



# Amino acids and peptides 1 and 2

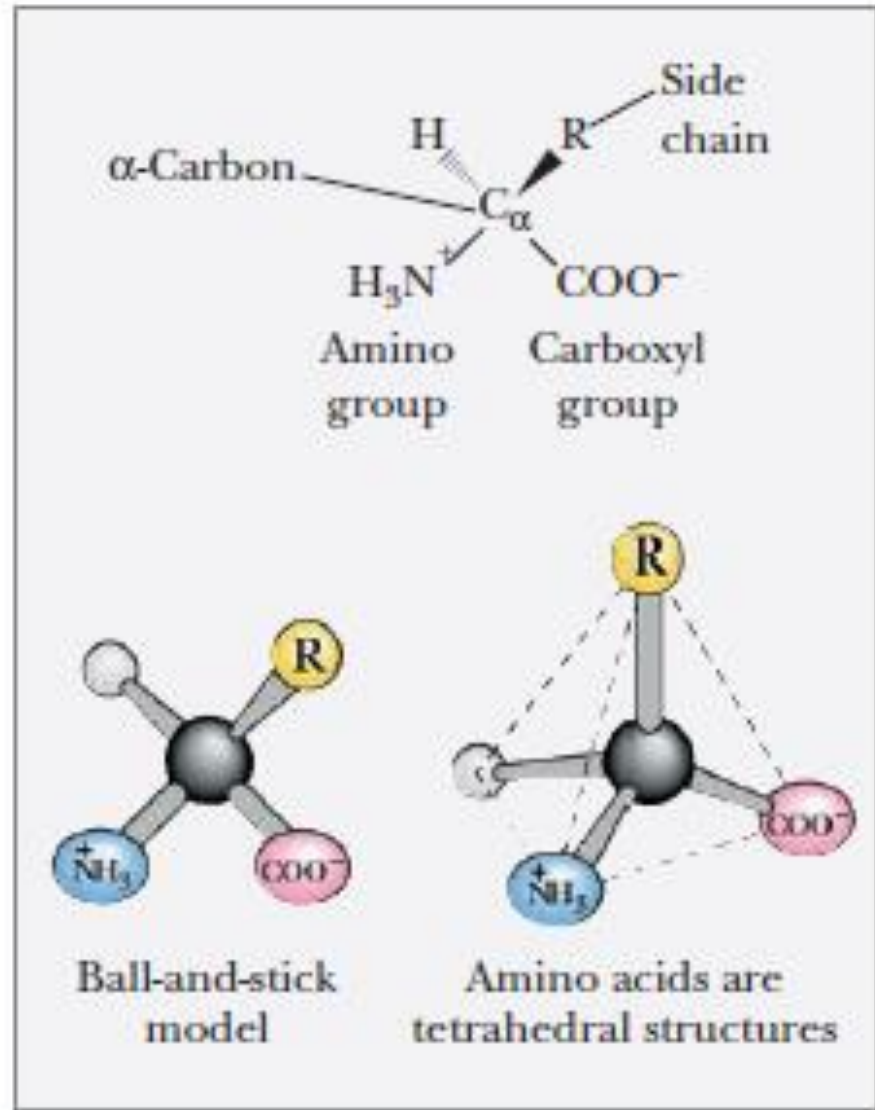
Dr. Diala Abu-Hassan, DDS, PhD

[Dr.abuhassand@gmail.com](mailto:Dr.abuhassand@gmail.com)

Medical students- summer semester  
2015

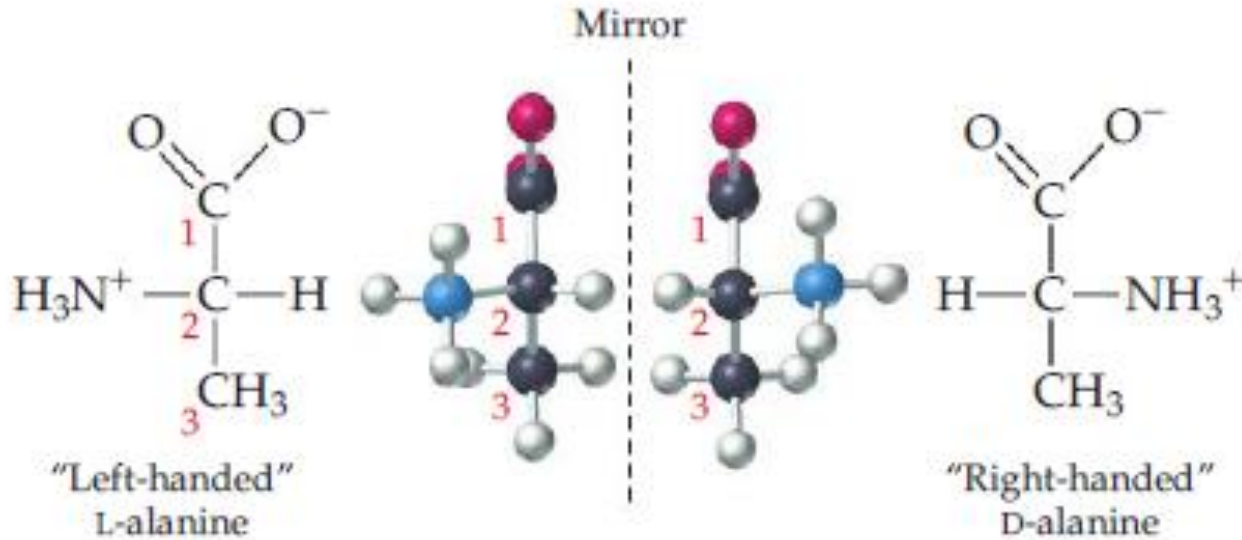
# Amino Acid Structure

Only 20 are usually found in proteins



# Amino acid stereoisomers or optical isomers

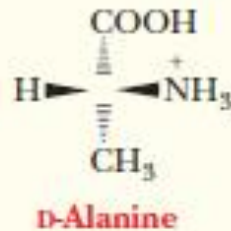
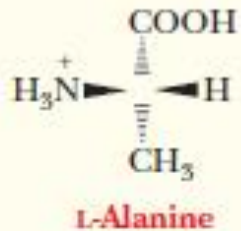
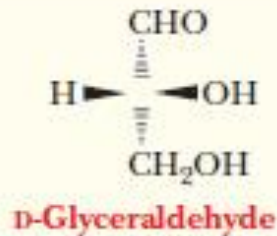
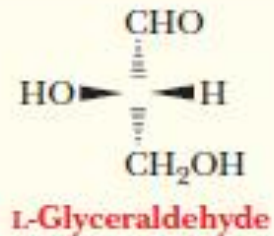
*Alanine, a chiral molecule*



The amino acids in proteins are not superimposable on their mirror images (with the exception of glycine).

Latin *laevus* and *dexter*, meaning "left" and "right," respectively, (the ability to rotate polarized light to the left or the right).

# Amino acid stereoisomers



D-amino acids occur in nature, in bacterial cell walls and in some antibiotics, but not in proteins.

# Amino acid classification

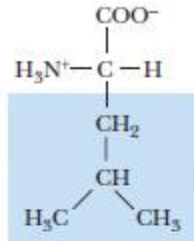
Polarity of the  
side chain

Acid/base  
properties of the  
side chain

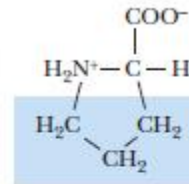
Functional group  
presence and  
nature in the side  
chain

# Non-polar (hydrophobic) Amino acids

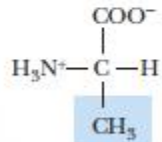
## A Non-polar (hydrophobic)



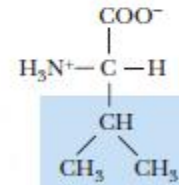
Leucine (Leu, L)



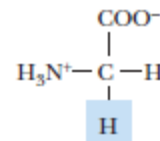
Proline (Pro, P)



Alanine (Ala, A)



Valine (Val, V)



Glycine (Gly, G)



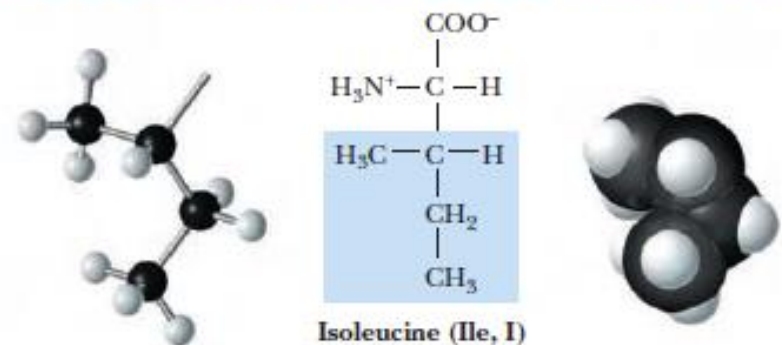
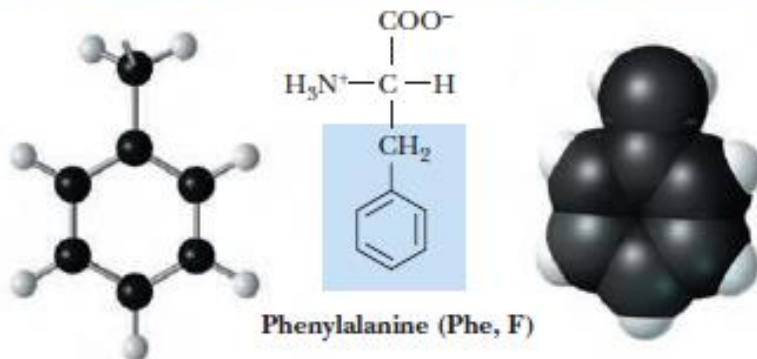
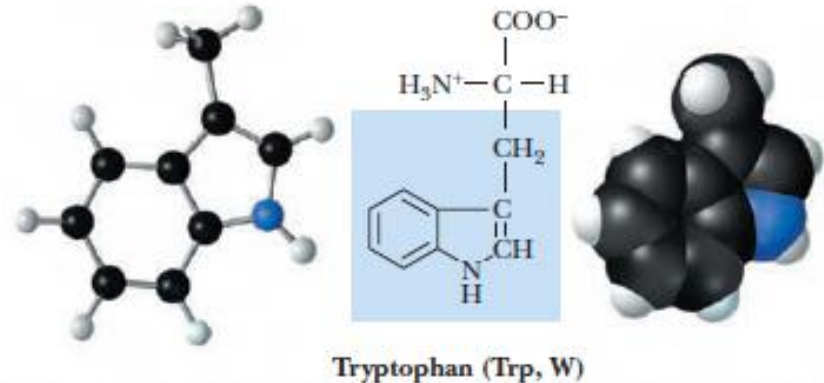
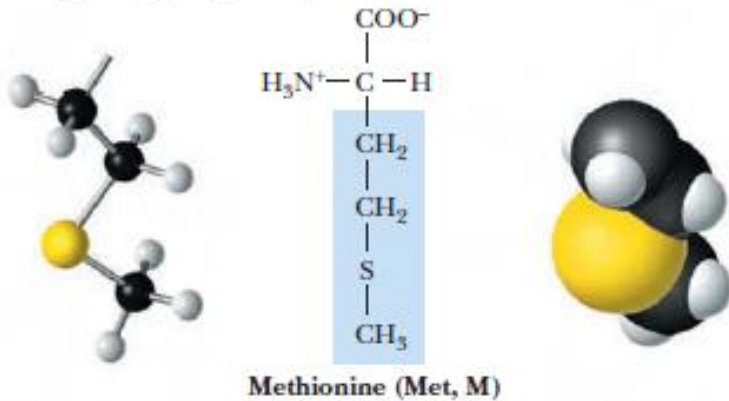
Aliphatic: no benzene ring

All amino acids are primary amines except Pro, a secondary amine



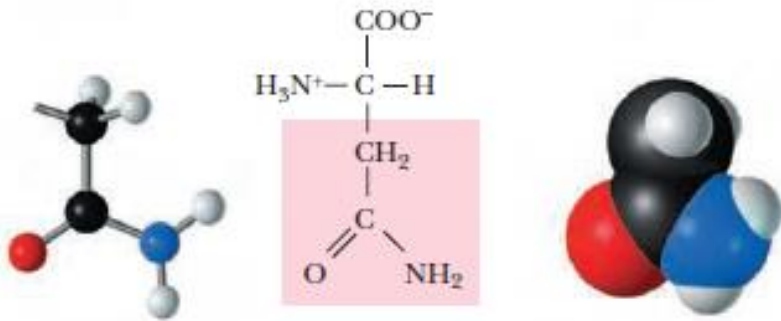
# Non-polar Hydrophobic Amino acids

## A Non-polar (hydrophobic)

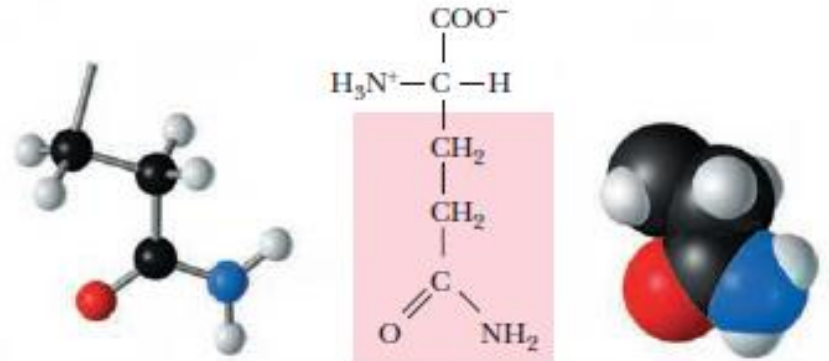


# Polar Uncharged Amino acids

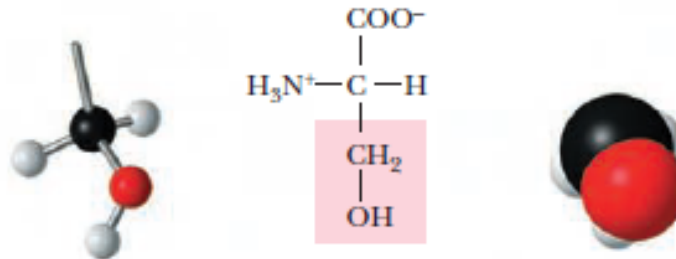
## B Polar, uncharged



Asparagine (Asn, N)



Glutamine (Gln, Q)

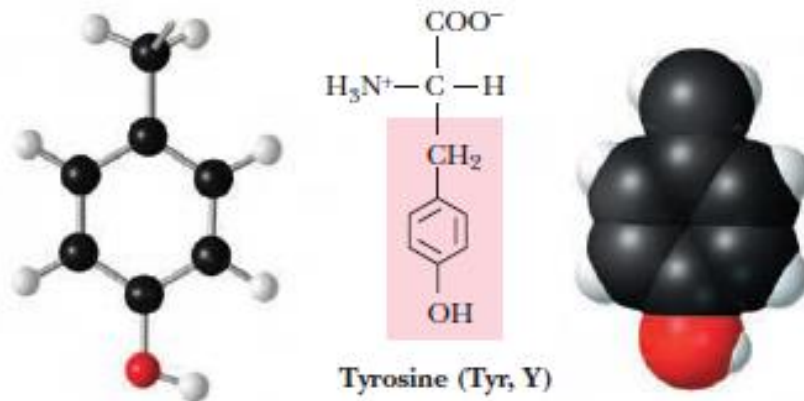
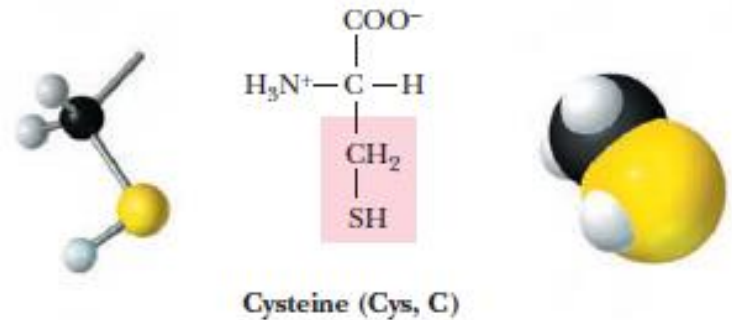
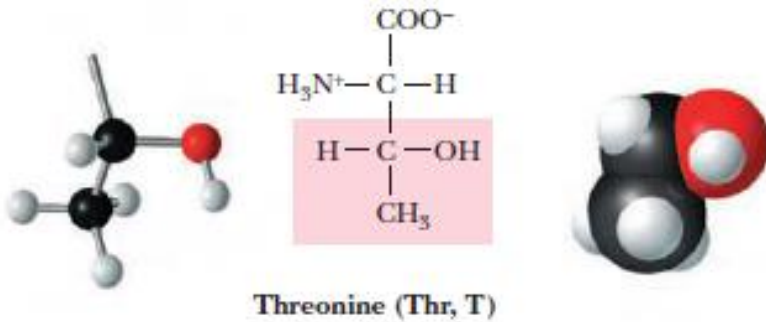


Serine (Ser, S)



# Polar Uncharged Amino acids

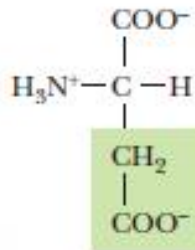
## B Polar, uncharged



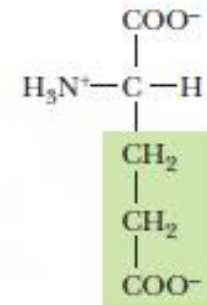
# Acidic Amino acids



Acidic



Aspartic acid (Asp, D)



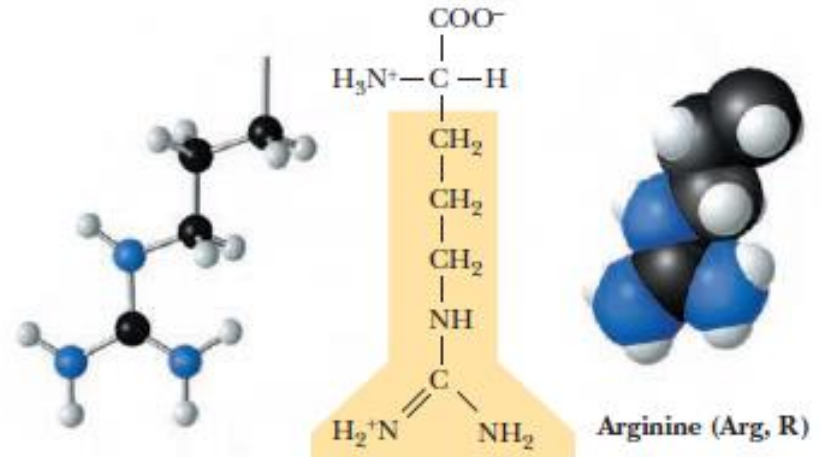
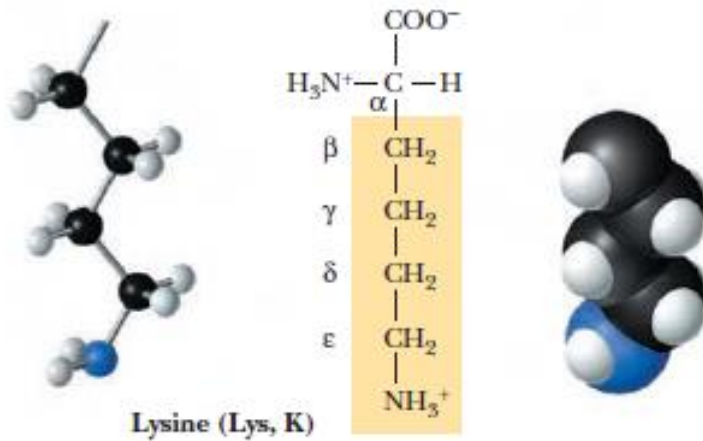
Glutamic acid (Glu, E)



Carboxylate anions  
Negatively charged at neutral pH

# Basic Amino acids

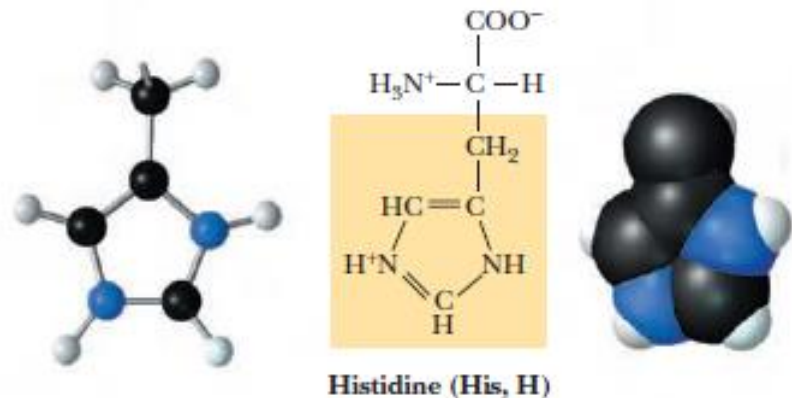
D Basic



The side chain is positively charged at or near neutral pH.

His can be found in the protonated or unprotonated forms in proteins

The properties of many proteins depend on whether each His residue is charged or not.



Imidazole group

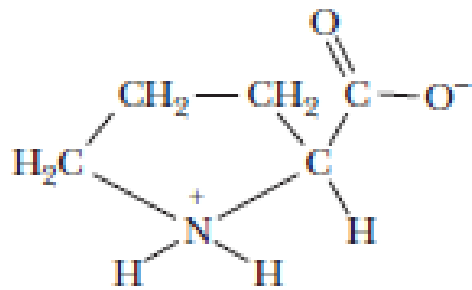
# QUIZ

What is specific about proline?

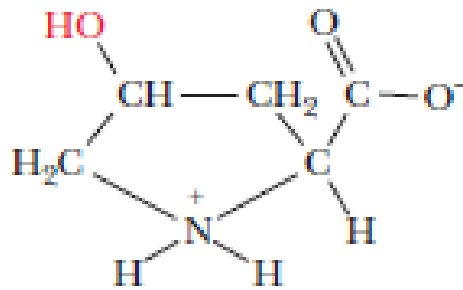
An acidic amino acid is \_\_\_\_\_ charged at physiological conditions

Name 2 amino acids that share a functional group in their side chain

# Uncommon Amino acids



**Proline**

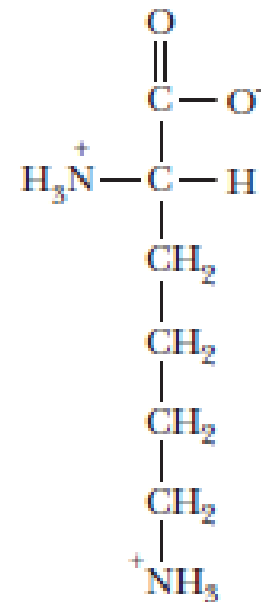


**Hydroxyproline**

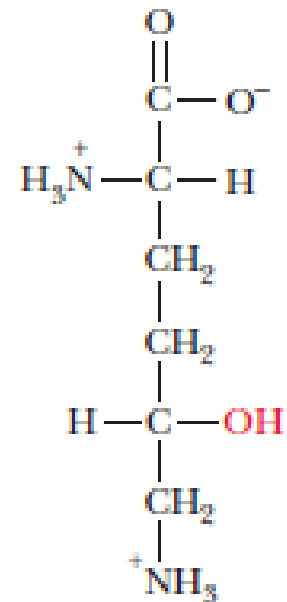
## Collagen

Derived from the common amino acids.

Produced by modification of the parent amino acid **after** the protein synthesis, posttranslational modification.



**Lysine**



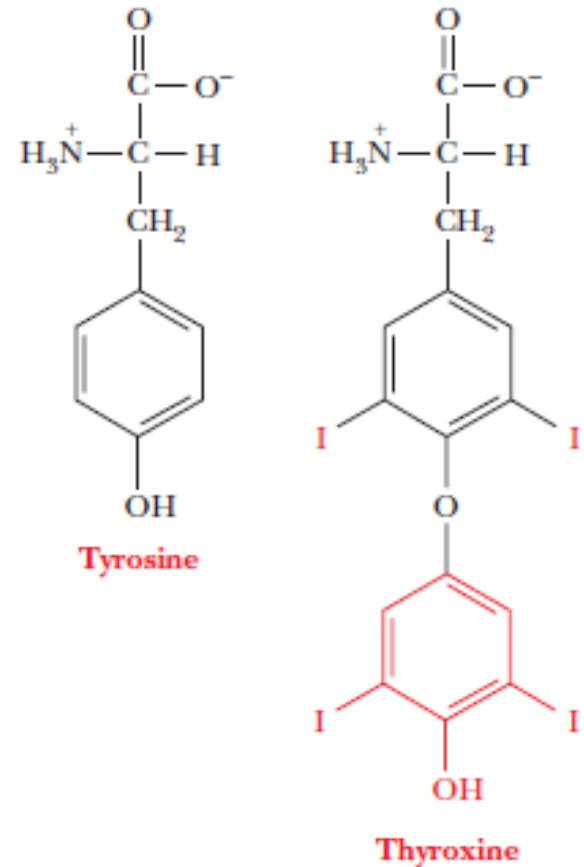
**Hydroxylysine**

## Collagen

# Uncommon Amino acids

Thyroxine is formed by posttranslational modification of tyrosine residues in the protein thyroglobulin.

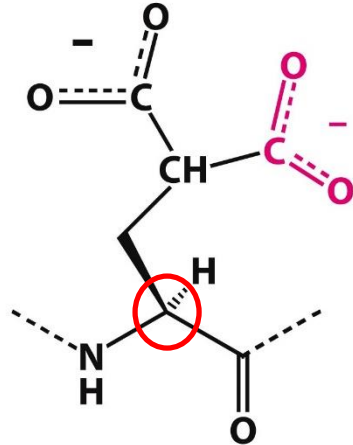
Thyroxine is then released as a hormone by proteolysis of thyroglobulin



Thyroxine

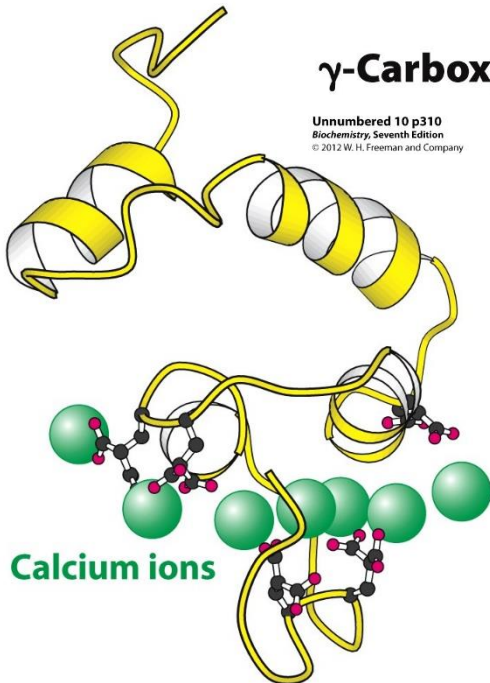
# Uncommon Amino acids

## $\gamma$ -carboxyglutamic acid (or $\gamma$ -carboxyglutamate)



**$\gamma$ -Carboxyglutamate residue**

Unnumbered 10 p310  
Biochemistry, Seventh Edition  
© 2012 W. H. Freeman and Company



Is a post-translational carboxylation of glutamic acid residues.

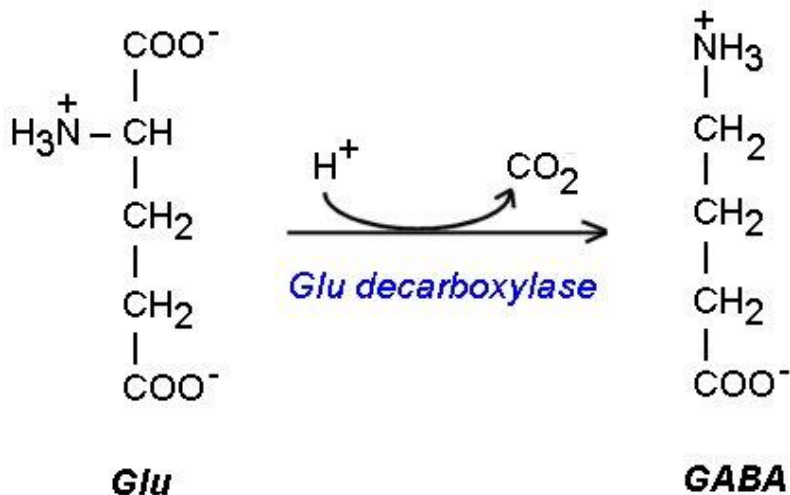
Found in clotting factors and other proteins of the coagulation cascade to introduce an affinity for calcium ions.

Vitamin K is required to introduce  $\gamma$ -carboxylation of clotting factors II, VII, IX, X



# Uncommon Amino acids

## $\gamma$ -aminobutyric acid (GABA)

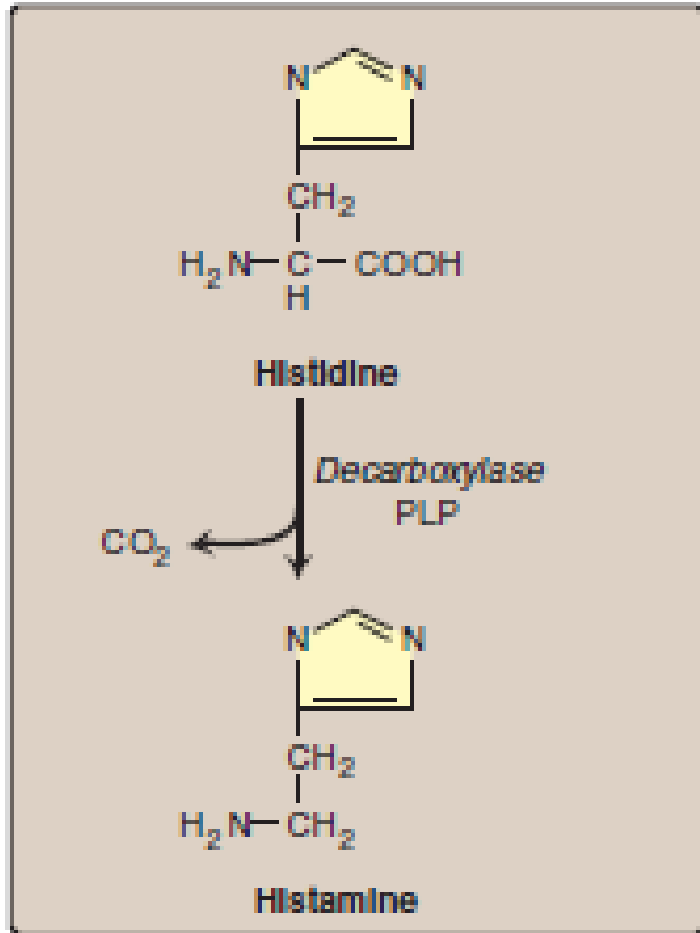


Is an essential inhibitory neurotransmitter in the CNS by reducing neuronal excitability.

GABA is synthesized in brain because it does not cross the BBB.

GABA have relaxing, anti-anxiety, and anti-convulsive effects.

# Amino acids and the synthesis of other nitrogen containing compounds



## Histamine

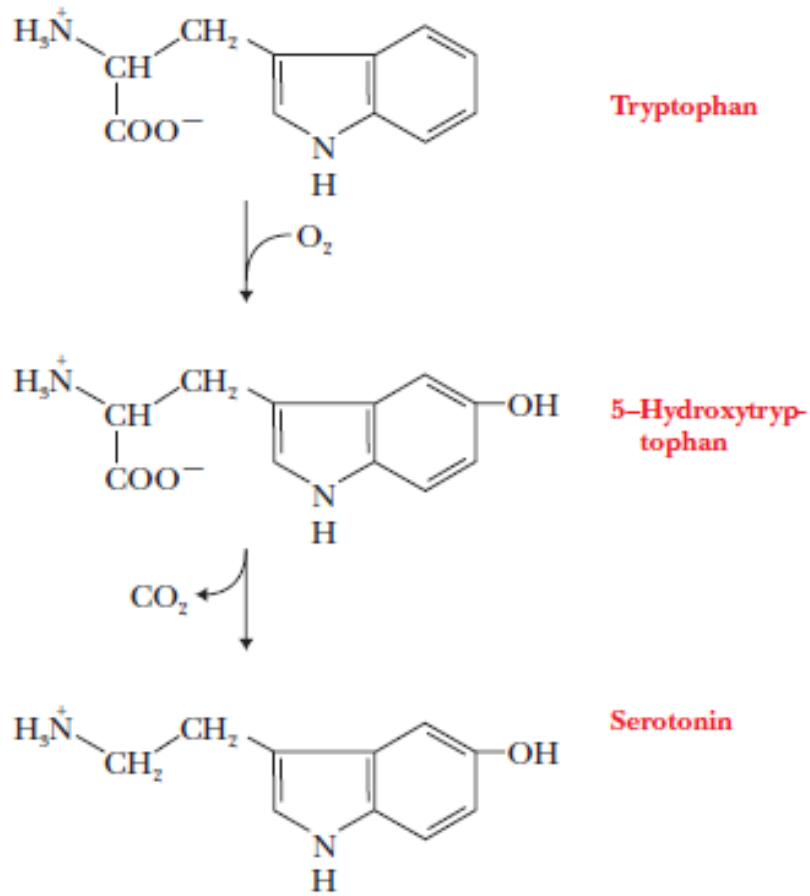
Is a potent vasodilator

Is released as part of the immune response, increases the localized blood volume for white blood cells resulting in swelling and stuffiness associated with a cold.

Most cold medications contain antihistamines to overcome stuffiness.

# Amino acids and the synthesis of other nitrogen containing compounds

## Serotonin



Serotonin has a sedative effect, giving a pleasant feeling.

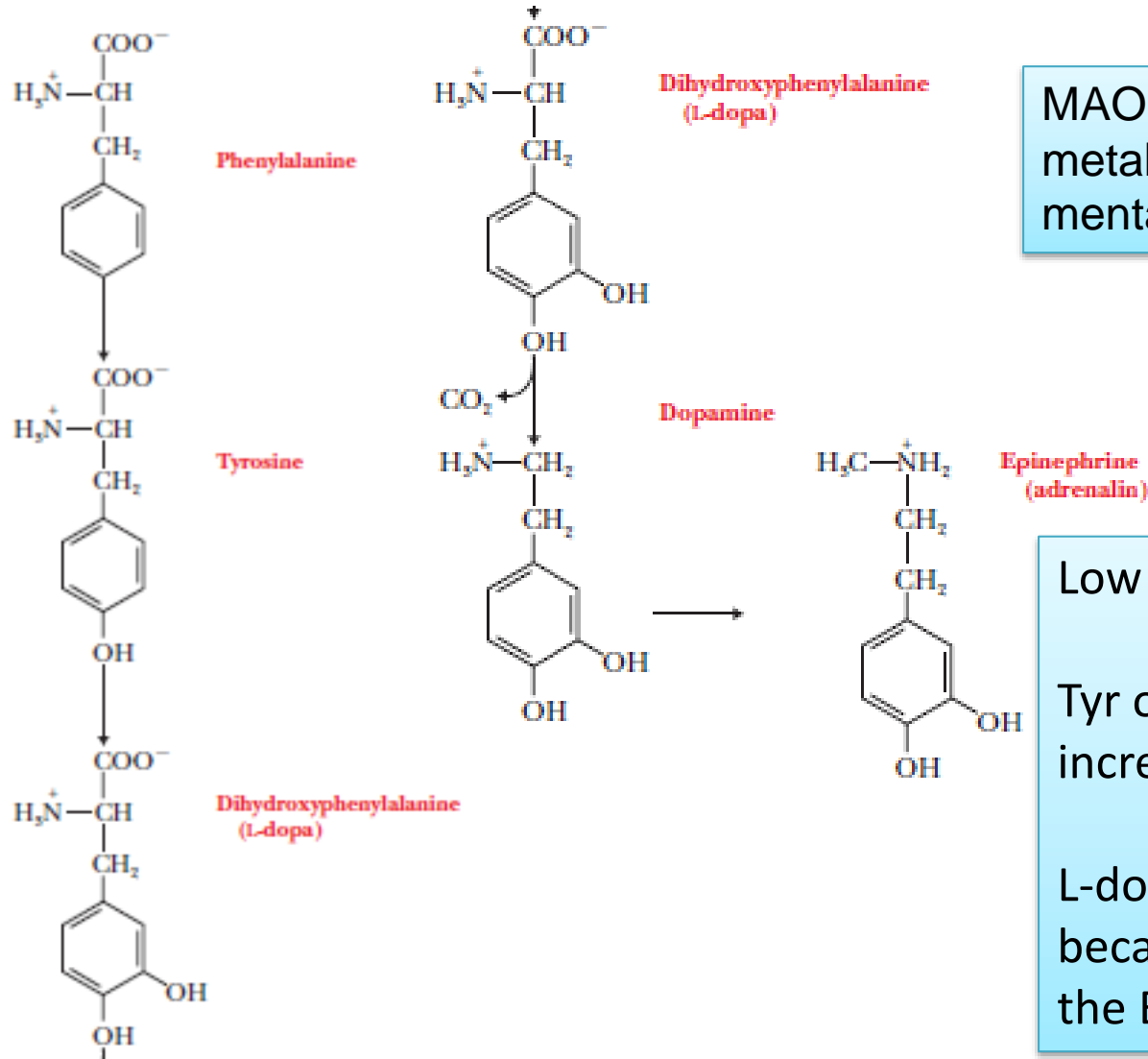
Low serotonin, depression

High serotonin levels, a manic state.

Bipolar disorder (manic depressive illness) can be managed by controlling the levels of serotonin and its further metabolites.

# Amino acids and the synthesis of other nitrogen containing compounds

## Catecholamines



MAO inhibitors inhibit epinephrine metabolism and results in a high mental state

Low L-dopa, Parkinson's disease.

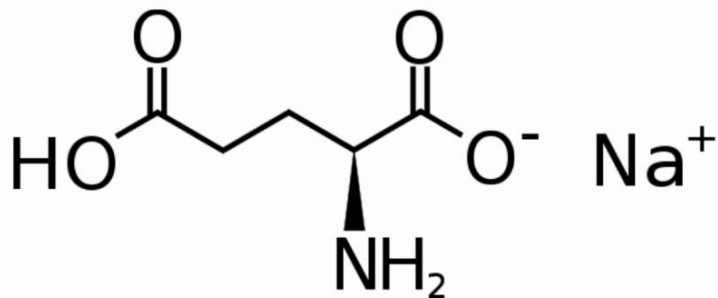
Tyr or Phe supplements might increase the levels of dopamine

L-dopa is usually prescribed because it passes quickly through the BBB

# Biochemical applications: Monosodium glutamate (MSG)



## MONOSODIUM GLUTAMATE



## SODIUM SALT OF GLUTAMIC ACID

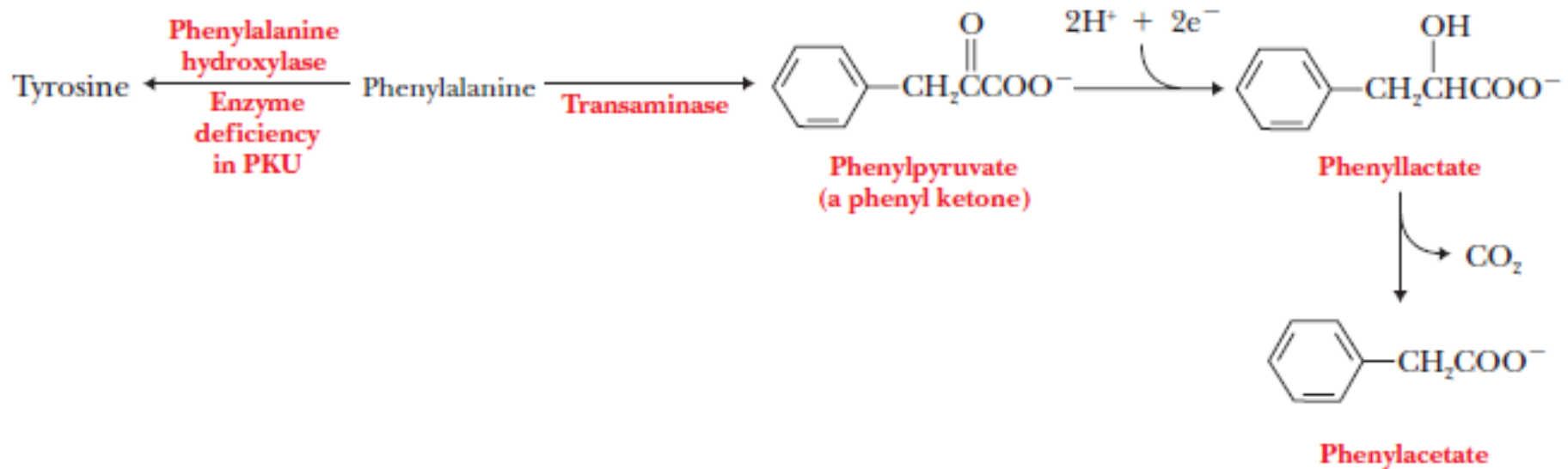
Glutamic acid derivative

Flavor enhancer, Asian food.

MSG causes a physiological reaction in some people (chills, headaches, and dizziness)

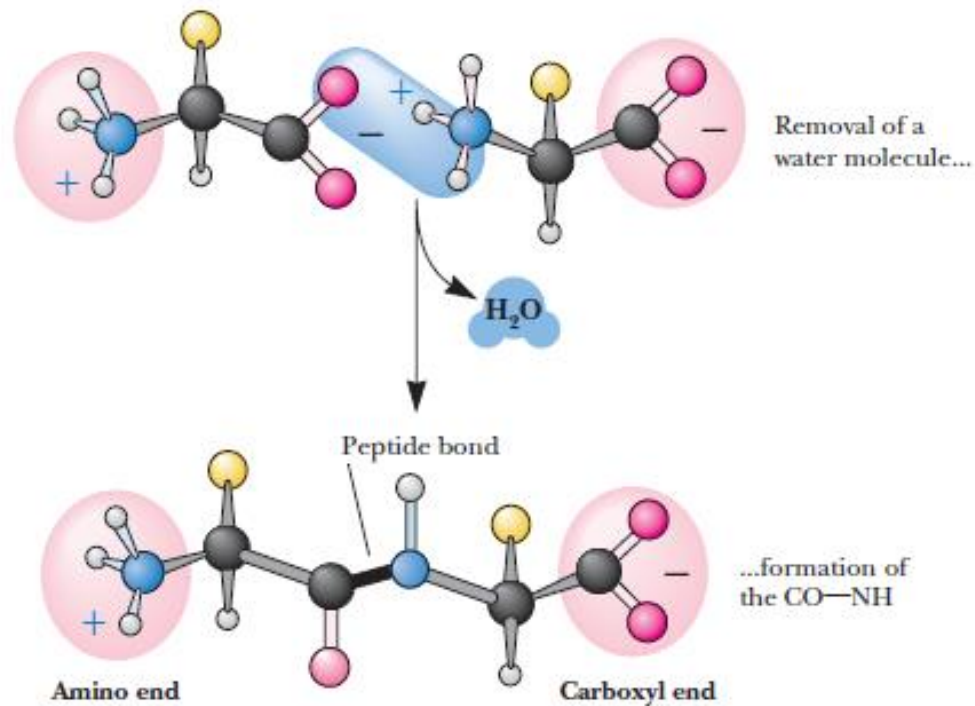
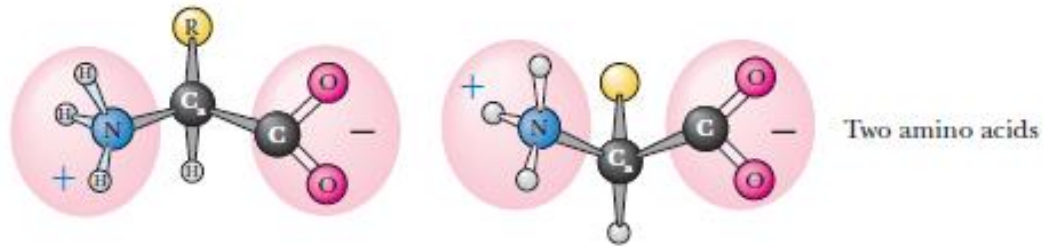
Chinese restaurant syndrome.

# Clinical hint: Phenylketonuria (PKU)



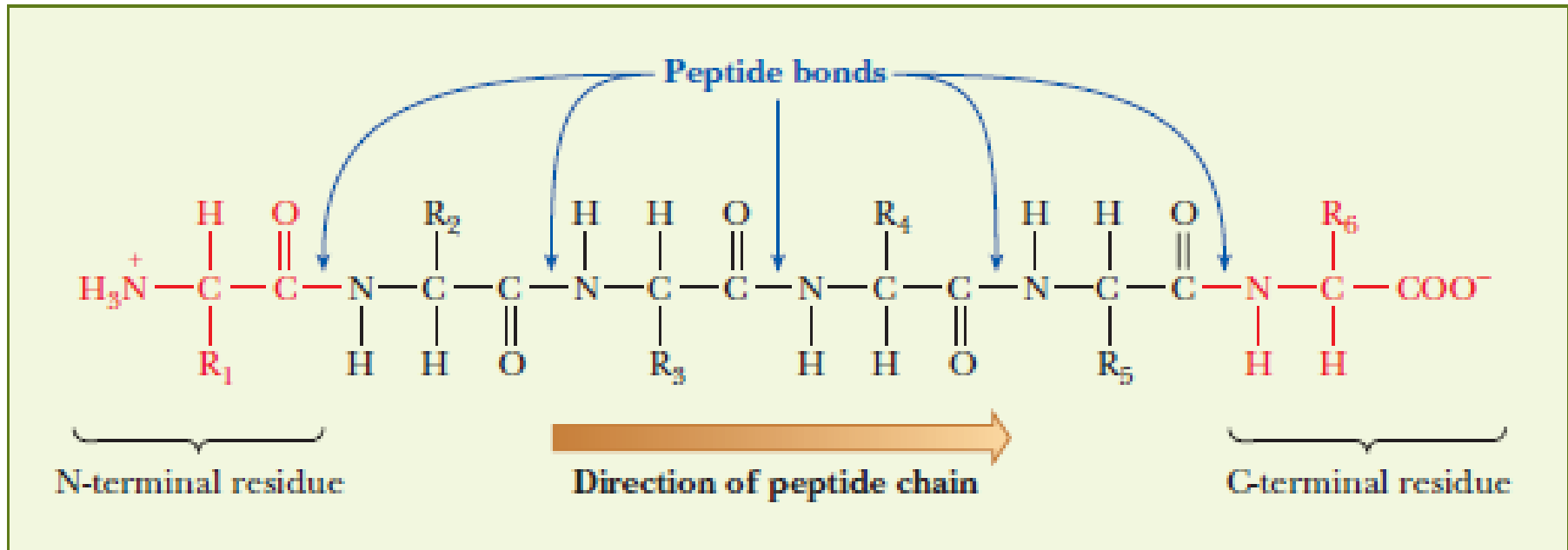
■ Reactions involved in the development of phenylketonuria (PKU). A deficiency in the enzyme that catalyzes the conversion of phenylalanine to tyrosine leads to the accumulation of phenylpyruvate, a phenyl ketone.

# The peptide bond





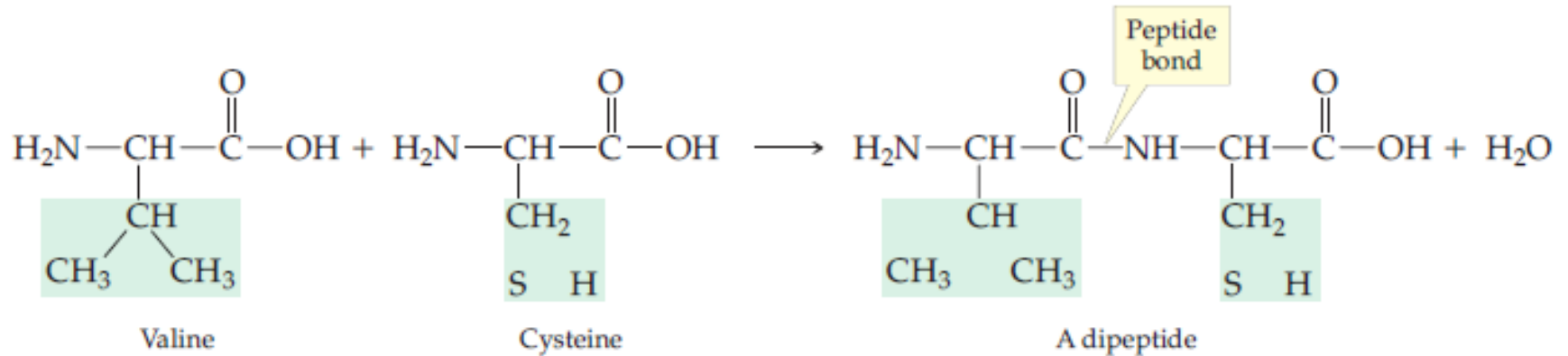
# Peptide and polypeptide chains



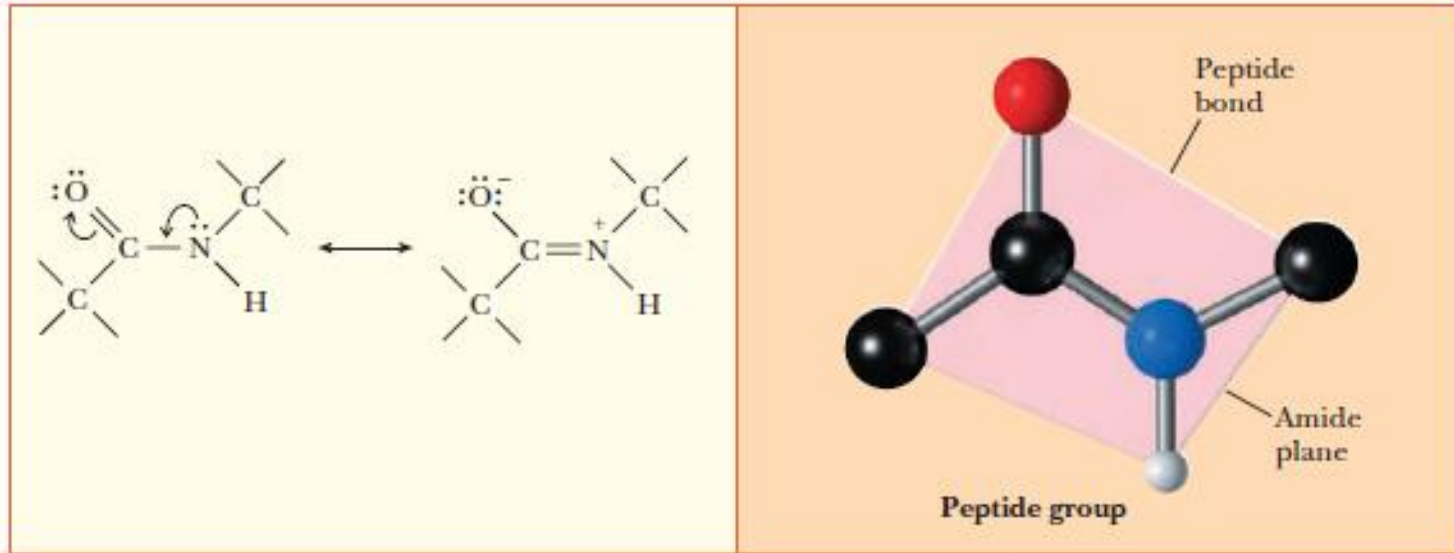
**Peptides:** two to several dozens AA.

**Polypeptide chain:** many amino acids (usually more than a hundred)

# Proteins are polymers of amino acids



# Resonance structures



**A** Resonance structures of the peptide group.

**B** The planar peptide group.

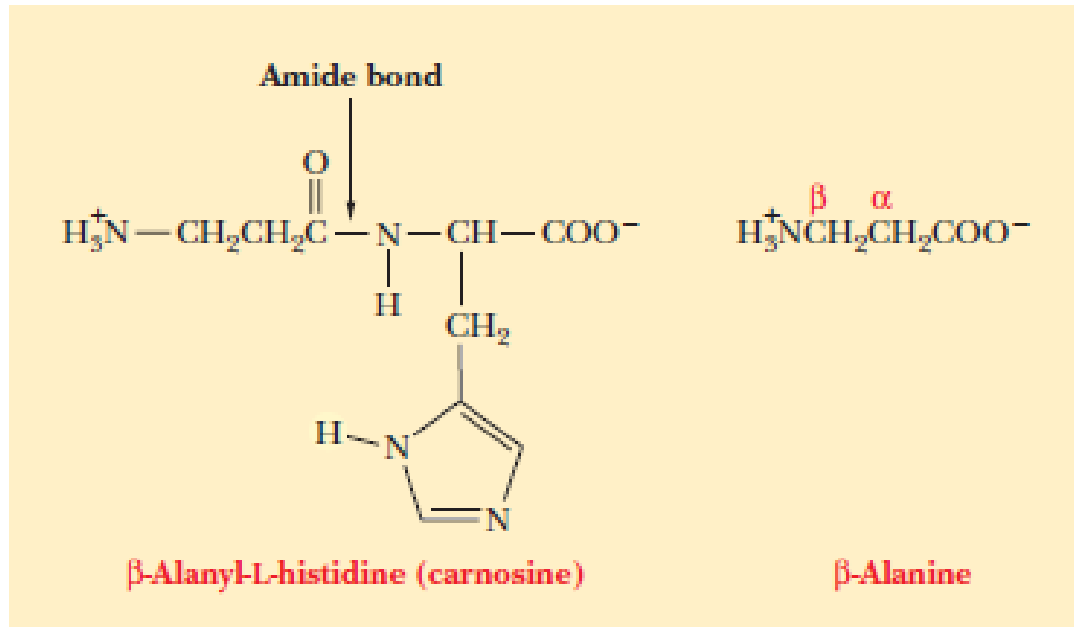
The peptide bond group is planar because it has partial double bond character.

The peptide bond is stronger than an ordinary single bond because of the resonance stabilization.

No significant rotation around the peptide bond acts as a stereochemical constraint that affects protein folding.

# Small peptides with physiological functions

## Carnosine



■ **FIGURE 3.11** Structures of carnosine and its component amino acid  $\beta$ -alanine.

A naturally occurring dipeptide

Found in muscle tissue



# Small peptides with physiological functions

## Enkephalins

Tyr—Gly—Gly—Phe—Leu (three-letter abbreviations)

Y—G—G—F—L (one-letter abbreviations)

Leucine enkephalin

Tyr—Gly—Gly—Phe—Met

Y—G—G—F—M

Methionine enkephalin

3D structures of opiates, such as morphine, and enkephalins are similar, hence, opiates bind to enkephalin receptors in the brain to produce their physiological activities.

Two pentapeptides found in the brain

Naturally occurring analgesics (pain relievers).

The aromatic side chains of Tyr and Phe in these peptides play a role in their activities.

# Small peptides with physiological functions

## Oxytocin and vasopressin

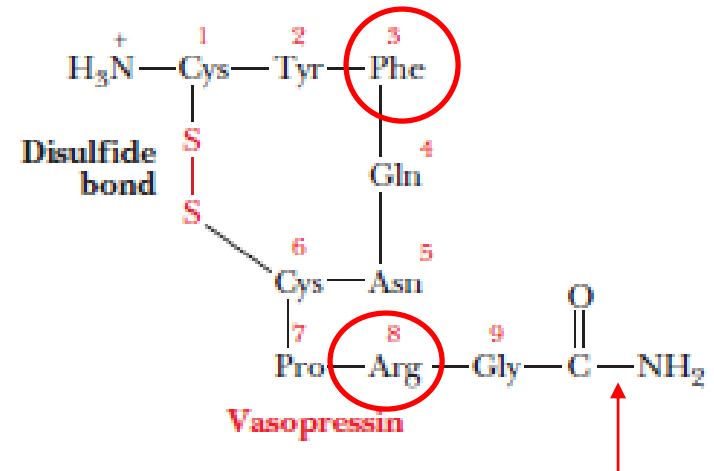
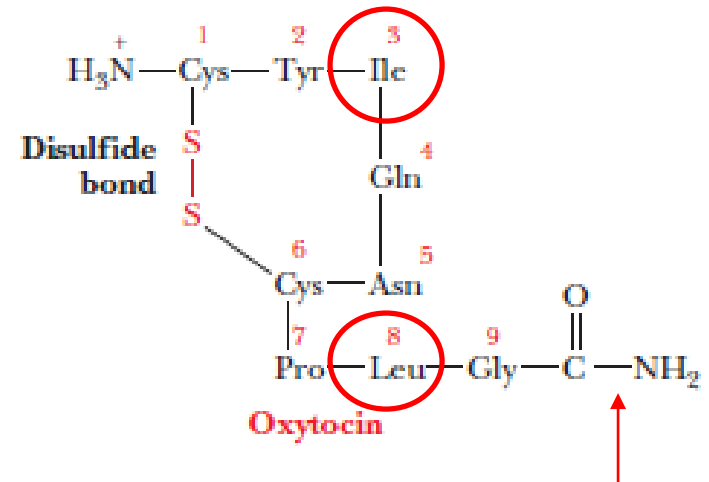
Cyclic structures due to an —S—S— bond

Each contains nine amino acid residues

Each has an amide group (rather than a free carboxyl group) at the C-terminal end

Each has a disulfide link between Cys residues at positions 1 and 6.

Both are hormones



■ **FIGURE 3.13** Structures of oxytocin and vasopressin.



# Peptide hormones: oxytocin and vasopressin

Oxytocin induces labor in pregnant women by controlling contraction of uterine muscle and stimulates the flow of milk in a nursing mother

During pregnancy, the number of receptors for oxytocin in the uterine wall increases.

As the cervix stretches, sending nerve impulses to the hypothalamus as a positive feedback to release more oxytocin by the posterior pituitary gland.

Vasopressin controls of blood pressure by regulating smooth muscle contraction.

Vasopressin is released by the action of the hypothalamus on the posterior pituitary.

Vasopressin stimulates water reabsorption by the kidney (an antidiuretic effect) resulting in water retention and blood pressure increase.





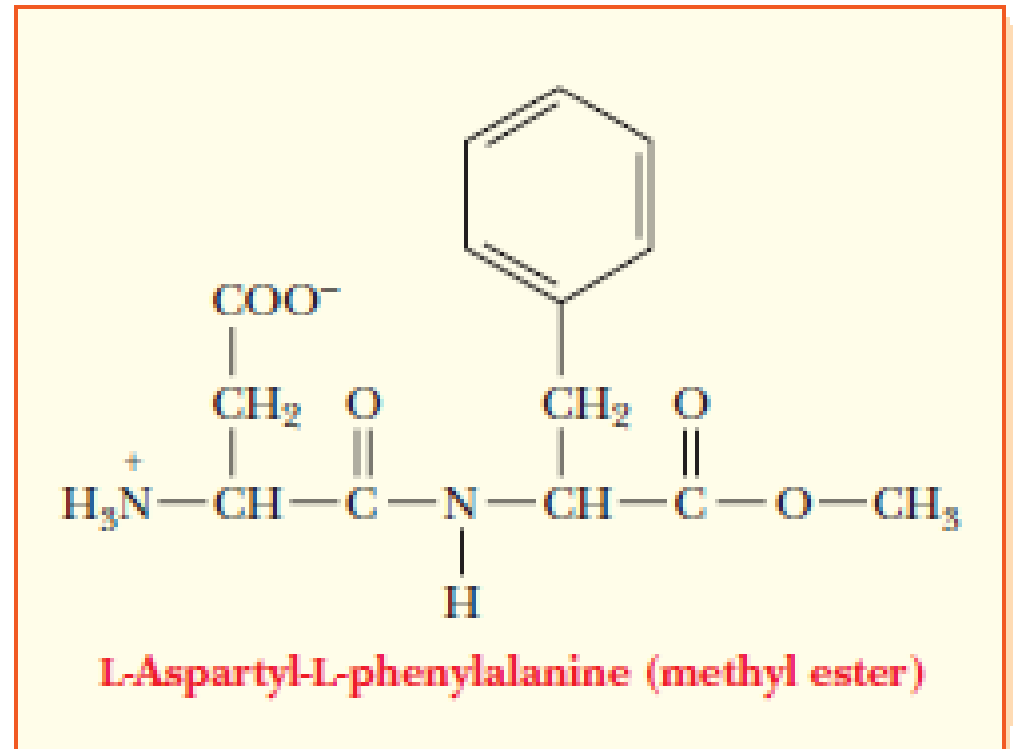
# Biochemical applications: Aspartame

~200 times sweeter than sugar

Controversial safety

Diet soft drinks

If both Asp and Phe or one is  
D-isomer, it tastes bitter.



**A** Structure of aspartame.

Textbook

Campbell Biochemistry, 7<sup>th</sup> edition

Chapter 3, Amino Acids and Peptides