

Amino Acids and Peptides

Nafith Abu Tarboush

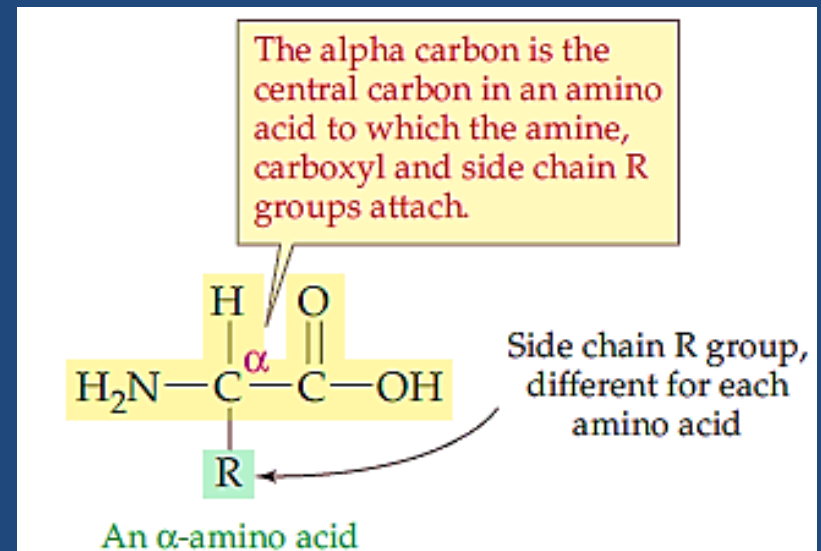
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Protein structure and function

- Greek: proteios, primary (importance)
- 50 % of body's dry weight is protein
- Wide range of different functions (next slide)
- Polymers of amino acids
- Structure of the amino acids (backbone vs. Side-chain)
- Free vs. attached (residue)

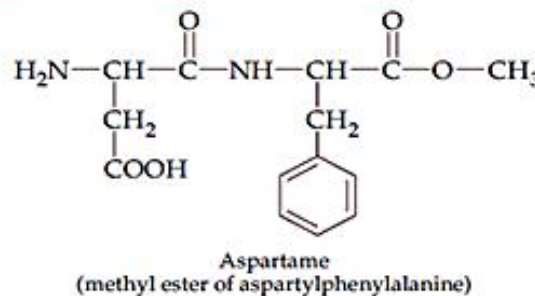
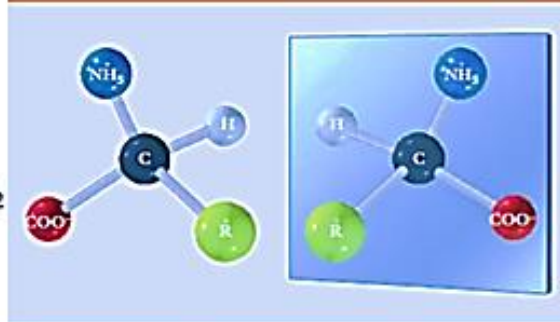
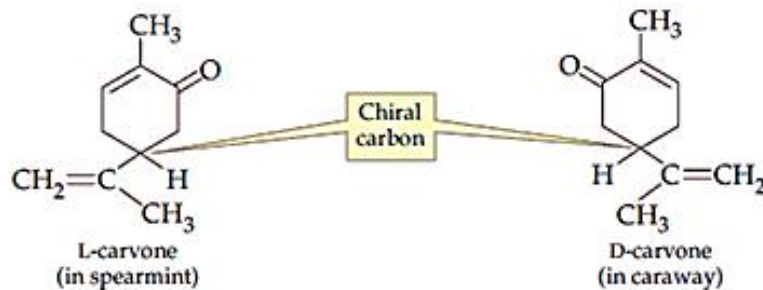
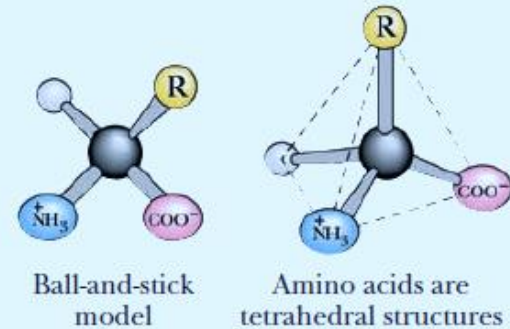
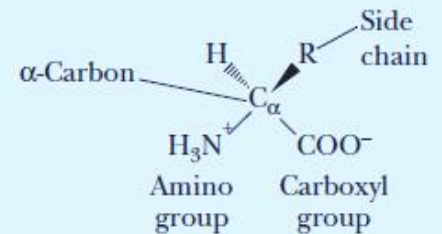


Protein structure and function

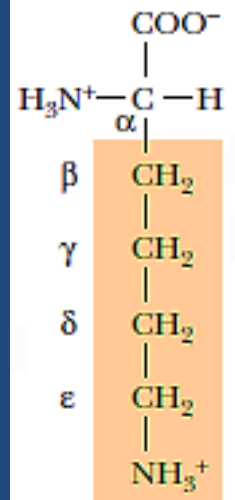
TYPE	FUNCTION	EXAMPLE
Enzymes	Catalysts	<i>Amylase</i> —begins digestion of carbohydrates by hydrolysis
Hormones	Regulate body functions by carrying messages to receptors	<i>Insulin</i> —facilitates use of glucose for energy generation
Storage proteins	Make essential substances available when needed	<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
- The basis of their classification
- Handedness and chirality (L vs. D)



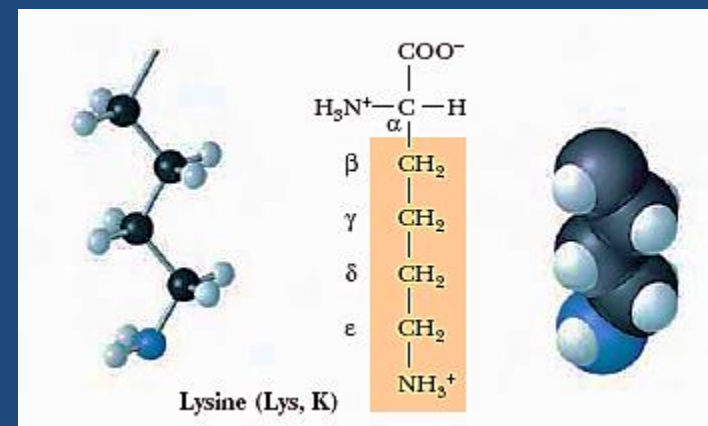
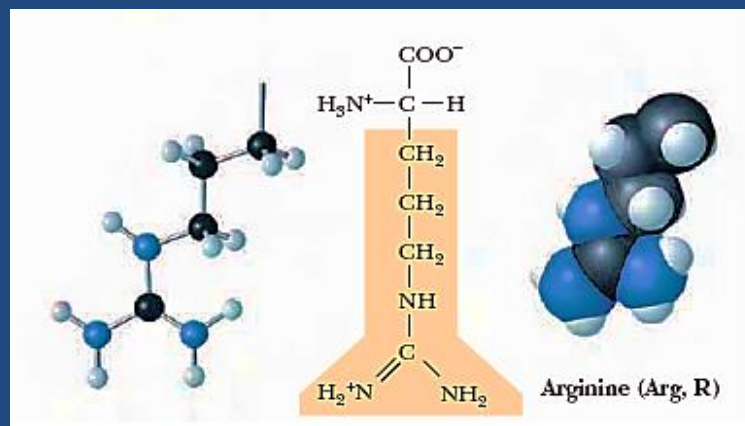
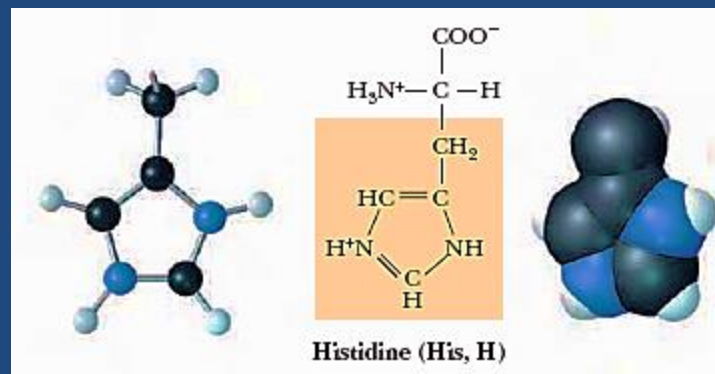
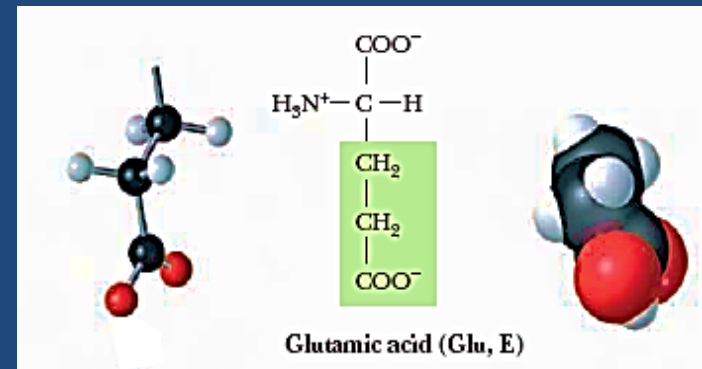
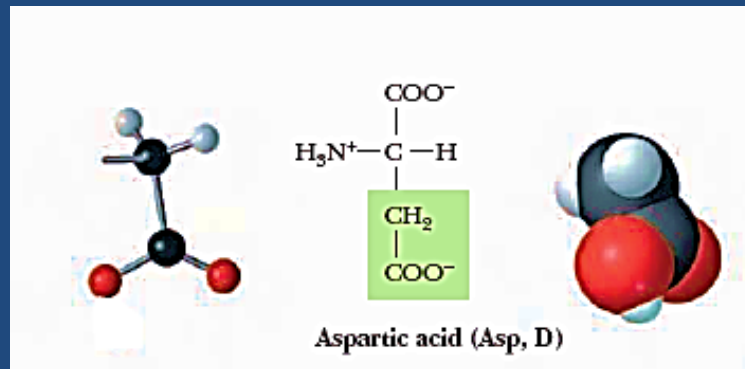
ω -carbon



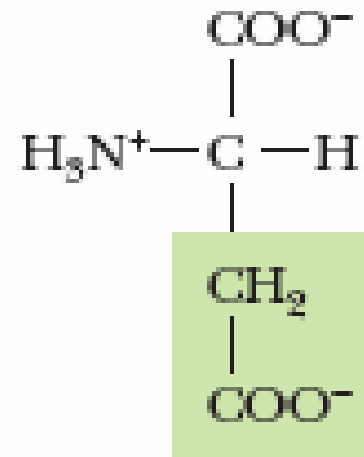
Names and codes

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

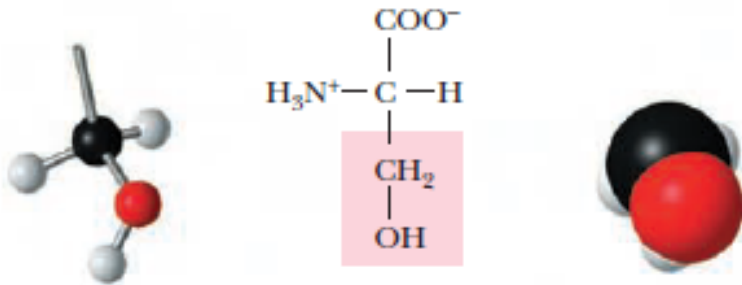


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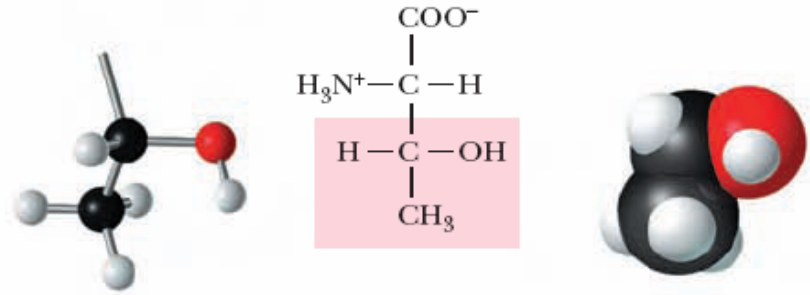


Aspartic acid (Asp, D)

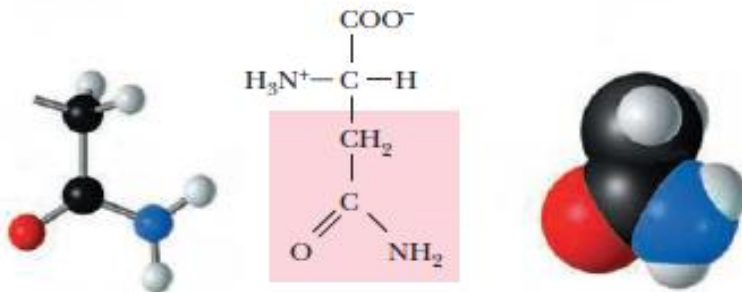
Polar, Uncharged



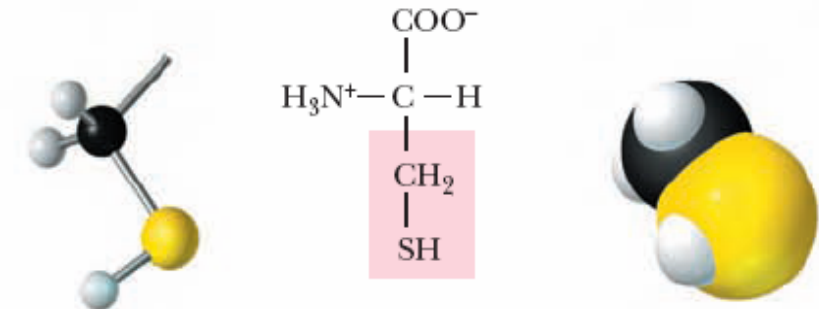
Serine (Ser, S)



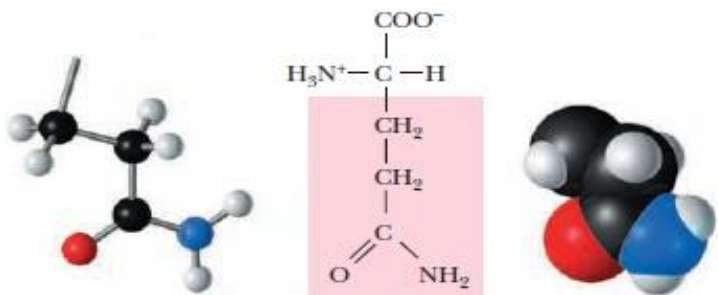
Threonine (Thr, T)



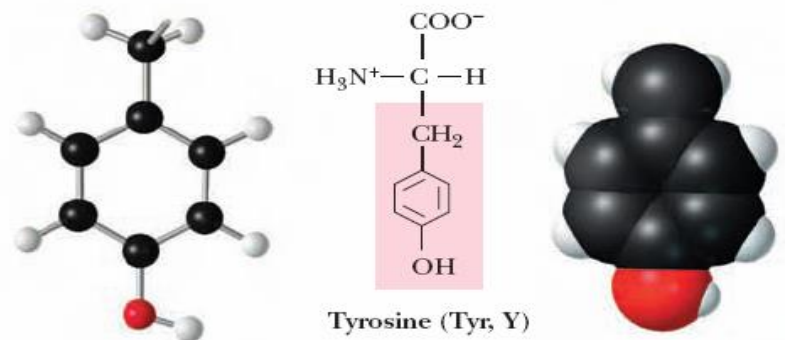
Asparagine (Asn, N)



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

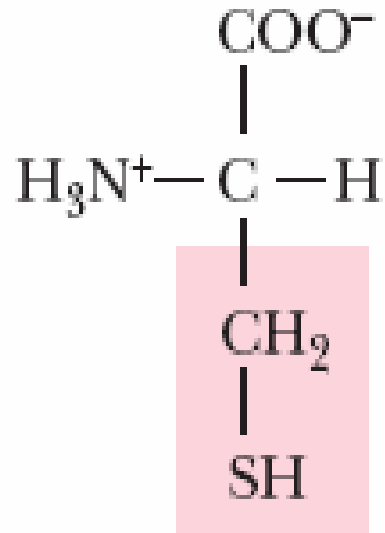
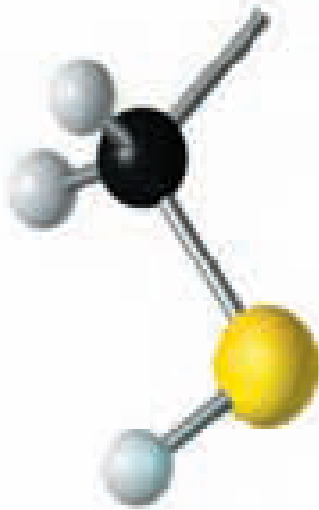


Glutamine (Gln, Q)



Tyrosine (Tyr, Y)

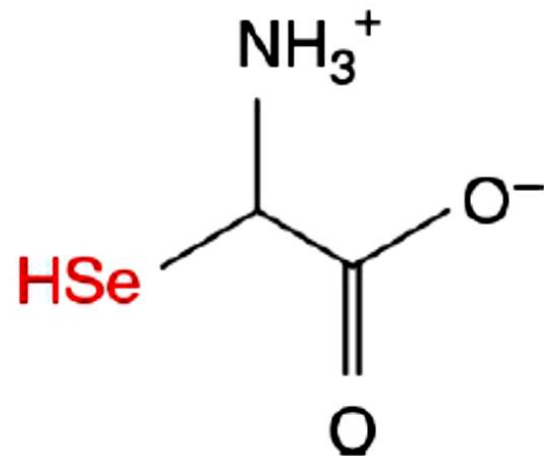
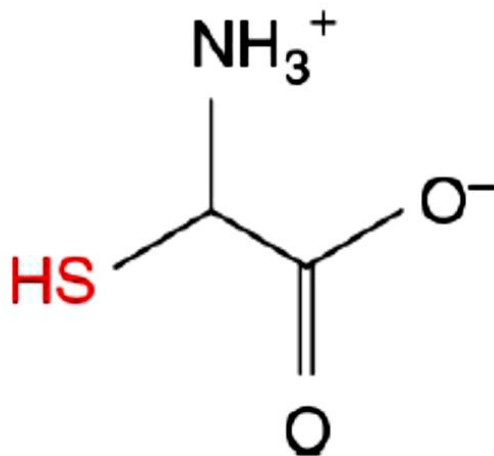
Polar, Uncharged



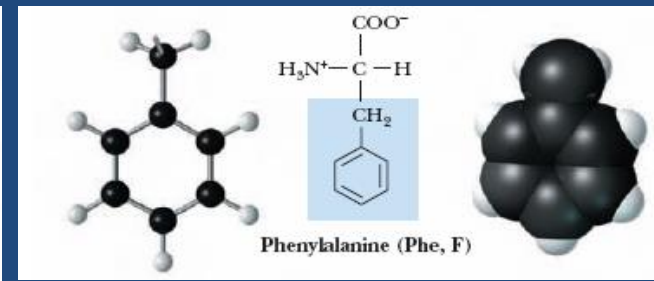
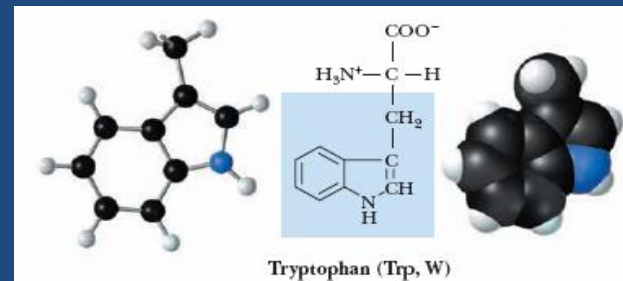
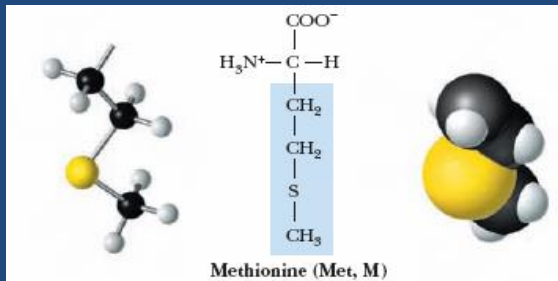
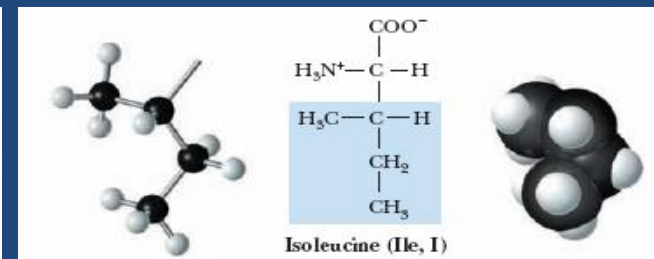
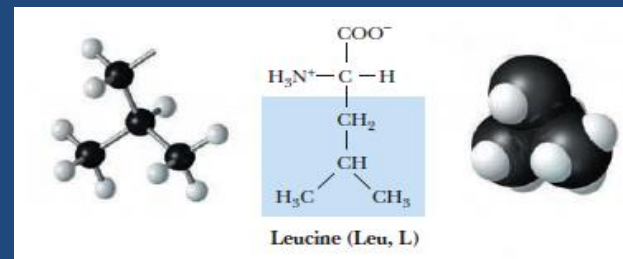
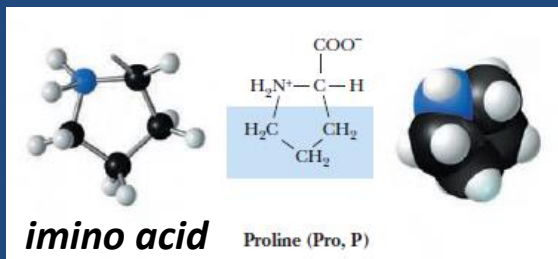
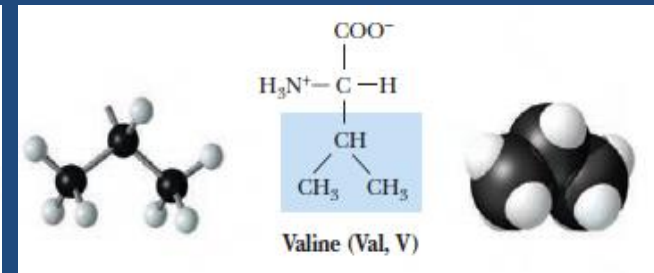
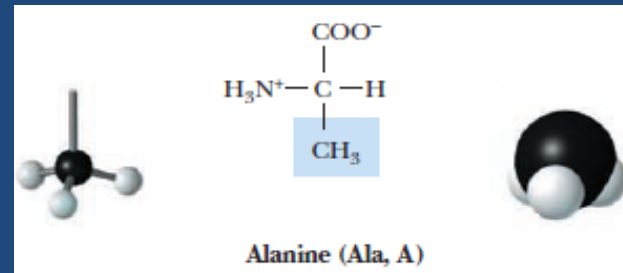
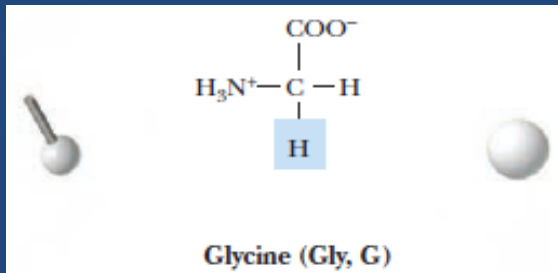
Cysteine (Cys, C) (—S—S—)

Selenocysteine, the 21st Protein L- α -Amino Acid

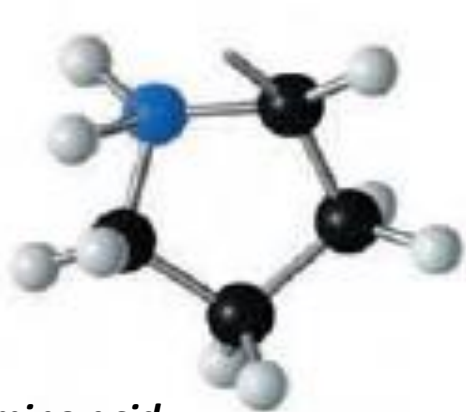
- How does the modification occur?
- What is the codon? (UGA)
- Deiodinase ($T4 \rightarrow T3$)
- $pK_3 = 5.2$ (vs. 8.3)



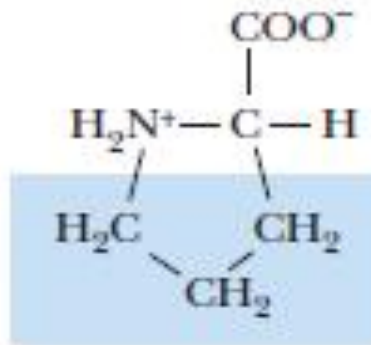
Non-polar, Uncharged



Non-polar, Uncharged



imino acid

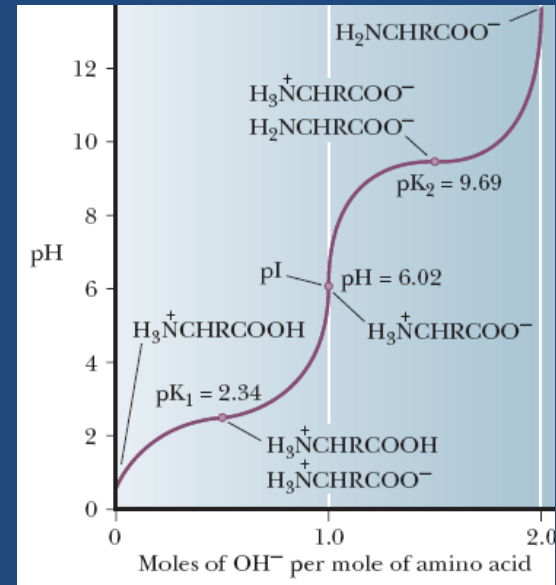
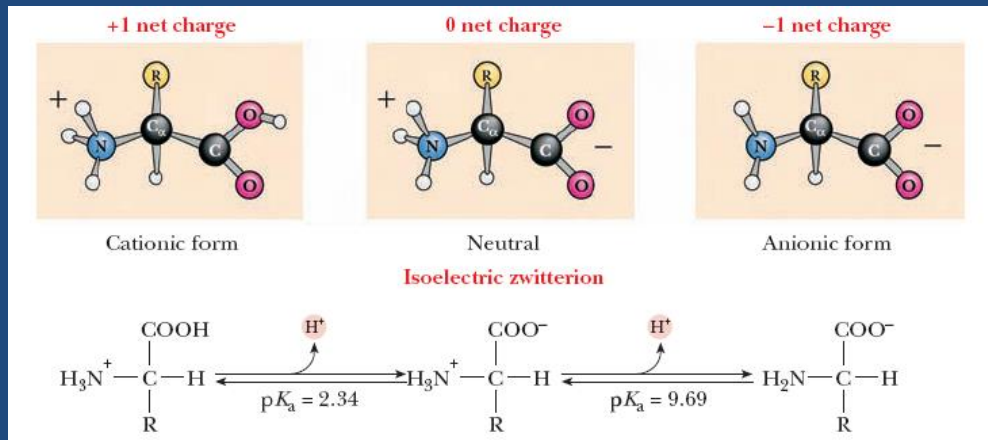


Proline (Pro, P)

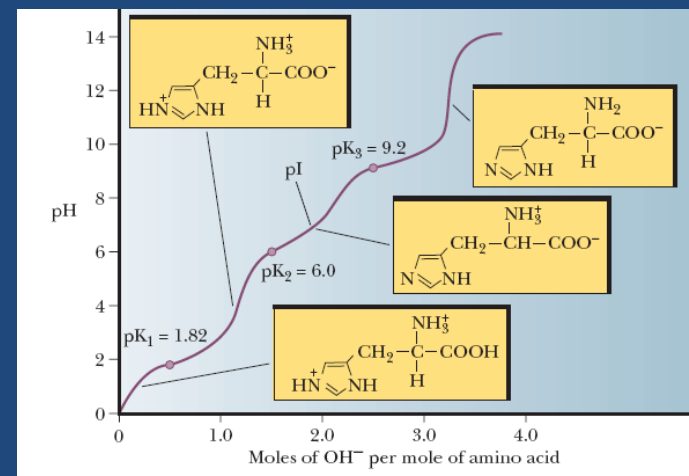
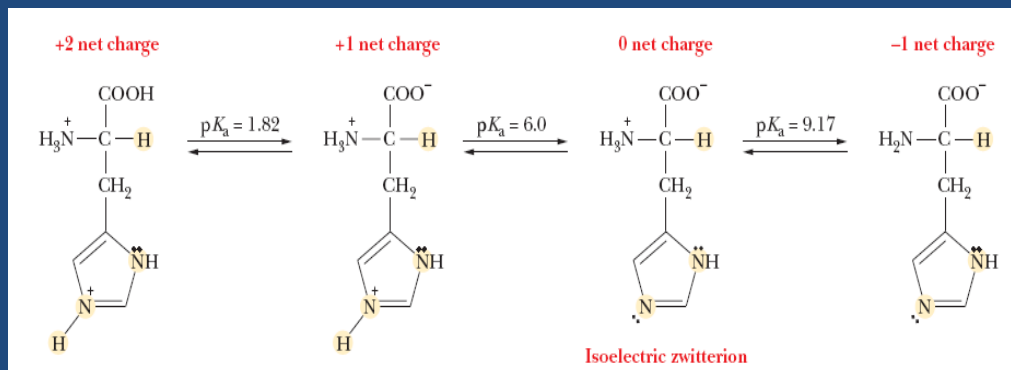


Titration of amino acids: what happens?

And what is an isoelectric point (pI)?



$$\text{pI} = (\text{pK}_{a1} + \text{pK}_{a2})/2$$



Amino Acid	Abbreviation		pK ₁	pK ₂	pK _R	pI
	3-Letters	1-Letter	-COOH	-NH ₃ ⁺	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.

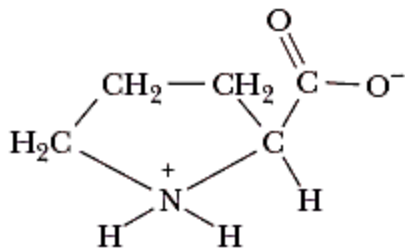
Is it the same in proteins?

Dissociating Group	pK_a Range
α-Carboxyl	3.5-4.0
Non-α COOH of Asp or Glu	4.0-4.8
Imidazole of His	6.5-7.4
SH of Cys	8.5-9.0
OH of Tyr	9.5-10.5
α-Amino	8.0-9.0
ε-Amino of Lys	9.8-10.4
Guanidinium of Arg	~12.0

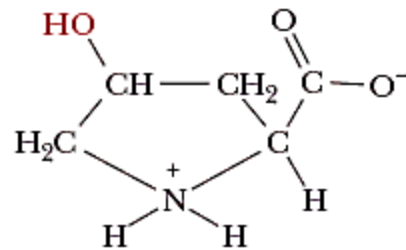
Posttranslational modification of Amino Acids

- Includes:
 - Hydroxylation (-OH)
 - Carboxylation (-COOH)
 - Methylation (-CH₃)
 - Formylation (-CH=O)
 - Acetylation (CH₃CO)
 - Prenylation (a farnesyl or a geranylgeranyl)
 - Phosphorylation ($-\text{PO}_3^{2-}$)
- These modifications significantly extend the biologic diversity of proteins by altering their solubility, stability, catalytic activity, and interaction with other proteins

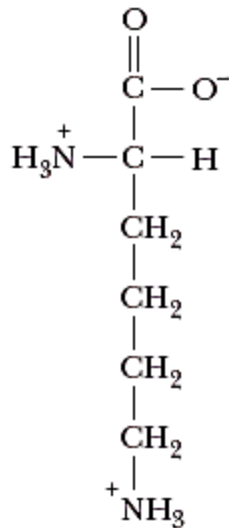
Posttranslational modification of Amino Acids



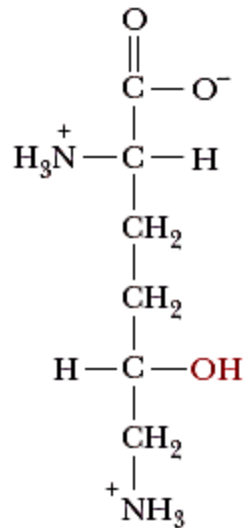
Proline



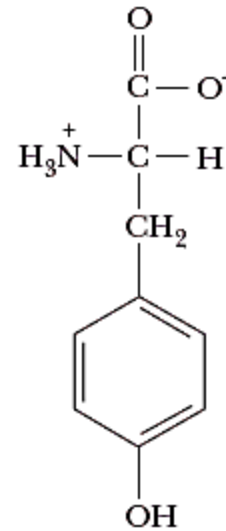
Hydroxyproline



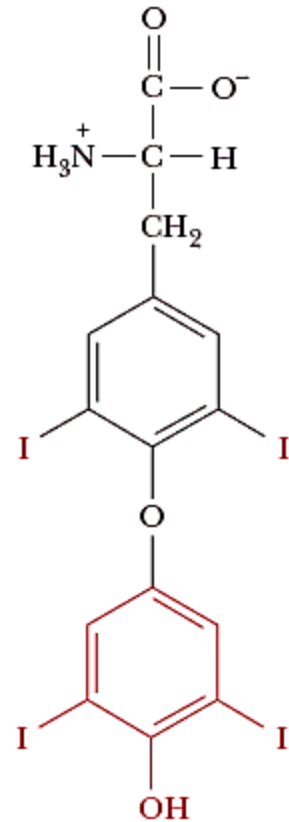
Lysine



Hydroxylysine

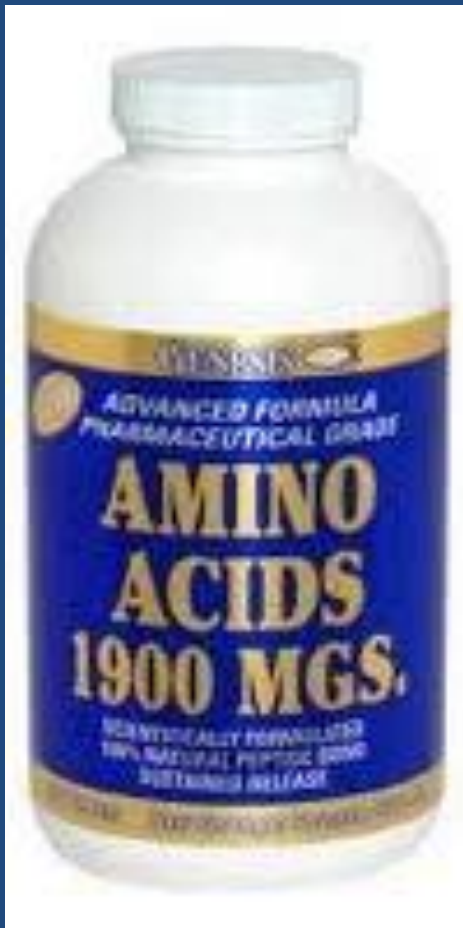


Tyrosine



Thyroxine

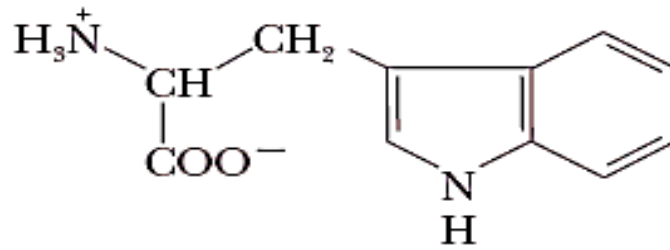
Amino Acids & life



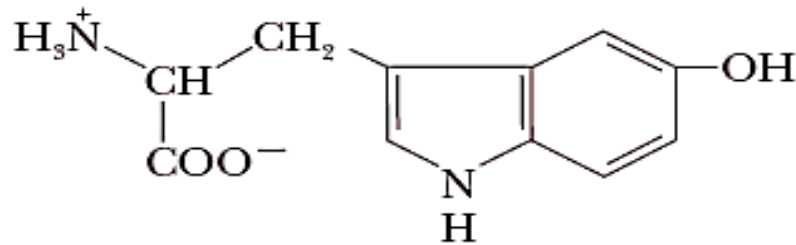
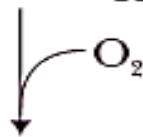
Amino acids & life

- 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

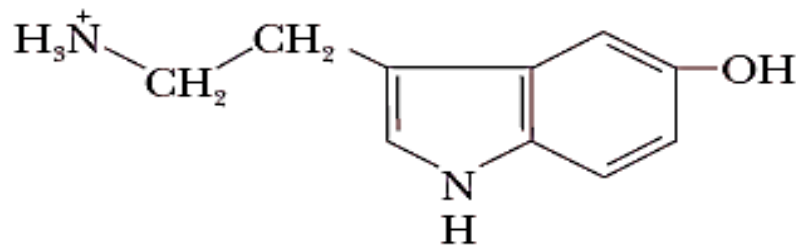
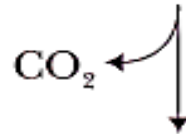
Amino acids & life



Tryptophan



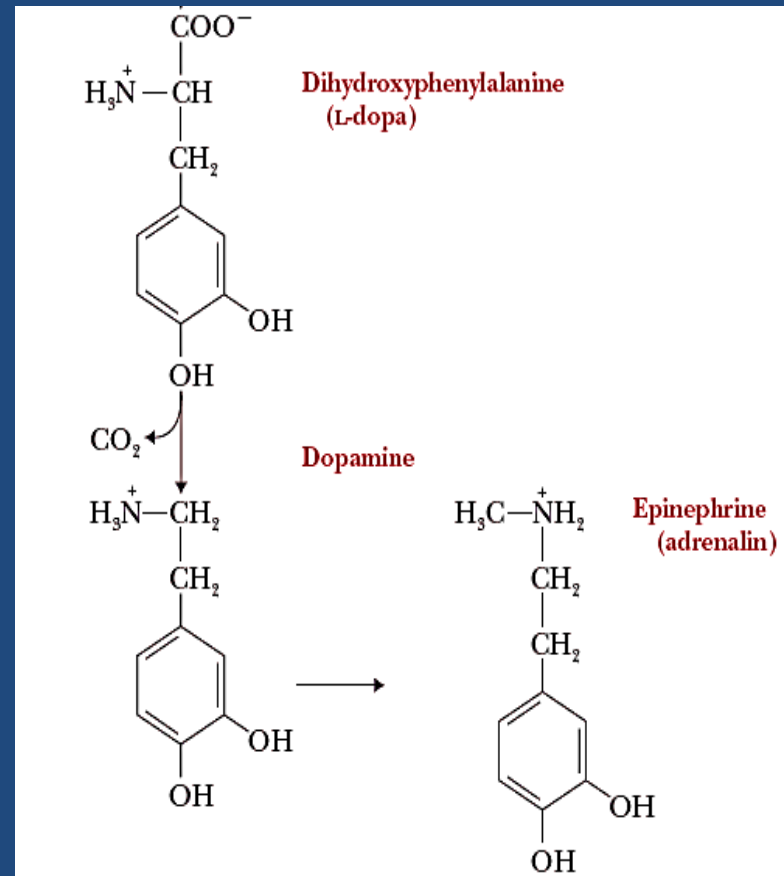
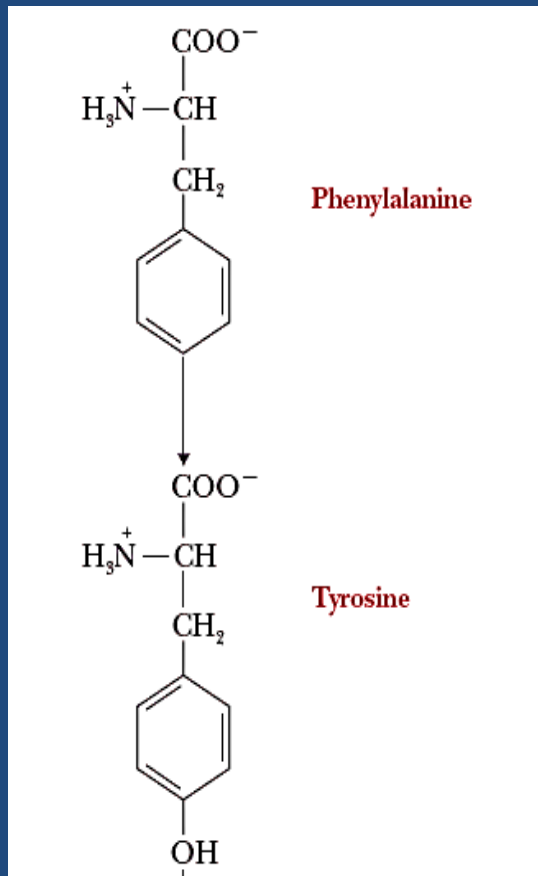
5-Hydroxytryptophan



Serotonin

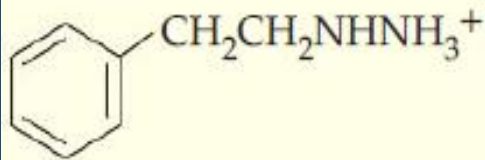
Amino acids & life

- The active products of Tyr metabolism are monoamine derivatives (MA). **MAO vs. MAO_i** makes metabolism slow
- *A Beautiful Mind, focused on Dopamine*

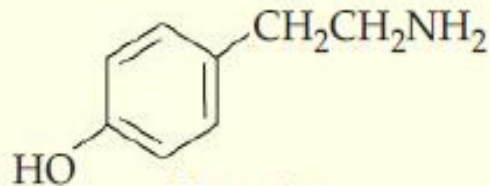


Amino acids & life

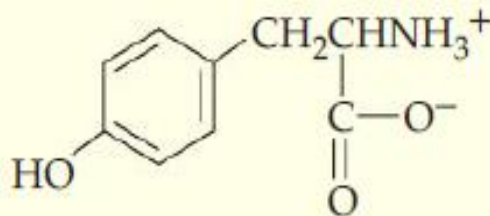
- Tyrosine supplements & morning lift
- Cheese and red wines (tyramine; mimics epinephrine); a cheese omelet is a favorite way to start the day



Phenelzine
(an antidepressant)



Tyramine
(a pressor)



Tyrosine
(α -amino acid)

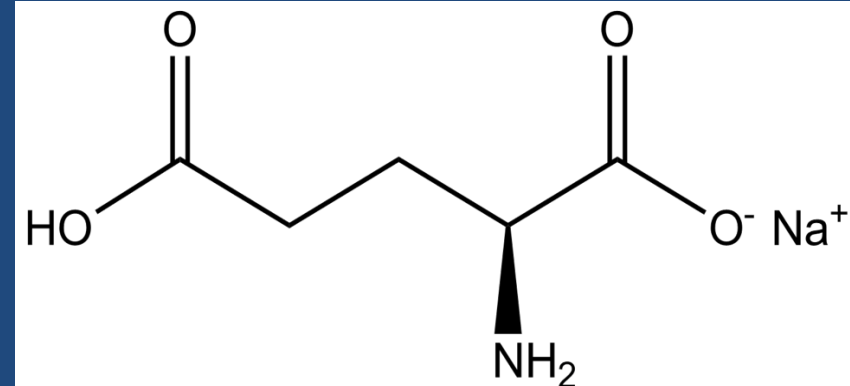
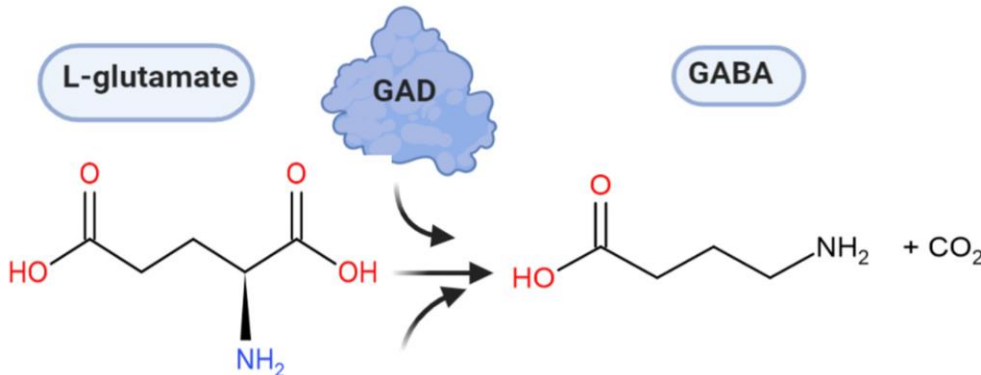
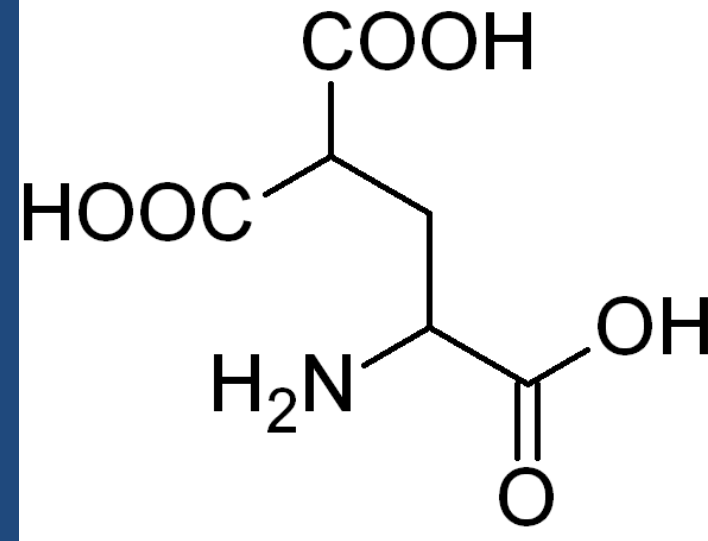


Other amino acids



- **Glutamic Acid:**

- MSG, a flavor enhancer
- Causes a physiological reaction in some people (*Chinese restaurant syndrome*) or MSG symptom complex: chills, headaches, and dizziness



Other amino acids

- **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.

