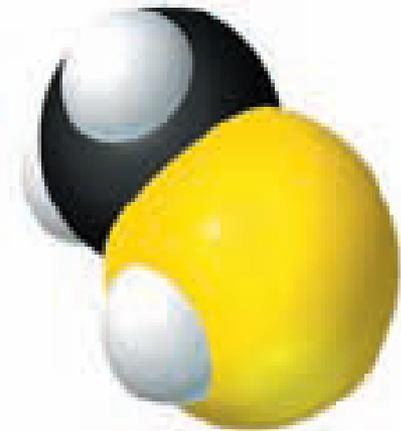
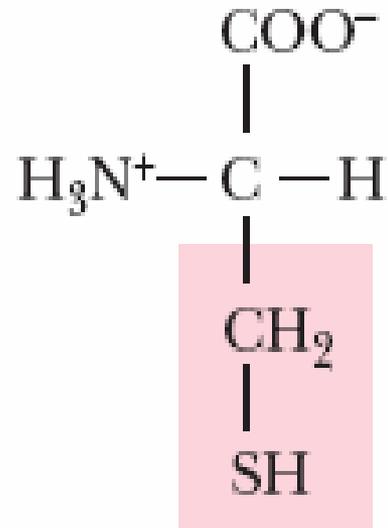


Glutamine (Gln, Q)



Tyrosine (Tyr, Y)

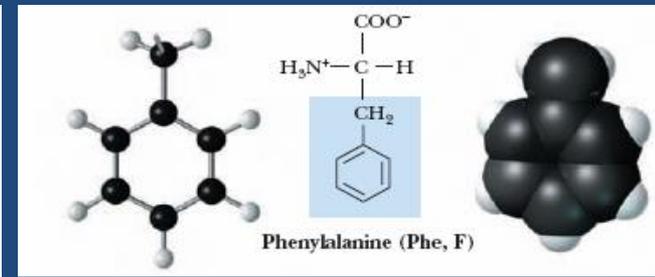
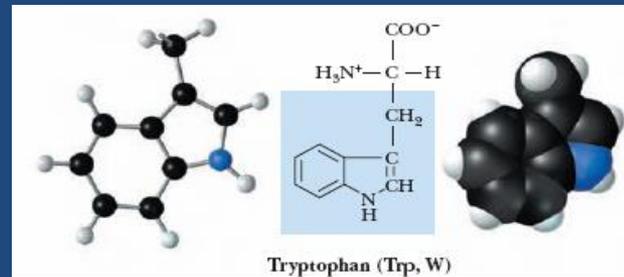
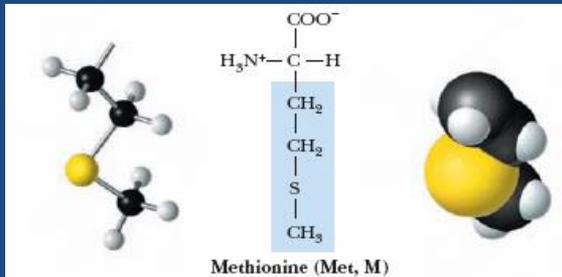
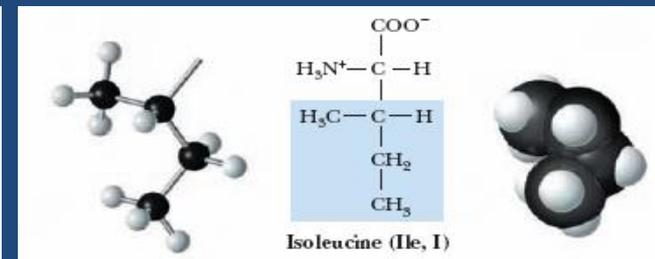
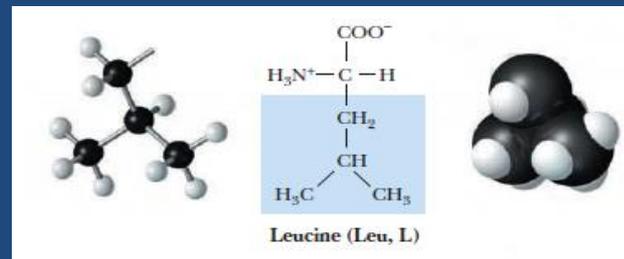
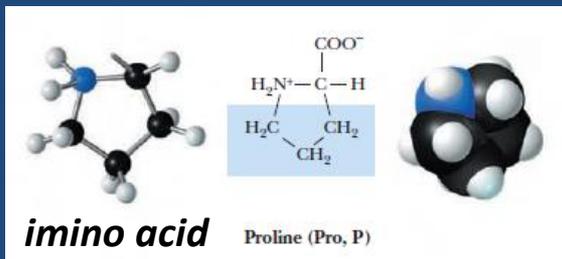
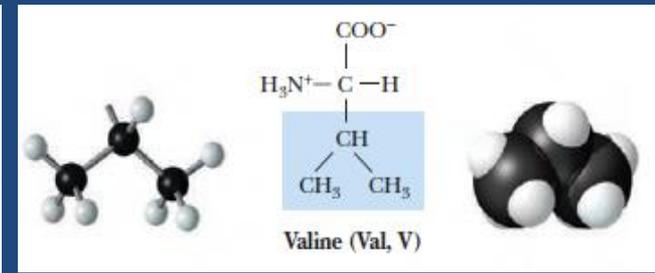
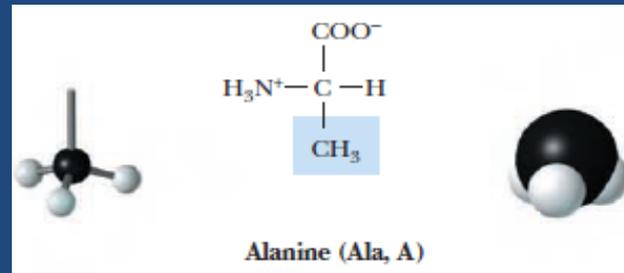
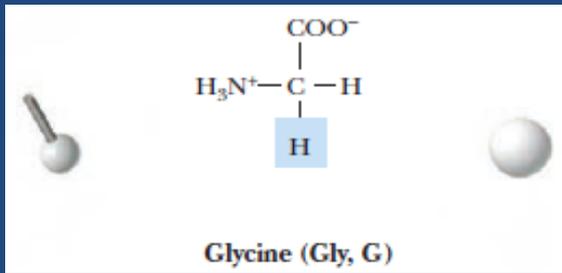
# Polar, Uncharged



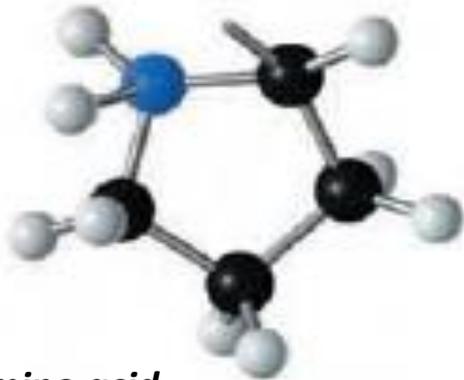
**Cysteine (Cys, C)**



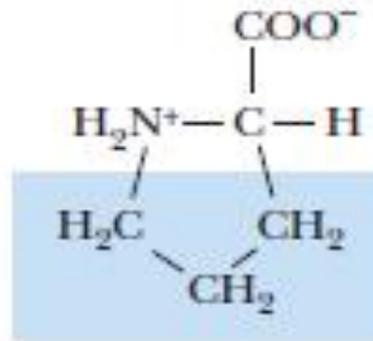
# Non-polar, Uncharged



# Non-polar, Uncharged



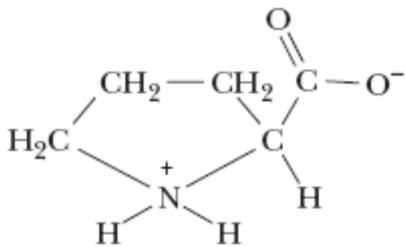
*imino acid*



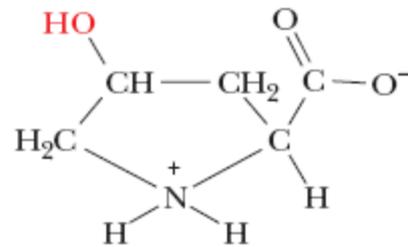
**Proline (Pro, P)**



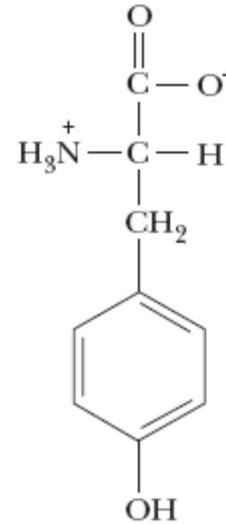
# Posttranslational modification of Amino Acids



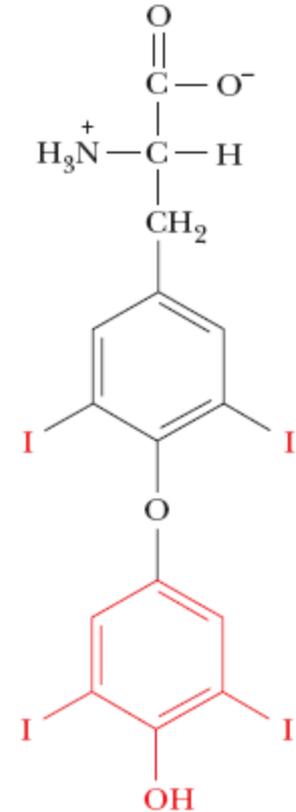
**Proline**



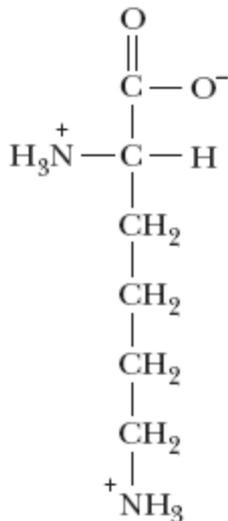
**Hydroxyproline**



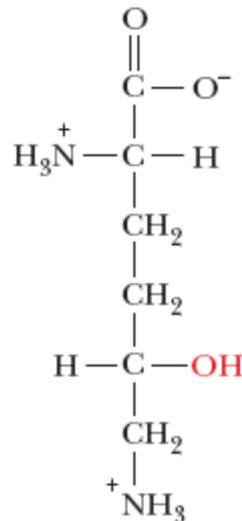
**Tyrosine**



**Thyroxine**



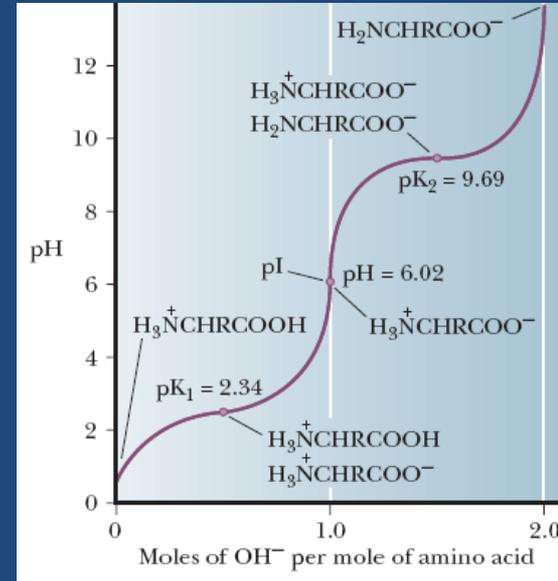
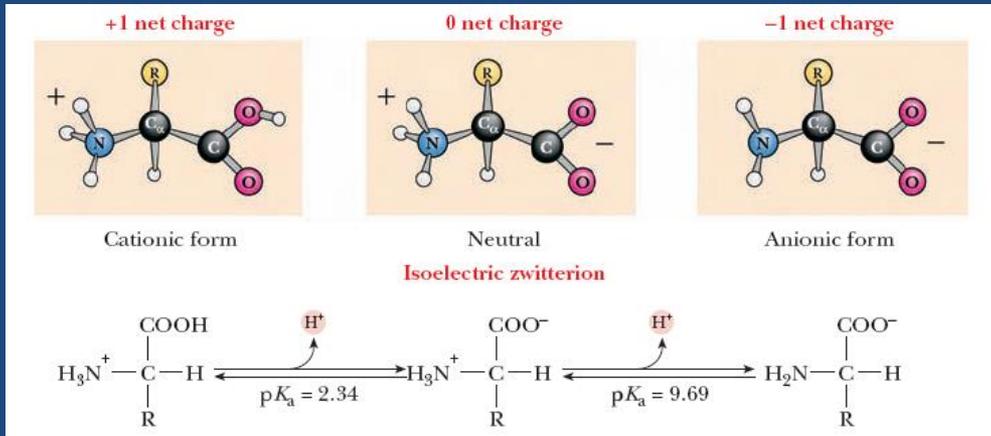
**Lysine**



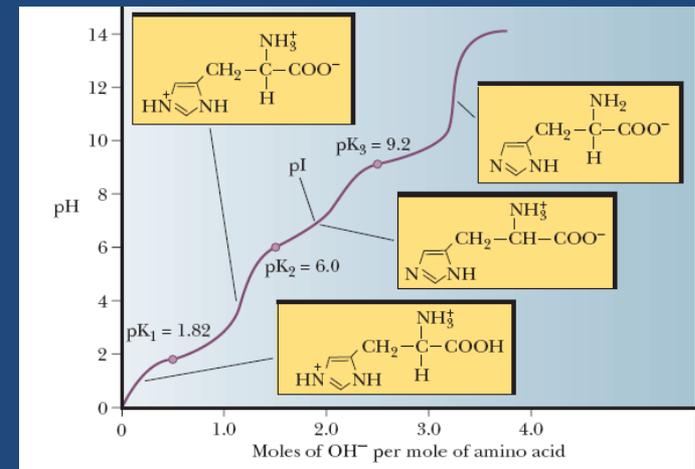
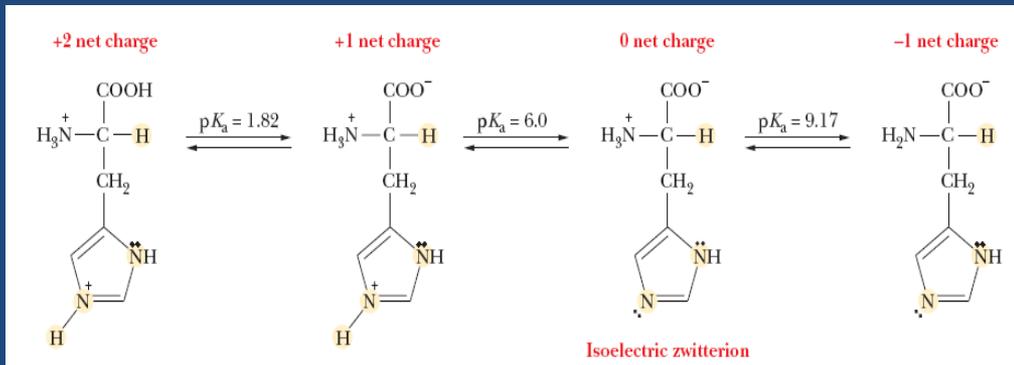
**Hydroxylysine**

# Titration of amino acids: what happens?

## And what is an isoelectric point (pI)?



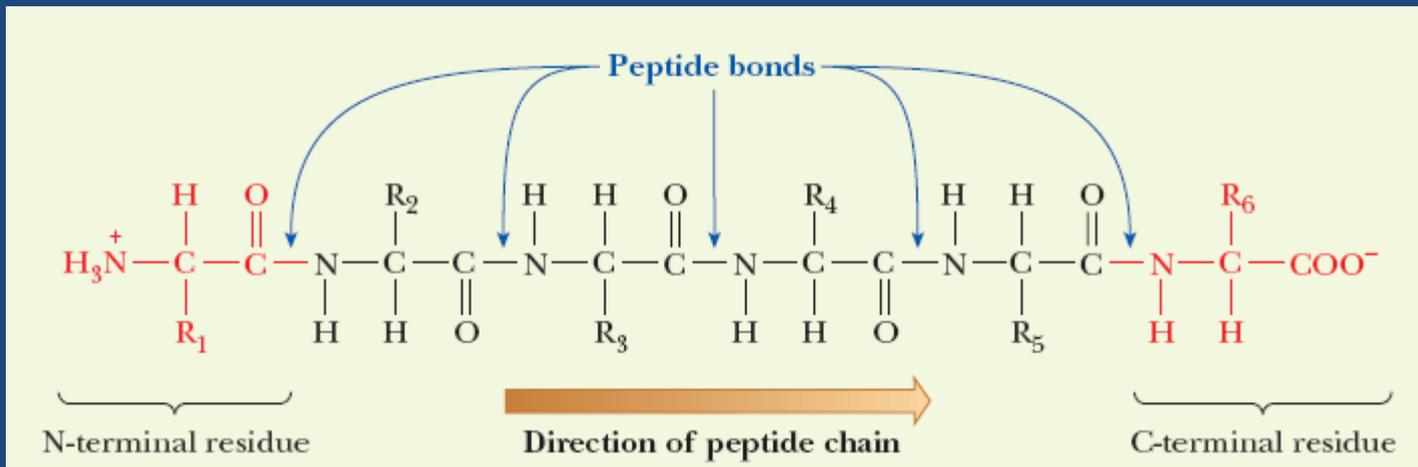
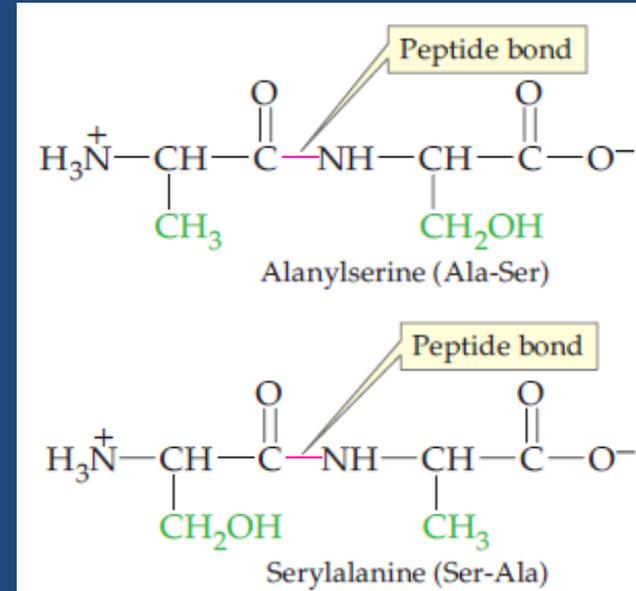
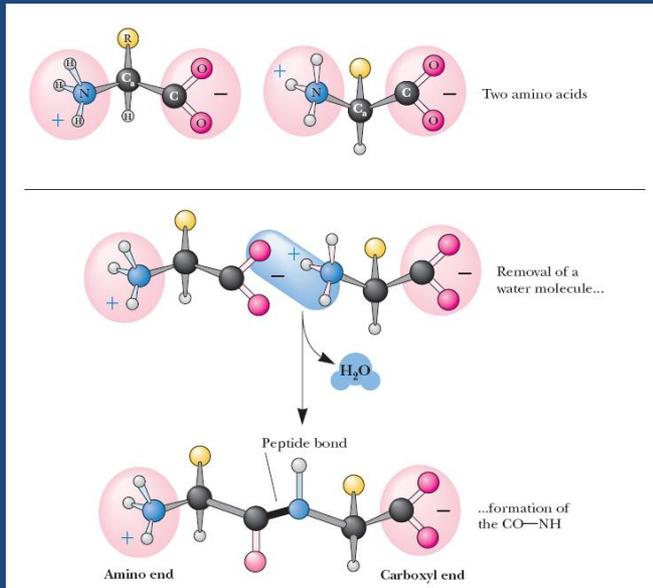
$$\text{pI} = (\text{p}K_{a1} + \text{p}K_{a2}) / 2$$



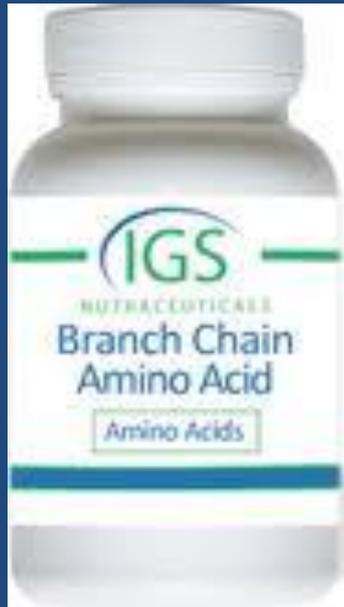
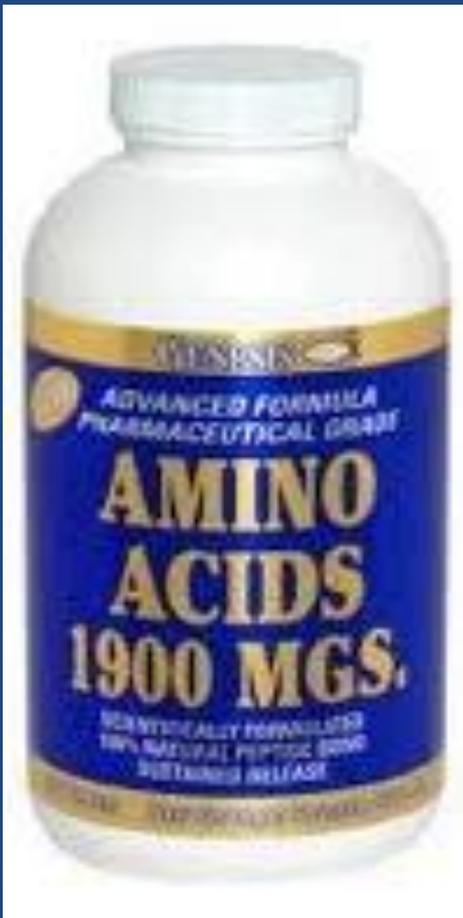
Amino Acid	Abbreviation		pK <sub>1</sub>	pK <sub>2</sub>	pK <sub>R</sub>	pI
	3-Letters	1-Letter	-COOH	-NH <sub>3</sub> <sup>+</sup>	R group	
Alanine	Ala	A	2.34	9.69	-	6.00
Arginine	Arg	R	2.17	9.04	12.48	10.76
Asparagine	Asn	N	2.02	8.80	-	5.41
Aspartic Acid	Asp	D	1.88	9.60	3.65	2.77
Cysteine	Cys	C	1.96	10.128	8.18	5.07
Glutamic Acid	Glu	E	2.19	9.67	4.25	3.22
Glutamine	Gln	Q	2.17	9.13	-	5.65
Glycine	Gly	G	2.34	9.60	-	5.97
Histidine	His	H	1.82	9.17	6.00	7.59
Isoleucine	Ile	I	2.36	9.60	-	6.02
Leucine	Leu	L	2.36	9.60	-	5.98
Lysine	Lys	K	2.18	8.95	10.53	9.74
Methionine	Met	M	2.28	9.21	-	5.74
Phenylalanine	Phe	F	1.83	9.13	-	5.48
Proline	Pro	P	1.99	10.60	-	6.30
Serine	Ser	S	2.21	9.15	-	5.58
Threonine	Thr	T	2.09	9.10	-	5.60
Tryptophan	Trp	W	2.83	9.39	-	5.89
Tyrosine	Tyr	Y	2.20	9.11	10.07	5.66
Valine	Val	V	2.32	9.62	-	5.96

From Lehninger Principle of Biochemistry.

# The peptide bond, peptides, and proteins

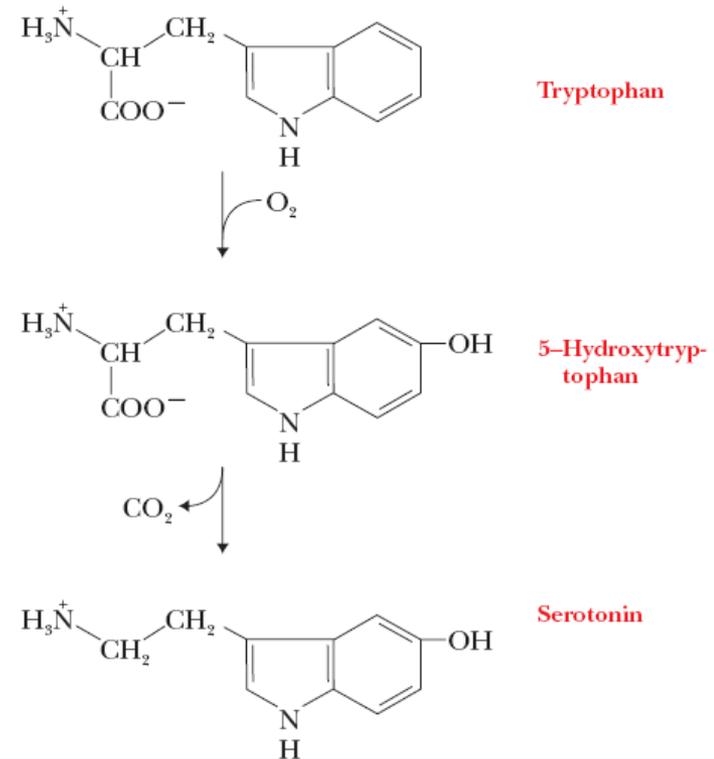


# Amino Acids & life



# Amino acids & life

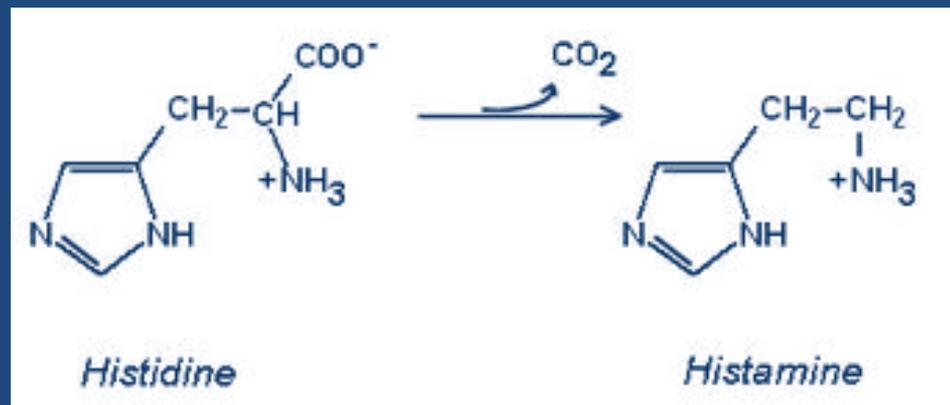
- Two amino acids deserve special attention (**Tyr & Trp**) with respect to neurotransmission.
- Tryptophan converted to 5-hydroxytryptamine (**serotonin**, sedative effect).
- Very low levels are associated with depression, while extremely high levels produce manic state.
- Tryptophan, milk and sleep





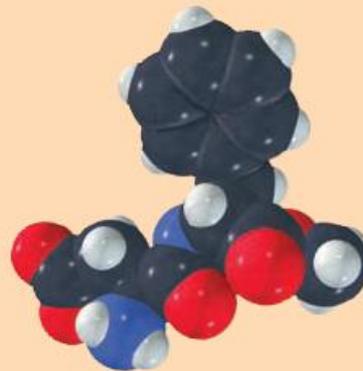
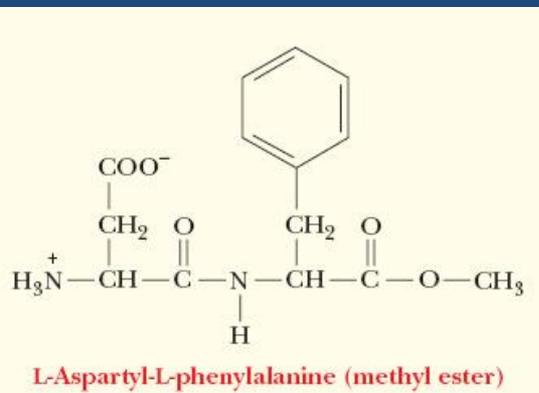
# Other amino acids

- **Glutamic Acid:** Monosodium glutamate, or MSG, a flavor enhancer. MSG causes a physiological reaction in some people, with chills, headaches, and dizziness resulting in (*Chinese restaurant syndrome*)
- **Histidine:** converted to histamine, a potent vasodilator, part of the immune response, results in swelling and stuffiness that are associated with cold. Most cold medications contain antihistamines to overcome this stuffiness.



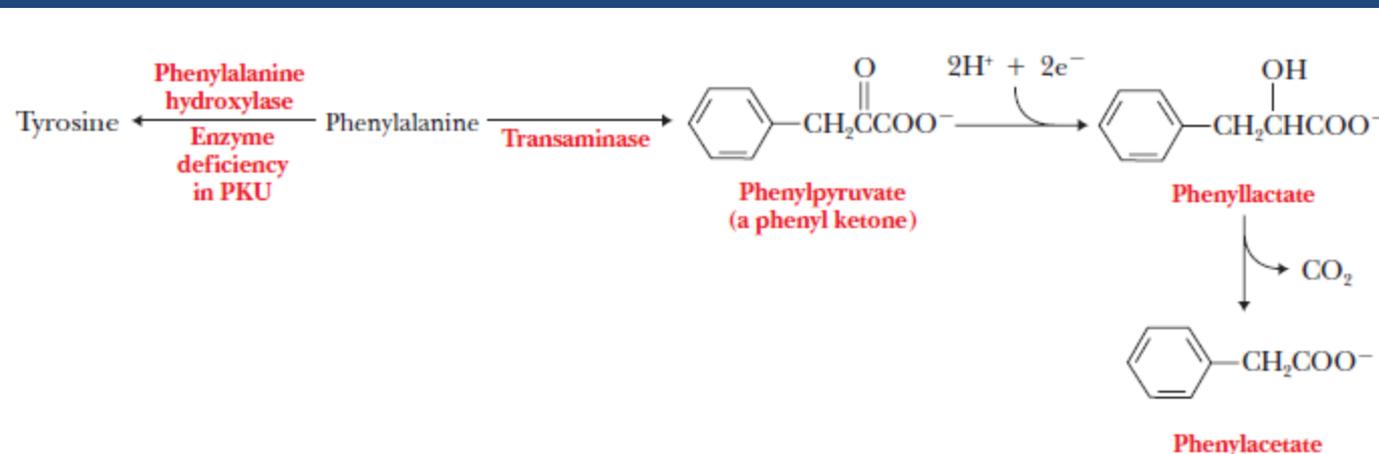
# Aspartame, the Sweet Peptide

- L-aspartyl-L-phenylalanine, commercial importance
- The methyl ester derivative is called *aspartame*
- 200 times sweeter than sugar



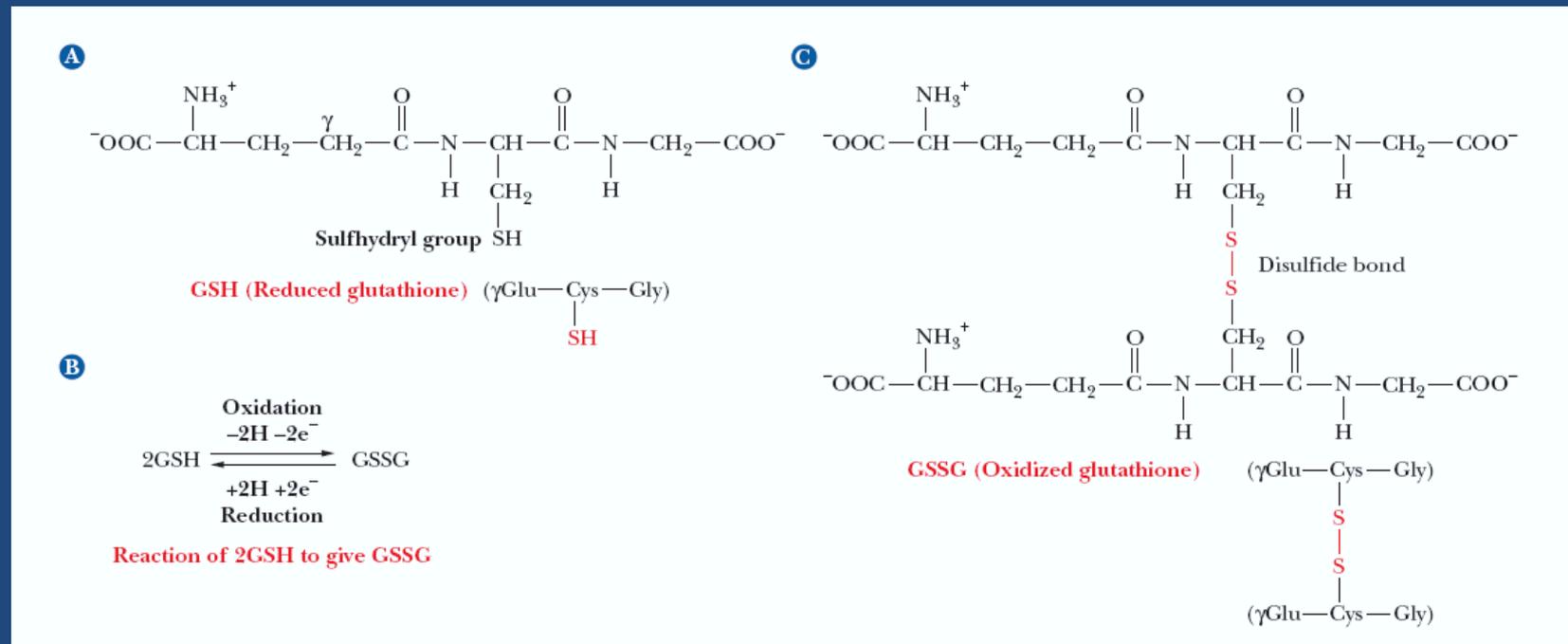
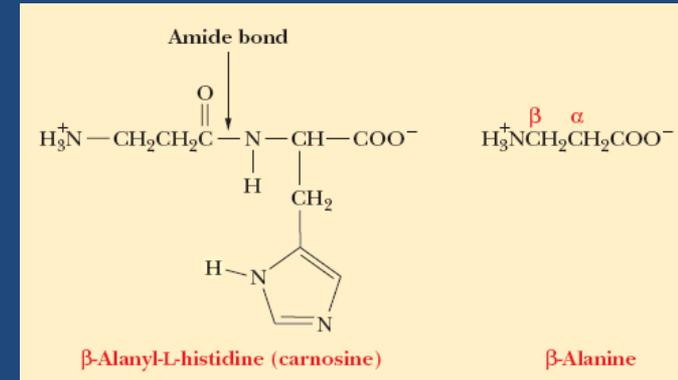
# Phenylketonuria

- Inborn errors of metabolism; errors in enzymes of amino acids metabolism
- May have disastrous consequences (mental retardation).
- Phenylketonuria (PKU) is a well-known example.
- PKU can be easily detected and managed in newborns
- Aspartame carry a warning
- Alatame (Ala instead of Phe) is a substituent



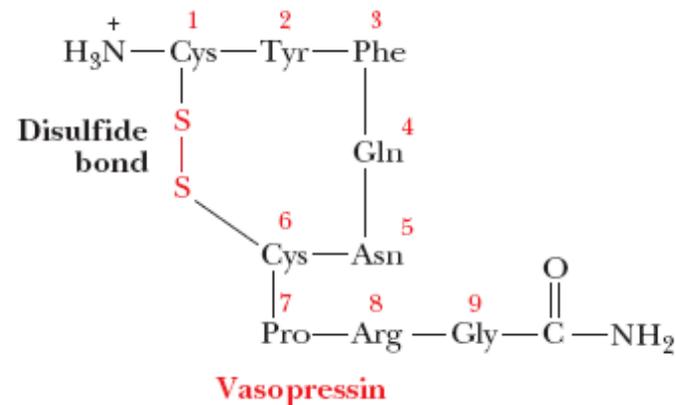
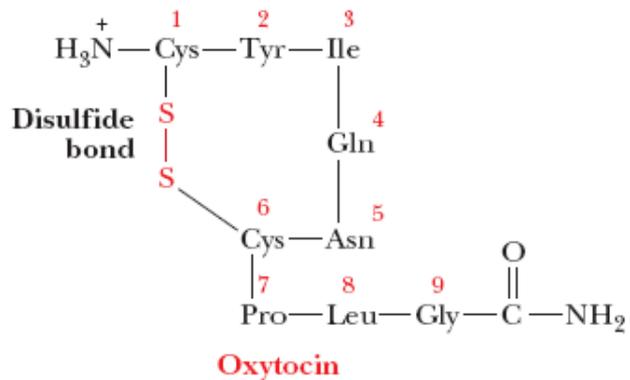
# Small Peptides with Physiological Activity

- Carnosine (dipeptide), found in muscle tissue, ( $\beta$ -alanyl-L-histidine), antioxidant, chelation of heavy metals
- Glutathione (tripeptide;  $\gamma$ -glutamyl-L-cysteinylglycine); a scavenger for oxidizing agents.



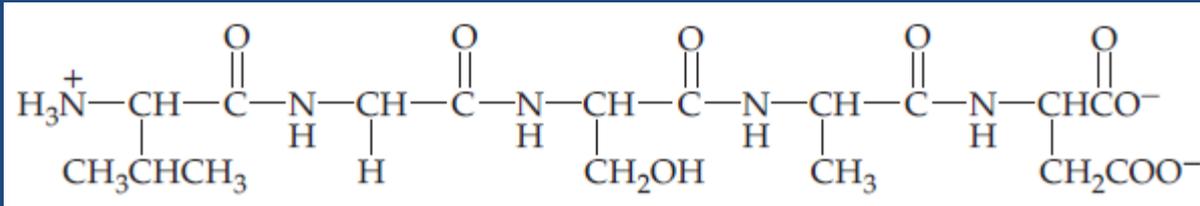
# Small Peptides with Physiological Activity

- Enkephalins (pentapeptides), naturally occurring analgesics.  
Tyr—Gly—Gly—Phe—Leu (Leucine enkekephalin)  
Tyr—Gly—Gly—Phe—Met (Methionine enkekephalin)
- Similarities of three-dimensional structures to opiates (e.x, morphine)
- Some important peptides have cyclic structures. Two well-known examples, oxytocin and vasopressin

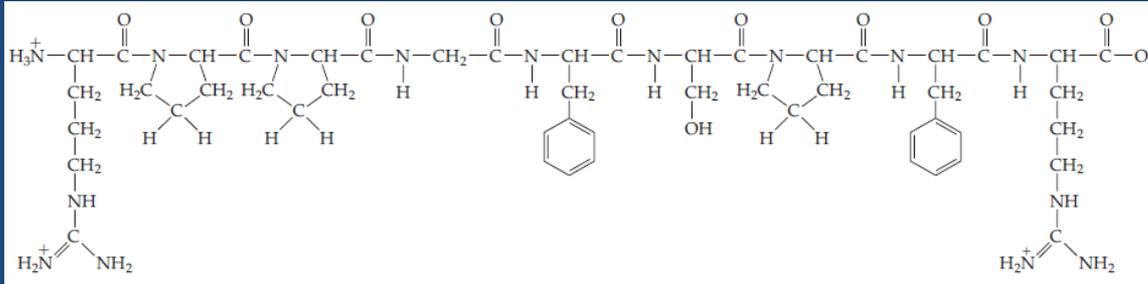


- Which of the following amino acid(s) are polar?
- (a) Serine
  - (b) Tyrosine
  - (c) Arginine
  - (d) All of these
- Which two of the following amino acids could form a ionic bond?
- (a) Aspartic acid and Lysine
  - (b) Arginine and Glutamine
  - (c) Glutamic acid and Valine
  - (d) Proline and Glycine
- Which of the following amino acids' side chains is a single methyl group?
- (a) Valine
  - (b) Isoleucine
  - (c) Leucine
  - (d) Alanine
- The three letter abbreviation "asn" corresponds to which amino acid?
- (a) Alanine (b) Aspartic acid (c) Asparagine (d) Arginine
- Of amino acids abbreviated "Lys", "Glu", "Trp", and "Gln", which is a basic amino acid with a positive charge?
- (a) Lysine
  - (b) Tryptophan
  - (c) Glutamic acid
  - (d) Glutamine
- Which of the following amino acids is NOT positively charged?
- (a) Lysine
  - (b) Aspartic acid
  - (c) Arginine
  - (d) Histidine
- Which of the following amino acids is the largest of all the amino acids?
- (a) Tyrosine
  - (b) Tryptophan
  - (c) Histidine
  - (d) Glutamic acid

- (a) Identify the amino acids present in the peptide shown below
- (b) Identify the N-terminal and C-terminal of the peptide



- Bradykinin, a peptide that helps to regulate blood pressure, has the primary structure Arg-Pro-Phe-Gly-Phe-Ser-Pro-Phe-Arg. Explain the kinking in the secondary structure?



- Which of the following amino acids is the smallest of all amino acids?

- (a) Alanine
- (b) Serine
- (c) Valine
- (d) Glycine

- Oxytocin is a small peptide that is used to induce labor by causing contractions in uterine walls. It has the primary structure Cys-Tyr-Ile-Gln-Asn-Cys-Pro-Leu-Gln. This peptide is held in a cyclic configuration, how?

- Which of the following amino acids can form a special covalent bond called a disulfide bond?

- (a) Tyrosine
- (b) Methionine
- (c) Cysteine
- (d) Lysine

☐ Interactions of amino acids on the interior of proteins are key to the shapes of proteins. In group (a) below, which pairs of amino acids form hydrophobic interactions? In group (b), which pairs form ionic interactions? Which pairs in group (c) form hydrogen bonds?

- (a) 1. Pro \* Phe; 2. Lys \* Ser; 3. Thr \* Leu; 4. Ala \* Gly
- (b) 1. Val \* Leu; 2. Glu \* Lys; 3. Met \* Cys; 4. Asp \* His
- (c) 1. Cys \* Cys; 2. Asp \* Ser; 3. Val \* Gly; 4. Met \* Cys

☐ What amino acids do the following abbreviations stand for?

- (a)** Ala      **(b)** Cys      **(c)** Asp

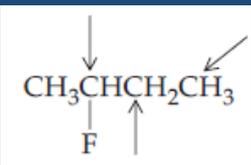
☐ Name the structures of the amino acids that fit the description

- (a) Contains a thiol group
- (b) Contains a phenol group

☐ At neutral pH, which of the following amino acids has a net positive charge, which has a net negative charge, and which is neutral?

- (a) Glutamine
- (b) Histidine
- (c) Methionine
- (d) Glutamic acid

☐ Which of the carbon atoms marked with arrows in the following compound are chiral?



☐ name all tripeptides that contain valine, methionine, and leucine

☐ Which of the following amino acids are most likely to be found on the outside of a globular protein, and which of them are more likely to be found on the inside

- (a) Valine
- (b) Aspartate
- (c) Histidine
- (d) Alanine

☐ Why do you suppose diabetics must receive insulin subcutaneously by injection rather than orally?

☐ Which would you expect to be more soluble in water, a peptide rich in alanine and leucine, or a peptide rich in lysine and aspartate?