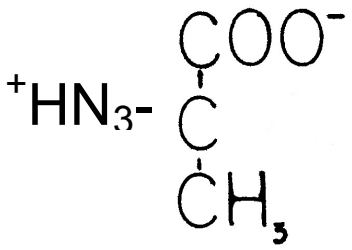
ANSC 619
PHYSIOLOGICAL CHEMISTRY OF LIVESTOCK SPECIES
Amino Acid Chemistry

I. Chemistry of amino acids

A. General amino acid structure



1. All amino acids are carboxylic acids, i.e., they have a –COOH group at the #1 carbon.
2. All amino acids contain an amino group at the #2 carbon (may amino acids have a second amino group).
3. All amino acids are zwitterions – they contain both positive and negative charges at physiological pH.

II. Essential and nonessential amino acids

A. Nonessential amino acids: can make the carbon skeleton
   1. From glycolysis.
   2. From the TCA cycle.

B. Nonessential if it can be made from an essential amino acid.
   1. Amino acid "sparing".
   2. May still be essential under some conditions.

C. Essential amino acids
   1. Branched chain amino acids (isoleucine, leucine and valine)
   2. Lysine
   3. Methionine
   4. Phenyalanine
   5. Threonine
   6. Tryptophan

D. Essential during rapid growth or for optimal health

1. Arginine
2. Histidine

E. Nonessential amino acids

1. Alanine (from pyruvate)
2. Aspartate, asparagine (from oxaloacetate)
3. Cysteine (from serine and methionine)
4. Glutamate, glutamine (from α-ketoglutarate)
5. Glycine (from serine)
6. Proline (from glutamate)
7. Serine (from 3-phosphoglycerate)
8. Tyrosine (from phenylalanine)

E. Nonessential and not required for protein synthesis

1. Hydroxyproline (made postranslationally from proline)
2. Hydroxylysine (made postranslationally from lysine)

III. Acidic, basic, polar, and hydrophobic amino acids

A. Acidic amino acids: amino acids that can donate a hydrogen ion (proton) and thereby decrease pH in an aqueous solution

1. Acidic amino acids contain a carboxyl group at the terminal carbon.
2. Acidic amino acids: aspartic acid and glutamic acid

B. Basic amino acids: amino acids that can accept a hydrogen ion and thereby raise pH in an aqueous solution

1. Basic amino acids contain an additional amino group.
2. Basic amino acids: lysine, arginine, and histidine

C. Polar amino acids: amino acids polar, uncharged side groups

1. Polar amino acids contain –OH, $-NH_2$, and –SH side groups.
2. Polar amino acids: serine, threonine, asparagine, and glutamine

D. Hydrophobic amino acids: amino acids with hydrophobic side chains

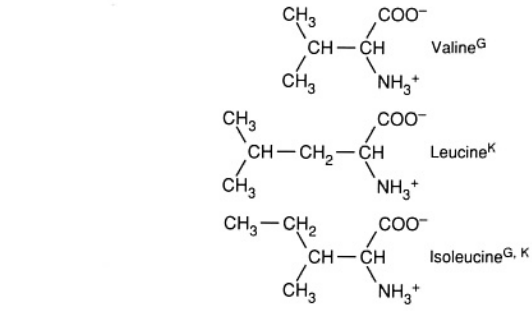
1. Hydrophobic amino acids contain $-CH_2-$ chains (branched or unbranched) or just a terminal $-CH_3$ group.

2. Hydrophobic amino acids: alanine, valine, isoleucine, leucine, methionine, phenylalanine, proline, and tryptophan

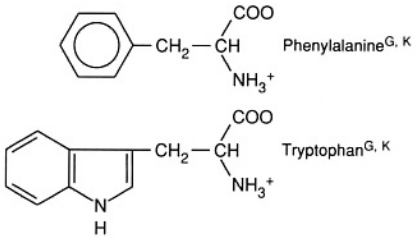
Table 4.1. Essential and Nonessential Amino Acids

Essential amino acids[a]

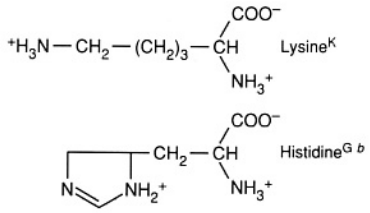
Branch Chain AAs



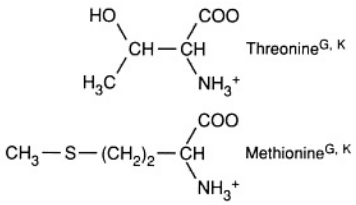
Aromatic AAs



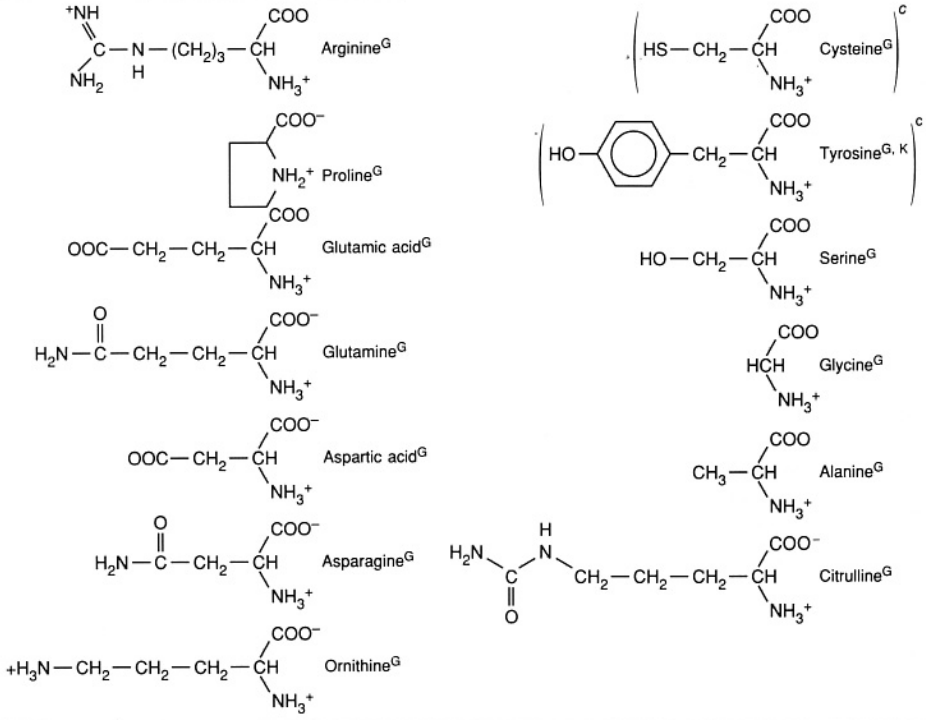
Basic AAs



Other AAs



Nonessential amino acids[a]

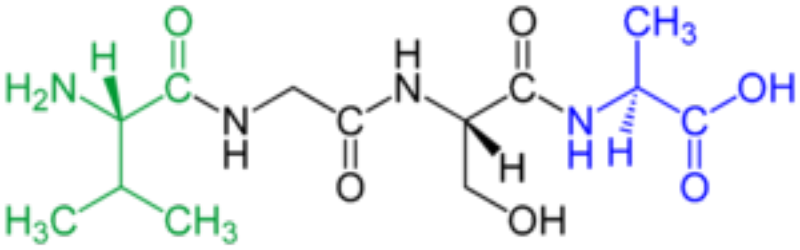


[a] G, glucogenic; K, ketogenic; G,K, both.
[b] May only be required in infancy.
[c] Produced from essential amino acids: phe → tyr; met → cys.

IV. Chemistry of proteins

A. Peptides and polypeptides

1. Peptide – amino acid chain containing 50 or fewer amino acids



Tetrapeptide containing valine, glycine, serine, and alanine

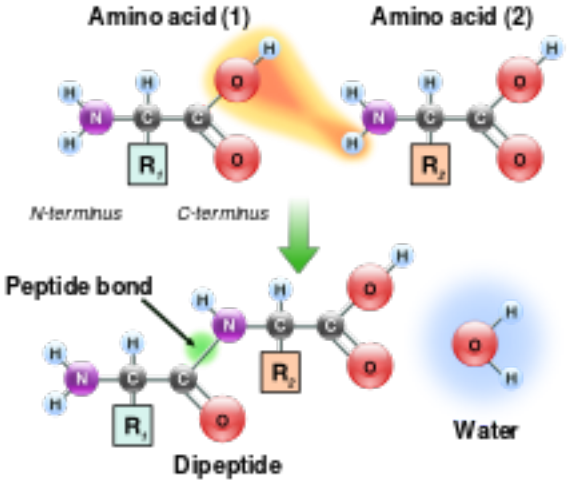
Insulin contains two peptide chains, the A chain (21 amino acids) and the B chain (30 amino acids), linked by two sulfhydral bonds. Insulin is considered the standard cutoff size for proteins.

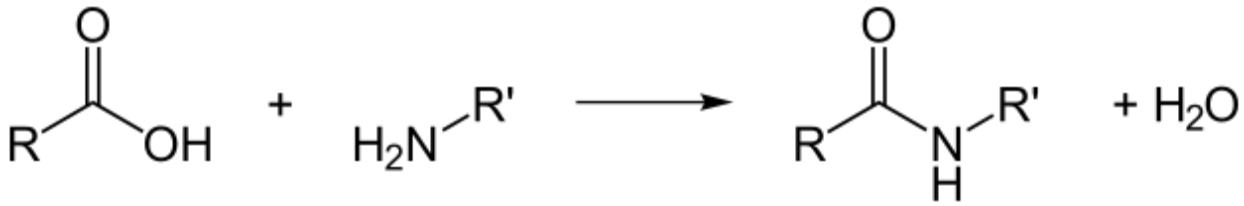
2. The peptide bond

a. The carboxyl group from one amino acid donates its –OH group to the H from the amino group of a second amino acid.

b. H_2O is released and a labile peptide bond is formed.

c. Successive addition of amino acids forms peptides.



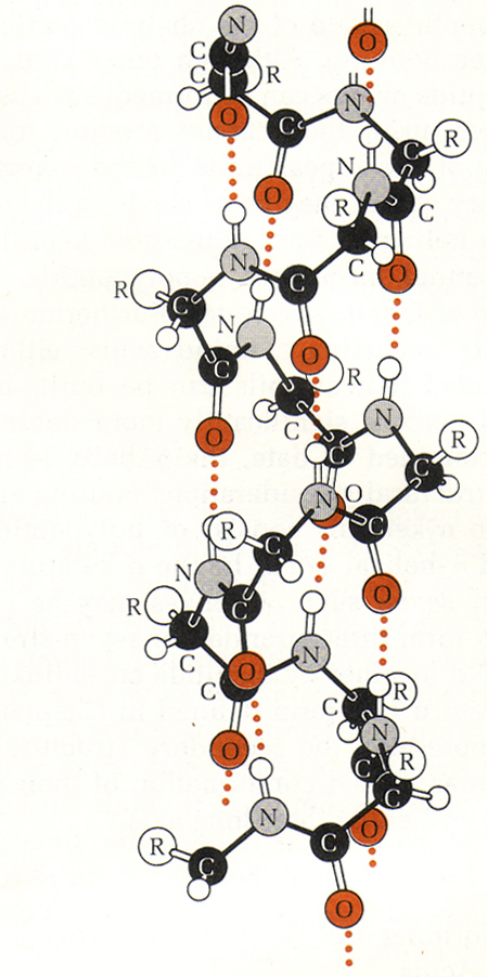


B. Protein structures

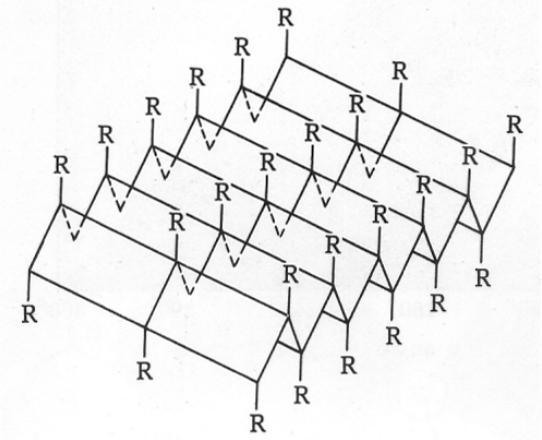
1. α-Helix

Helical formation allows intrachain hydrogen bonds extending between the hydrogen atom attached to the electronegative nitrogen of one peptide bond and the carbonyl oxygen of the third amino acid beyond it.

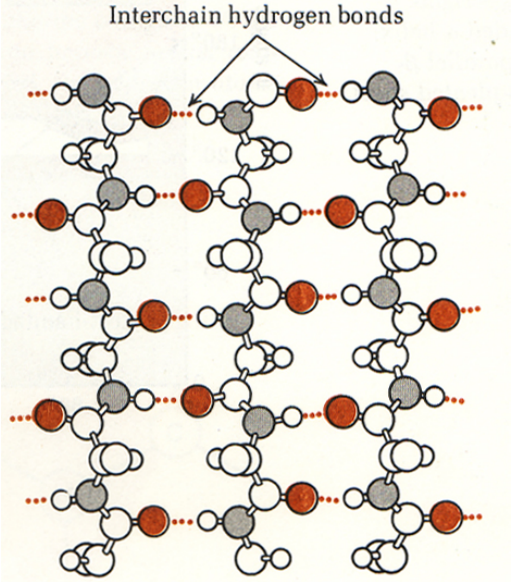
Ball-and-stick model of α helix, showing intrachain hydrogen bonds (colored dots).



Schematic representation of three parallel chains in β structure, showing the pleated-sheet arrangement. All the R groups project above or below the plane of the page. [Redrawn from T. P. Bennett, Graphic Biochemistry, vol. 1, The Macmillan Company, New York, 1968.]



Ball-and-stick models. Note the maximal hydrogen bonding between the chains to form a sheet in antiparallel arrangement. (Redrawn from H. D. Springall, The Structural Chemistry of Proteins, p. 64, Academic Press Inc., New York, 1954.)



2. ß-Pleated sheets

Side-by-side polypeptide chains in the ß-conformation are arranged in *pleated sheets*, which are cross-linked by interchain hydrogen bonds. All peptide bonds participae in this cross-linking and therefore give the structure great stability.

3. Orders of structure

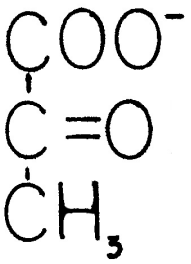
a. Primary – amino acid sequence of a protein or peptide

b. Secondary – twisting of a protein or peptide; the α-helix

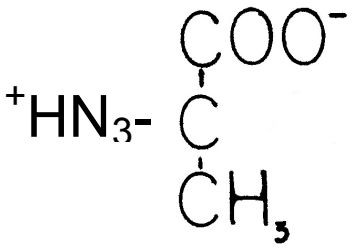
c. Tertiary – folding of a protein or peptide; e.g. myoglobin

d. Quanternary – association of multiple protein subunits; e.g. hemoglobin, ß-pleated sheets

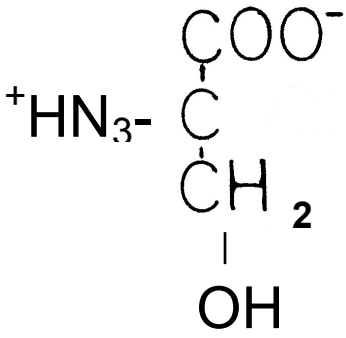
Important structures to remember



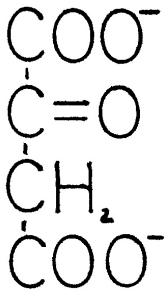
Pyruvate



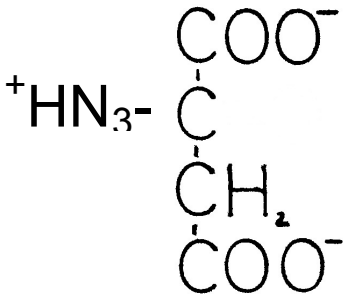
Alanine



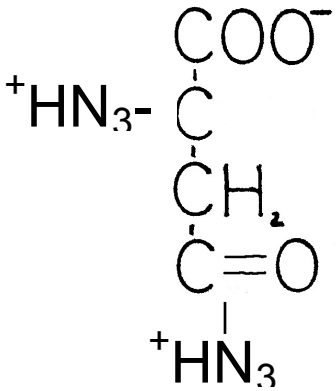
Serine



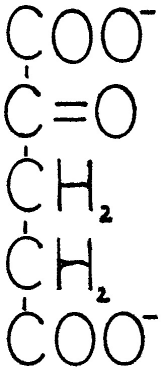
Oxaloacetate



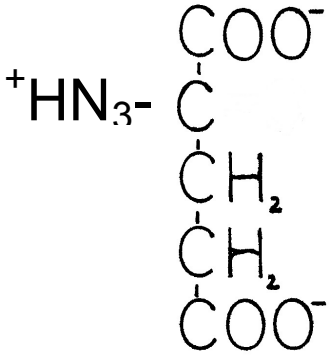
Aspartate



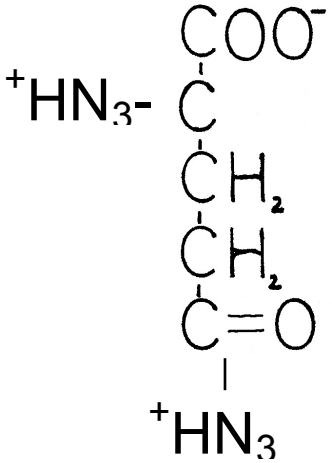
Asparagine



α-Ketoglutarate



Glutamate



Glutamine