# AMINO ACIDS, PEPTIDES & PROTEINS

↳ ≥ 2 Aminoacids linked by a peptide bond

* # of Peptide bonds = # of Aminoacids − 1
- e.g: a Protein contains 120 aminoacids, How many Peptide bonds it has?
  - # of Peptide bonds = 120 − 1
    = 119 bonds

# AMINO ACIDS

# Biochemical Properties

20 standard amino acids (a-amino acids) – proteins

each one has it's own genetic code (codons)

↳ In mammals

Uncommon amino acids in the body (in free form or in combined states) that are not associated with proteins. For example, citrulline and ornithine (disposal of waste nitrogen via the urea cycle)

aka: unstandard

One of the ways by which the body gets rid of nitrogen

* Excretion process:
1. Respiration: $CO_2$, $H_2O$
2. Sweating: $H_2O$, Salts
3. Urination: $H^+$, Urea, Creatinine

Precursors to hormones – tyrosine in the formation of thyroid hormones

source

↳ Standard a.a, contains benzine ring in side chain along with (-OH)

Glutamate – as neurotransmitter

Inhibitory neurotransmitter (GABA)

acidic a.a along with Aspartate

↳ contains Carboxyl group -COOH

* any a.a containing benzine ring will have a smell (Aromatic a.a), these include:
- Tyrosin
- Phenyl Alanin
- Tryptophan

- Tryptophan has two rings, thus it can absorbs & emit light → Flourscent

* Smallest a.a is Glycine

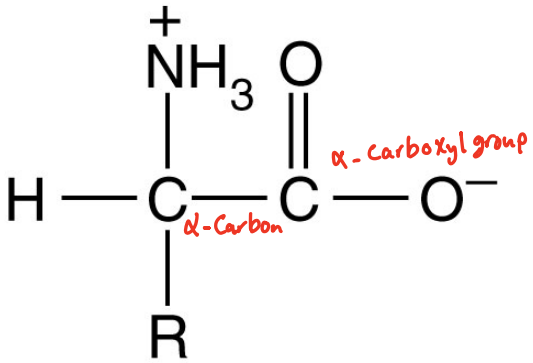



**Figure 5.3 General Structure of the a-Amino Acids**

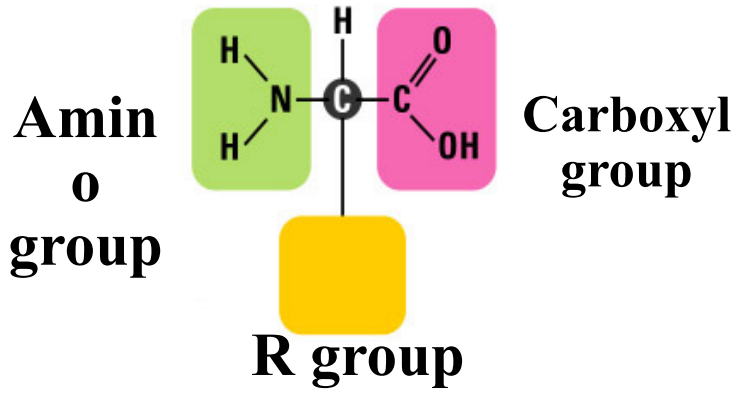
- 19 have the same general structure: central (a) carbon, an amino group, carboxylate group, hydrogen atom, and an R group (proline is the exception)

- At pH 7, the carboxyl group is in its dissociated conjugate base form (-COO-) while the amino group is its undissociated conjugate acid form (-NH3+); therefore, it is **amphoteric**

* Basic Amino Acids:
  - Histidine
  - Lysine
  - Arginine

# Structure of Amino Acids

Amino acids have a central carbon with 4 things boded to it:



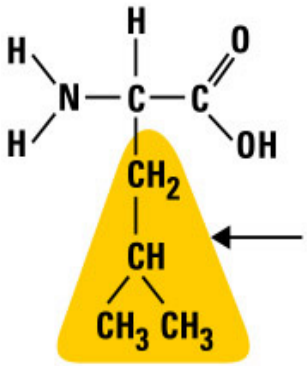

**Amino group -NH3**

**Carboxyl group -COOH**

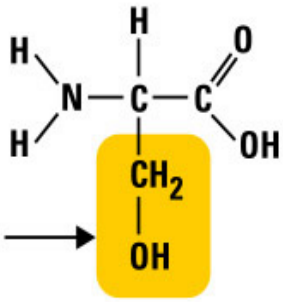
**Hydrogen -H**

**Side group -R**

chain



**Leucine -hydrophobic**



**Side groups**

**Serine-hydrophillic**

- **Amino Acid Stereoisomers** → مش داخل في الامتحان
- Because the a-carbon (**chiral carbon**) is attached to four different groups, they can exist as **stereoisomers**
- Except glycine, which is the only nonchiral standard amino acid

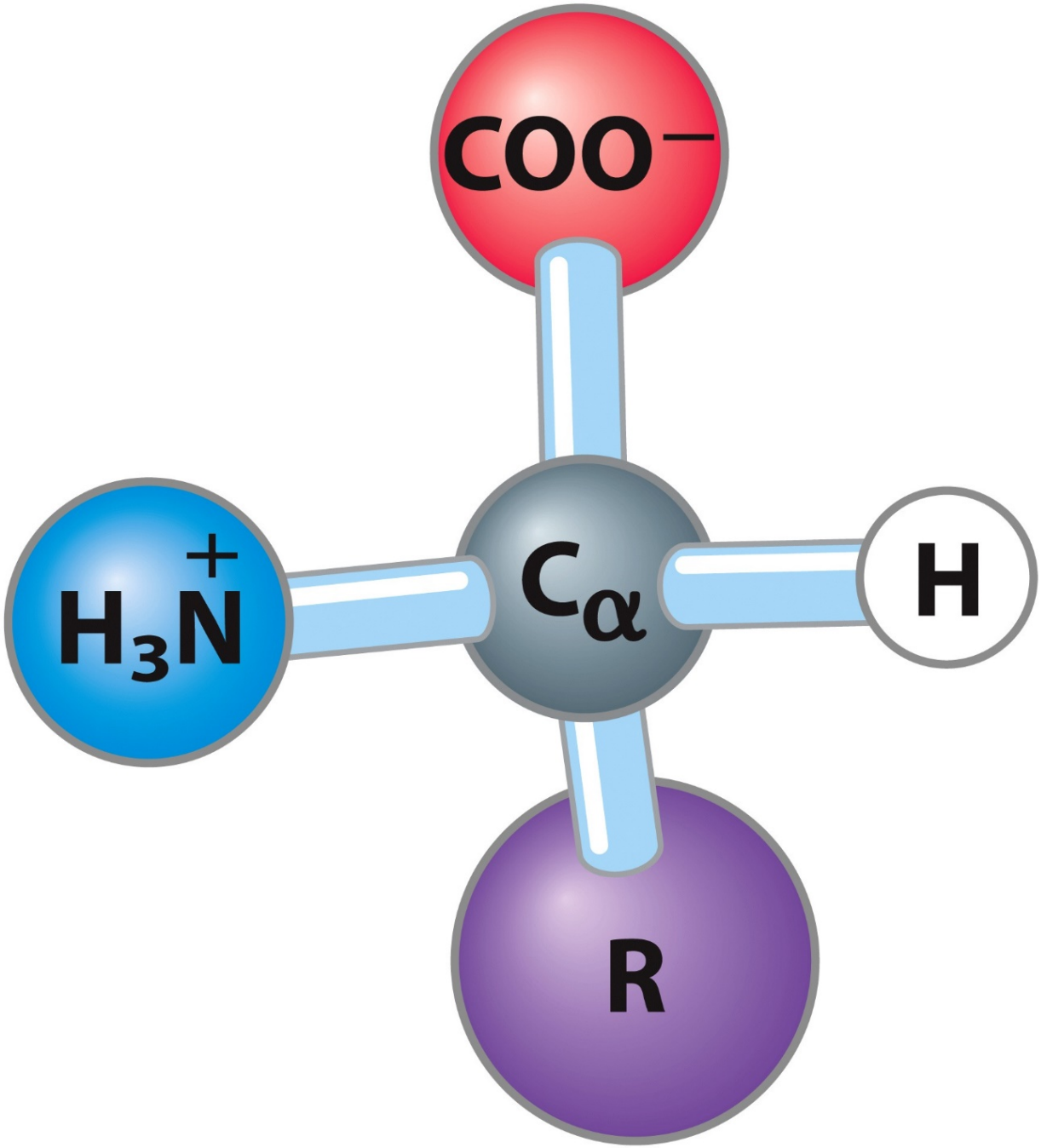
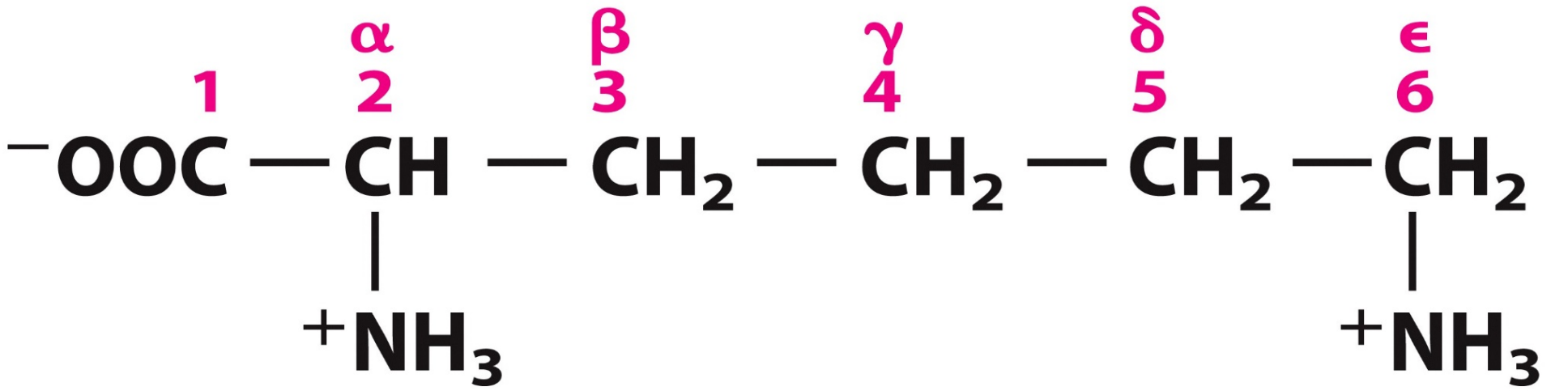



**Figure 3-2**
*Lehninger Principles of Biochemistry*, Sixth Edition




**Lysine**

**Unnumbered 3 p78**

*Lehninger Principles of Biochemistry*, Sixth Edition

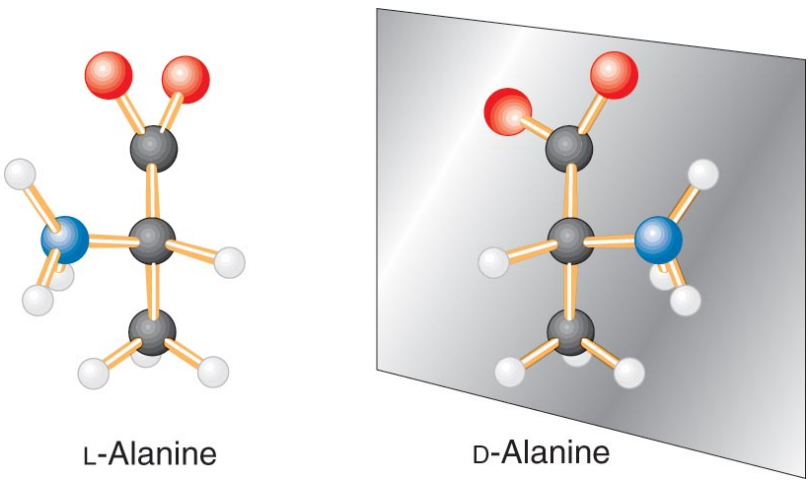


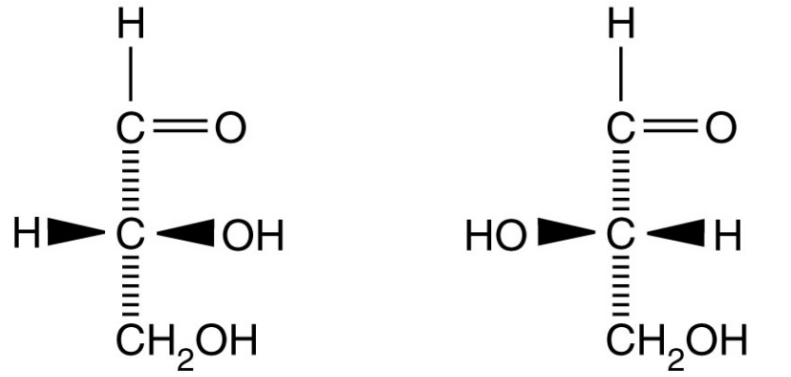

**Figure 5.7 Two Enantiomers**

حش مطلوب!!

- The molecules are mirror images of one another, or **enantiomers**
- They cannot be superimposed over one another and rotate plane, polarized light in opposite directions (**optical isomers**)

* just remember that Carbohydrates exist in our bodies in the D form

**Figure 5.8 D- and L-Glyceraldehyde**




D-Glyceraldehyde L-Glyceraldehyde

↓ ما حكاه الدكتور ↓

- Molecules are designated as D or L (glyceraldehyde is the reference compound for optical isomers)
- D or L is used to indicate the similarity of the arrangement of atoms around the molecule's asymmetric carbon to the asymmetric carbon of the glyceraldehyde isomers
- Chirality has a profound effect on the structure and function of proteins

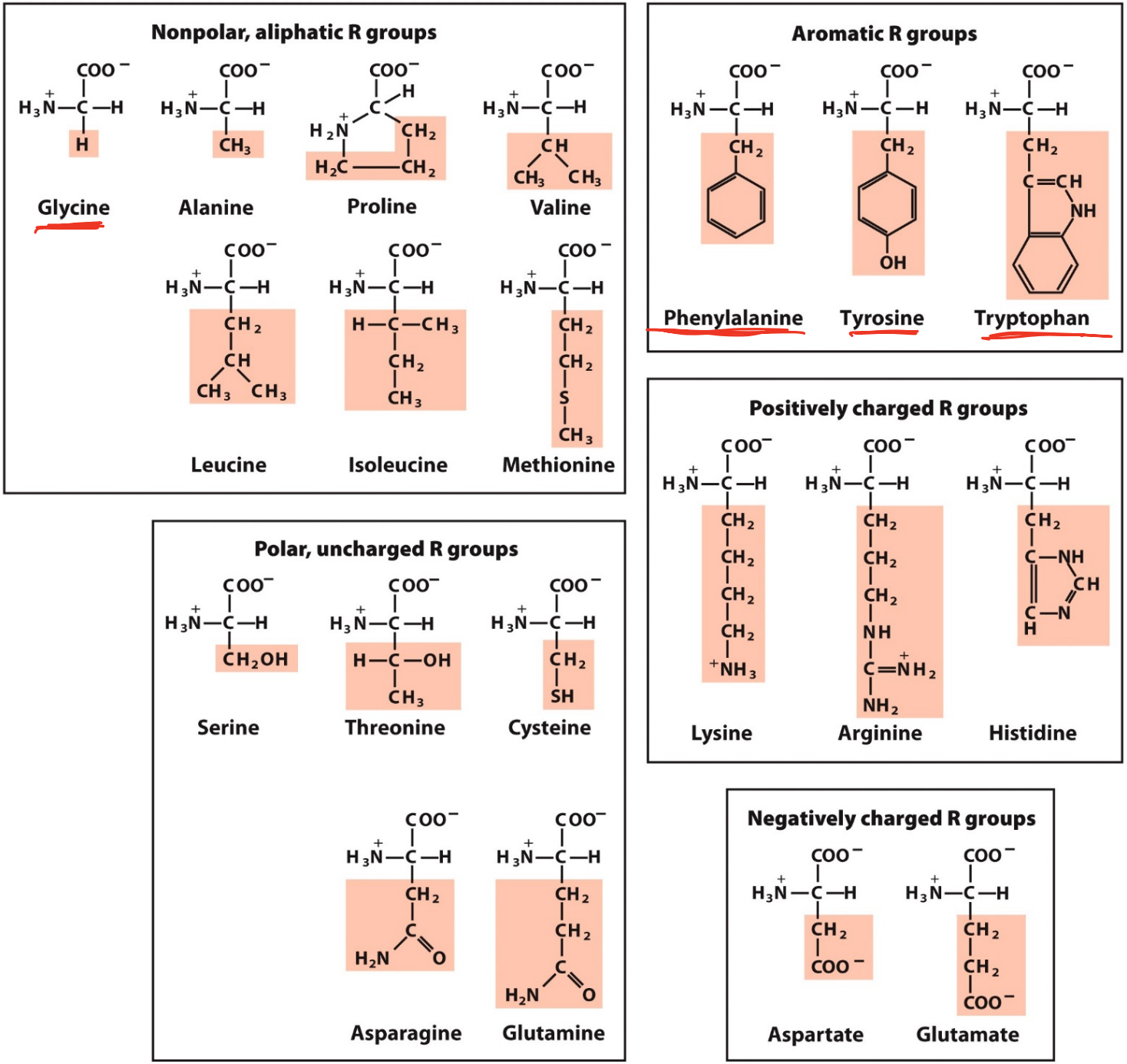



**Figure 3-5**

*Lehninger Principles of Biochemistry*, Sixth Edition

**TABLE 5.1** Names and Abbreviations of the Standard Amino Acids

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

- **Biologically Active Amino Acids** – Life is protein!! → Special senses, muscle contraction
- Amino acids can have other biological roles → other than being part of protein
  1. Some amino acids or derivatives can act as chemical messengers
- **Neurotransmitters** (tryptophan- derivative serotonin → excitation & activation of Brain.) and **hormones** (tyrosine-derivative thyroxine → Thyroid Gland)

سؤال امتحان

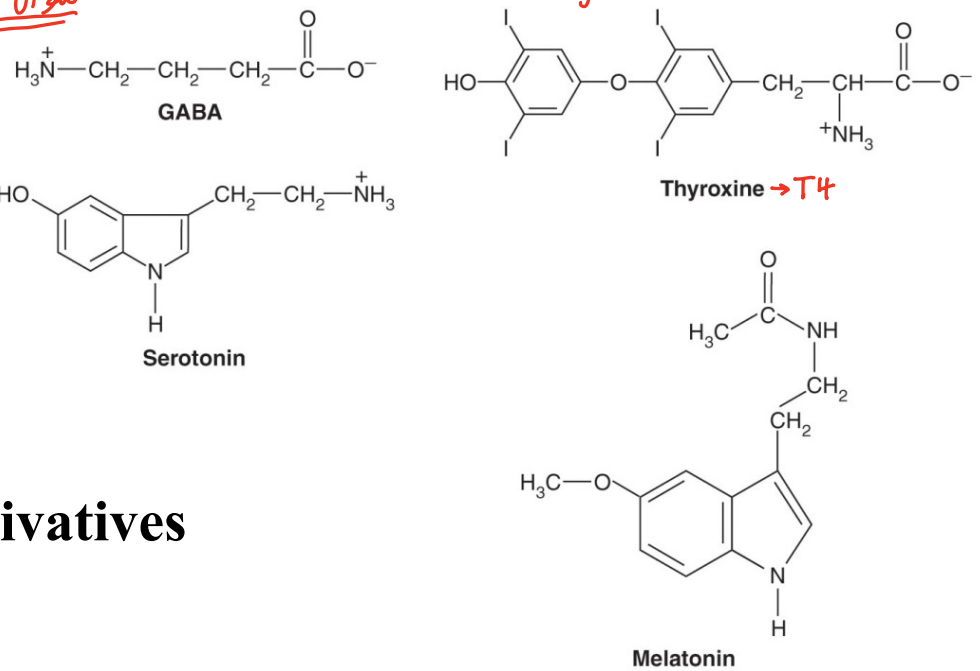



**Figure 5.4 Some Derivatives of Amino Acids**

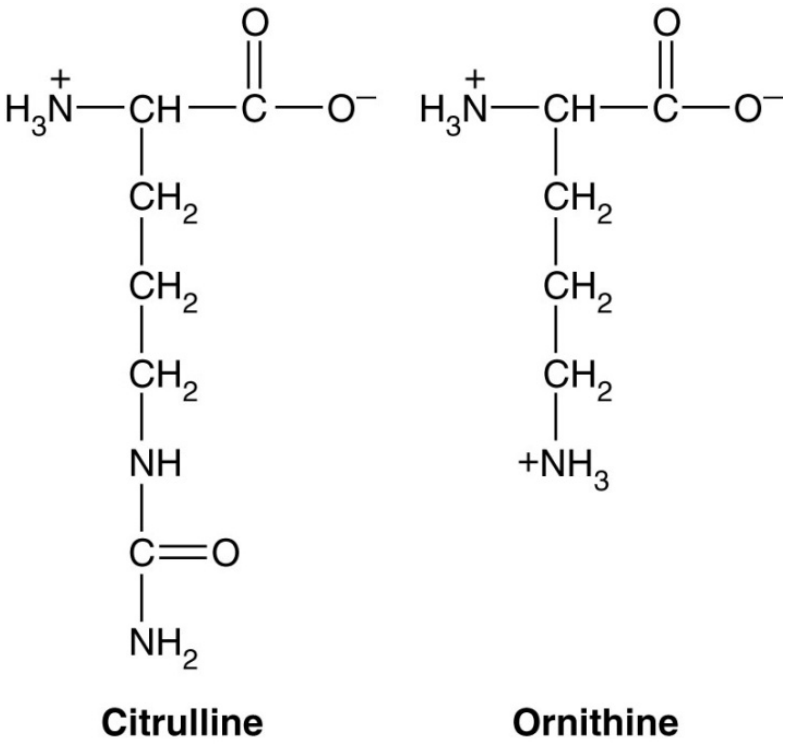



**Figure 5.5 Citruline and Ornithine**

* Heme:
- important for $O_2$ binding with a.a sidechains

Tetrapyrrol Ring


**2.** Act as precursors for other molecules (nucleotides and heme)

HemoProteins → "Super family" → Hundreds of Protein

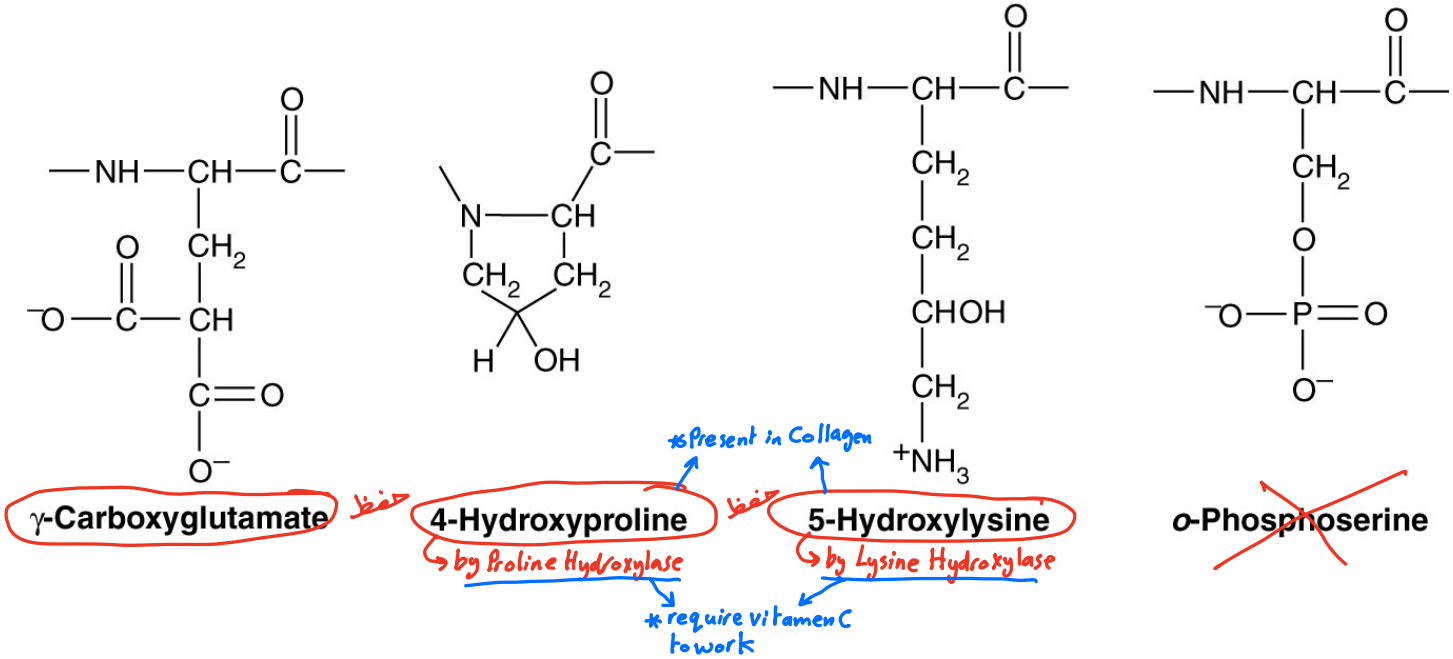
↳ Nucleic acids

e.g: Cytochromes
↳ Produced in the liver and deal with hormones and drugs

**3.** Metabolic intermediates (arginine, ornithine, and citrulline in the urea cycle)

* Essential A.As: A.As which Can't be produced inside the body therefor they must be obtained from diet.
- Arginine is essential during infancy & childhood, because hepatocytes are not mature enough to produce required enzymes.

**Figure 5.6 Modified Amino Acid Residues Found in Polypeptides**




- **Modified Amino Acids in Proteins**
- Some proteins have amino acids that are modified after synthesis
- Serine, threonine, and tyrosine can be phosphorylated
- g-Carboxyglutamate (prothtrombin), 4-hydroxyproline (collagen), and 5-hydroxylysine (collagen)

structral proteins don't dissolve in water
Elastin
most abundant Protein in the body

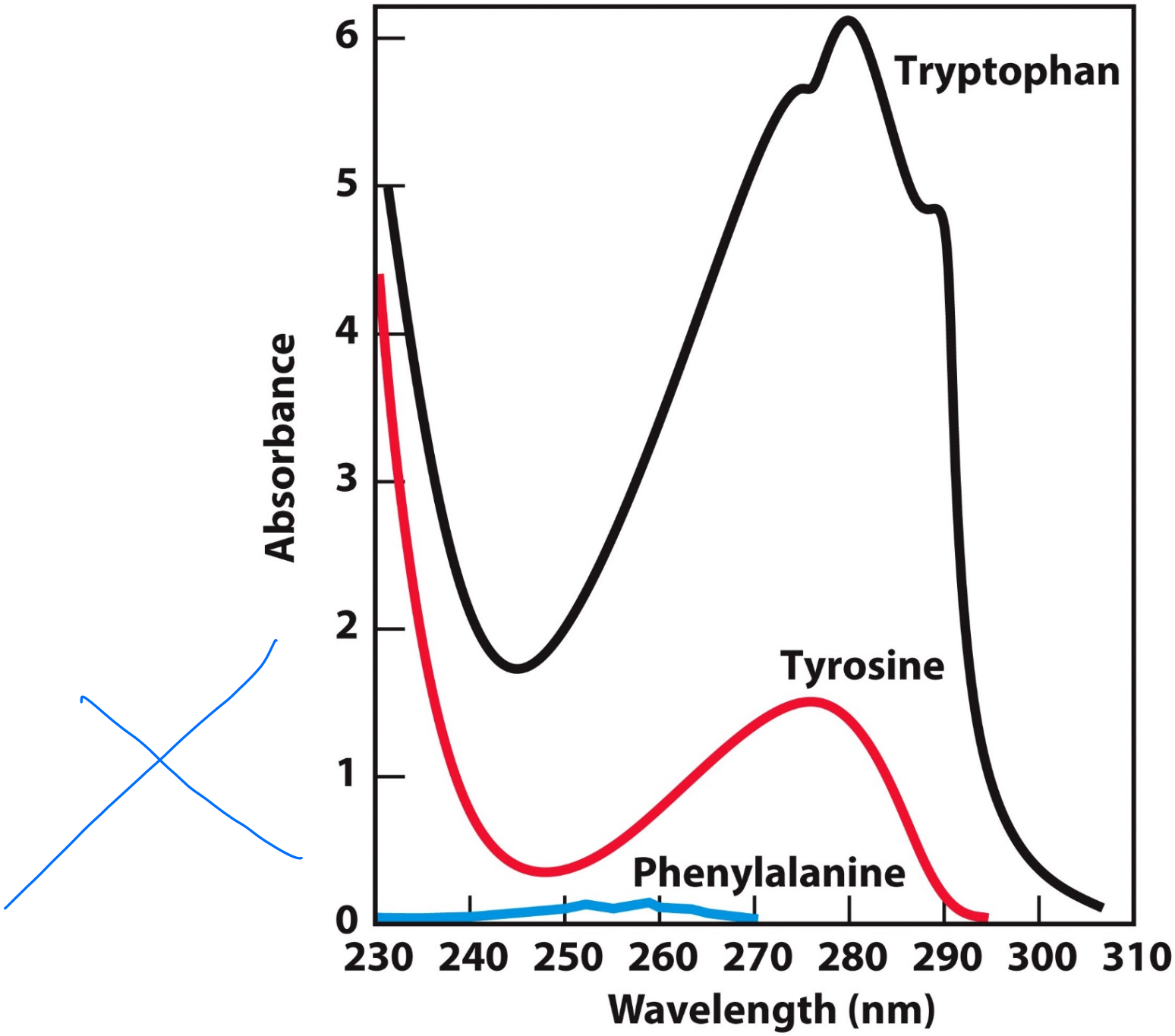
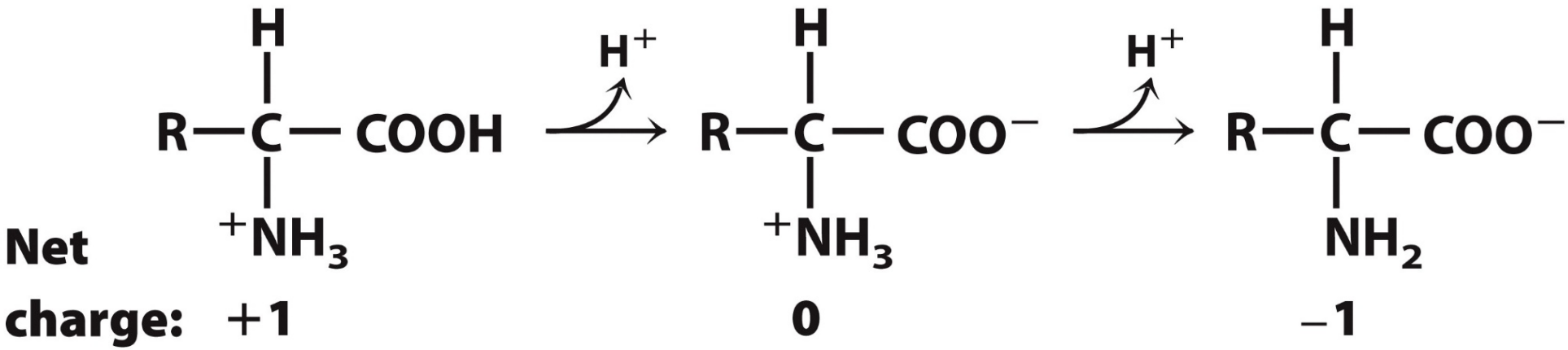



**Figure 3-6**
*Lehninger Principles of Biochemistry*, Sixth Edition

- Molecules that have both positive and negative charges on different atoms are **zwitterions** and have no net charge at pH 7

↳ For Non-polar A.As

- The R group is what gives the amino acid its unique properties




**Unnumbered 3 p81**

*Lehninger Principles of Biochemistry*, Sixth Edition

# Acid-Base Properties of Amino Acids

The a-COOH and a-NH2 groups in amino acids are capabale of ionizing (as are the acidic and basic R groups of the amino acids)

في الامتحان: $-COO^-$ : unprotonated/dissociated

At physiological pH (around 7.4), the carboxyl group will be unprotonated (dissociated) and the amino group will be protonated. An amino acid with no ionizable R group would be electrically neutral at this pH. This species is termed as a zwitterion

When the net charge of an amino acid or protein is zero, the pH will be equivalent to the isoelectric point (pI)

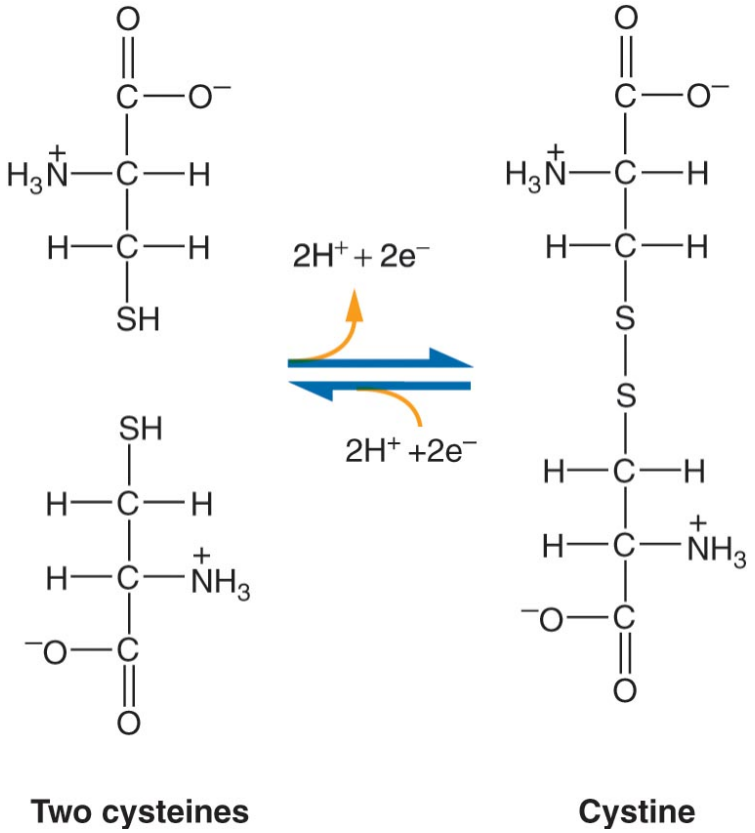
# Histidine

The imidazole ring of histidine allows it to act as either a proton donor or acceptor at physiological pH

Frequently found in the reactive center of enzymes

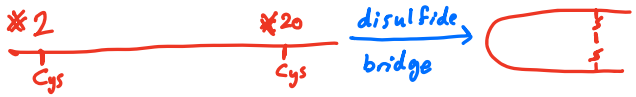
binding site / Active site

Histidine residues in hemoglobin are critical in its ability to buffer the H+ from carbonic acid ionization in red blood cells (RBCs)




- **Cysteine oxidation** leads to a reversible disulfide bond
- A **disulfide bridge** forms when two cysteine residues form this bond
- Helps stabilize polypeptides and proteins

**Figure 5.12 Oxidation of Two Cysteine Molecules to Form Cystine**



# PEPTIDES

# Peptides

Peptides – <30 amino acids

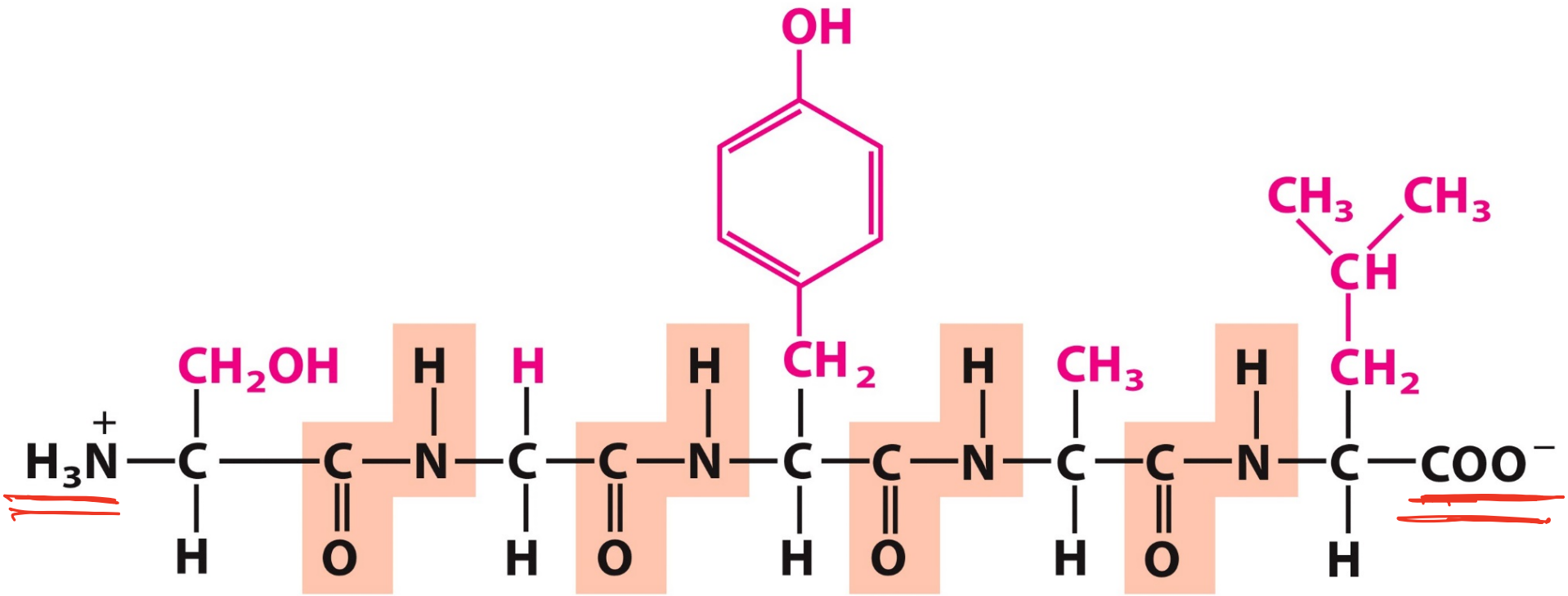
Proteins - >100 amino acids joined by peptide bonds

Polypeptide chain – the side chains and backbone groups interact with each other through many weak interactions, including van der Waals, hydrogen bonds, electrostatic interactions, as well as hydrophobic effect (non-polar groups) to bring about a protein's shape and target interactions

Non-covalent

# *Section 5.2: Peptides*

- Less structurally complex than larger proteins, **peptides** still have biologically important functions
  - **Glutathione** is a tripeptide found in most all organisms and is involved in protein and DNA synthesis, toxic substance metabolism, and amino acid transport
  - **Vasopressin** is an antidiuretic hormone that regulates water balance, appetite, and body temperature
  - **Oxytocin** is a peptide that aids in uterine contraction and lactation




**Amino-**
**N-terminal end**

* In any Protein, we have only 1 α- aminogroup & 1 α- Carboxyl group

**Carboxyl-**
**C- terminal end**

**Figure 3-14**
*Lehninger Principles of Biochemistry*, Sixth Edition

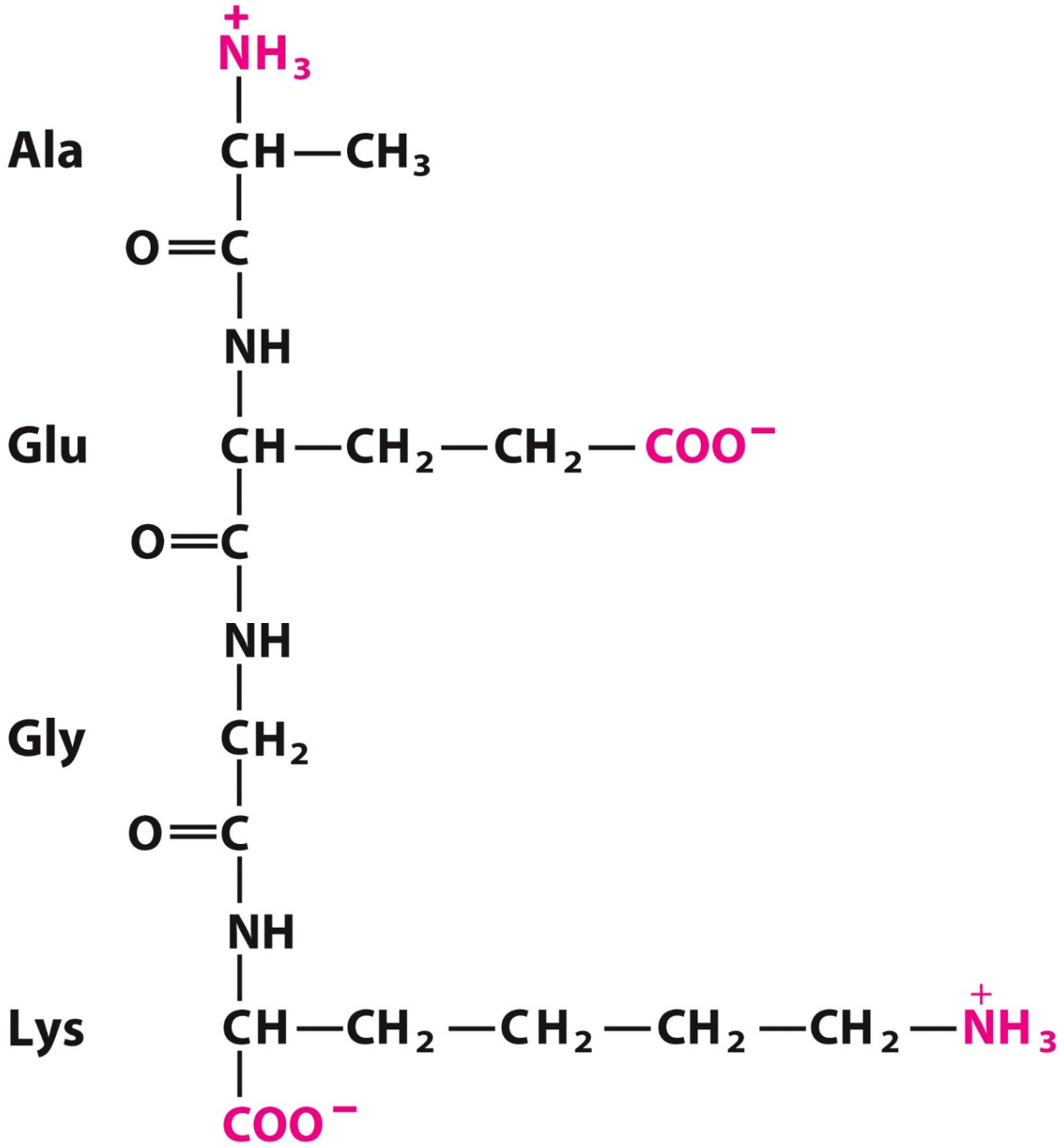



**Figure 3-15**
*Lehninger Principles of Biochemistry*, Sixth Edition

# Figure 3-15

This tetrapeptide (Alanyl glutamyl glycyl lysine)

has one free a-amino group, one free a-carboxyl group, and two ionizable R groups. The groups ionized at pH 7.0 are in red. Ionizable R groups in a peptide also contribute to the overall acid-base properties of the molecule

# Biologically Active Peptides

Naturally occurring peptides: 2 – 1000 amino acids

The artificial sweetener Aspartame (also called Nutra Sweet) – commercially synthesized dipeptide L-aspartyl-L-phenylalanyl methyl ester

Snake venoms (20 – 100 components) – the majority of these are peptides and proteins

a-amanitin (small peptide) – extremely toxic poison from the mushroom amanita phalloides

# PROTEINS

## TABLE 3–2 Molecular Data on Some Proteins

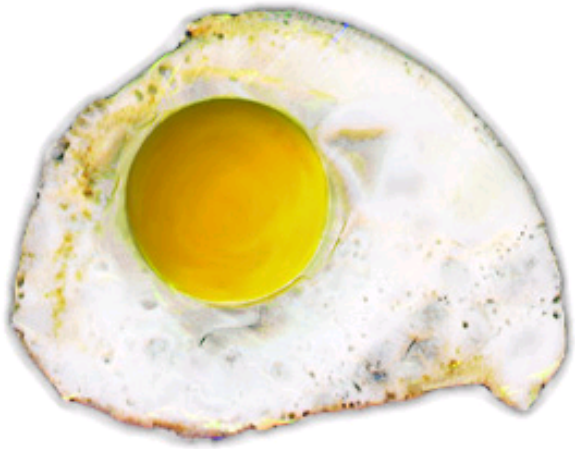
| | Molecular weight | Number of residues | Number of polypeptide chains |
|---|---|---|---|
| Cytochrome *c* (human) | 12,400 | 104 | 1 |
| Ribonuclease A (bovine pancreas) | 13,700 | 124 | 1 |
| Lysozyme (chicken egg white) | 14,300 | 129 | 1 |
| Myoglobin (equine heart) | 16,700 | 153 | 1 |
| Chymotrypsin (bovine pancreas) | 25,200 | 241 | 3 |
| Chymotrypsinogen (bovine) | 25,700 | 245 | 1 |
| Hemoglobin (human) | 64,500 | 574 | 4 |
| Serum albumin (human) | 66,000 | 609 | 1 |
| Hexokinase (yeast) | 107,900 | 972 | 2 |
| RNA polymerase (*E. coli*) | 450,000 | 4,158 | 5 |
| Apolipoprotein B (human) | 513,000 | 4,536 | 1 |
| Glutamine synthetase (*E. coli*) | 619,000 | 5,628 | 12 |
| Titin (human) | 2,993,000 | 26,926 | 1 |

**Table 3-2**
*Lehninger Principles of Biochemistry*, Sixth Edition

# Changes in temperature & pH can denature (unfold) a protein so it no longer works

## Denaturating Proteins

**Cooking denatures protein in eggs**



**Milk protein separates into curds & whey when it denatures**

- **DENATURING CONDITIONS**
  1. Strong acid or base
  2. Organic solvents
  3. Detergents
  4. Reducing agents
  5. Salt concentration
  6. Heavy metal ions
  7. Temperature