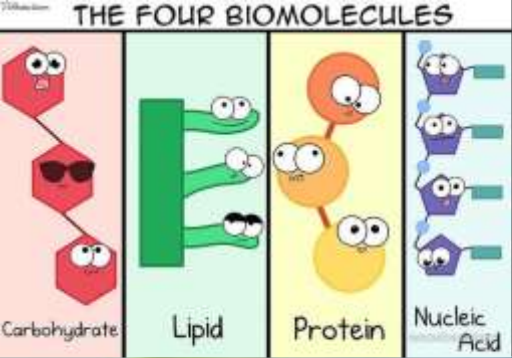
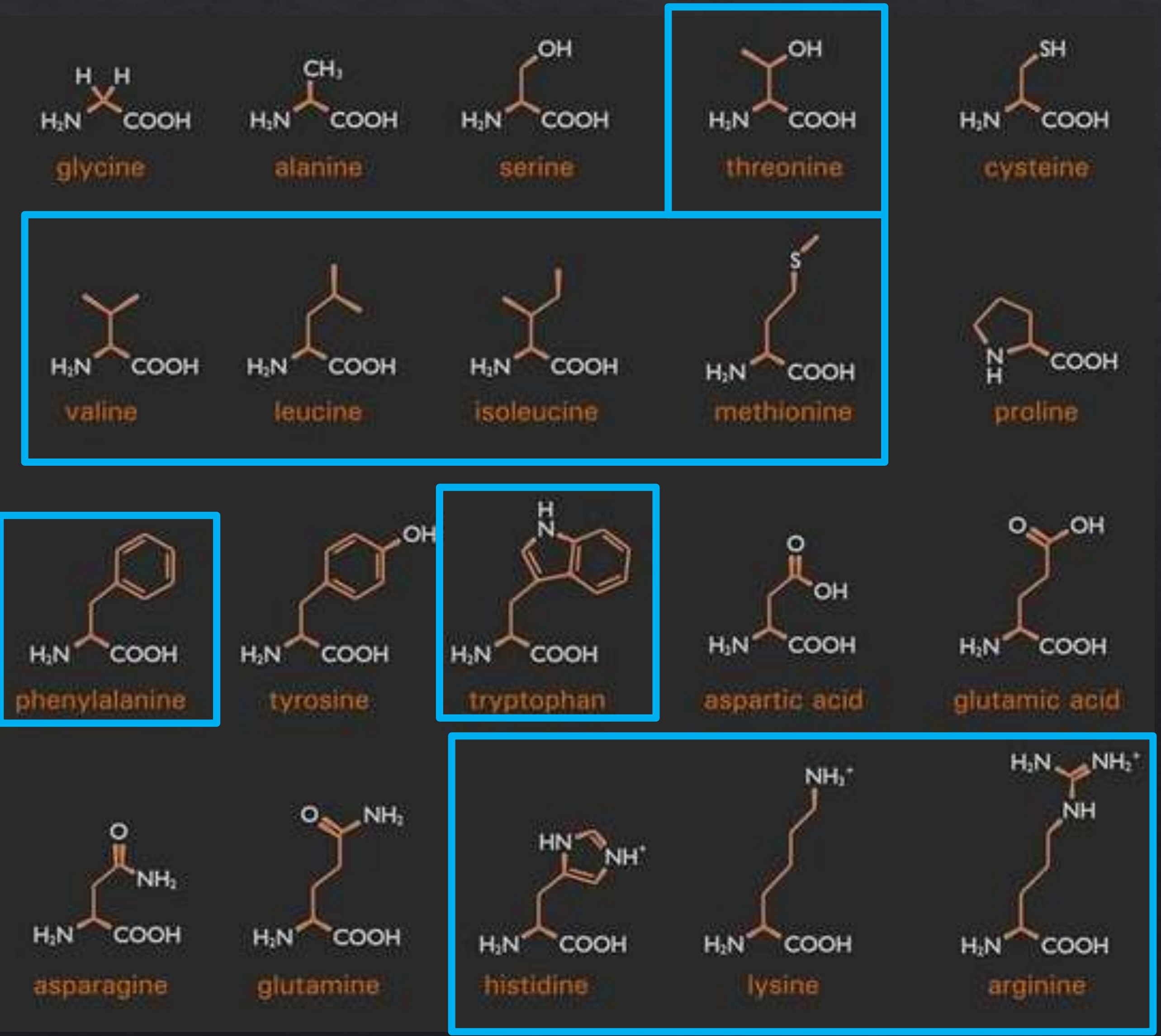


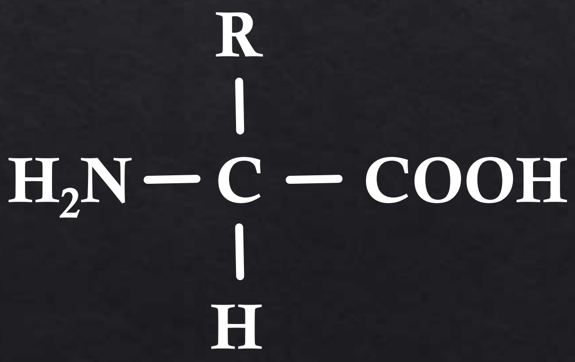
Amino acids & Proteins

Amino acids

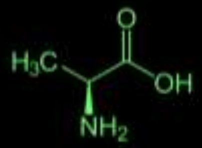


Amino acids (AA) are carboxylic acids with an amine group

RCH(NH_2)COOH

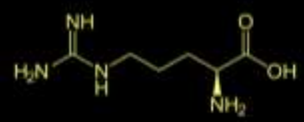


How amino acids got their names



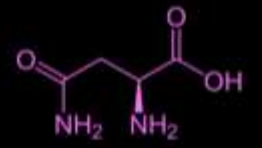
ALANINE

Al- is a shortening of *aldehyde*. The infix *-an-* was added to make it easier to pronounce.



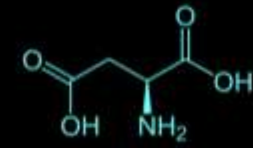
ARGININE

From the Greek word *arginóeis*, which meant "silver" due to the appearance of arginine nitrate.



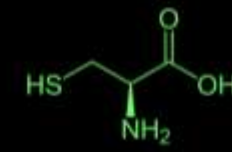
ASPARAGINE

First extracted in 1806 from a sample of asparagus juice, after which it was named.



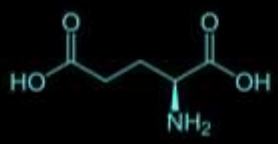
ASPARTIC ACID

Named after *asparagine*, because it was first isolated from it by hydrolysis in 1827.



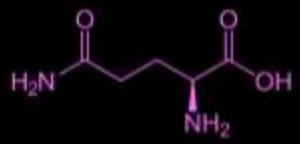
CYSTEINE

Had an earlier spelling of *cystine*. That comes from the Ancient Greek word for "bladder", *kústis*.



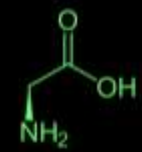
GLUTAMIC ACID

Glut- refers to how the compound was first isolated from gluten in 1866 by chemist Karl Ritthausen.



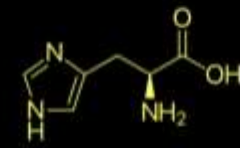
GLUTAMINE

Named before it was isolated, because it was hypothesized to be similar to *glutamic acid*.



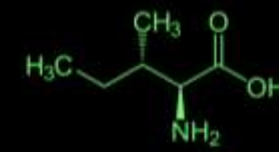
GLYCINE

From the Greek word *glukús*, meaning "sweet", because it was first isolated from gelatin.



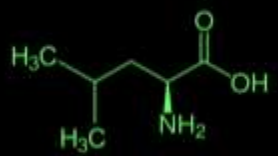
HISTIDINE

From Greek *histós*, meaning "tissue", because it was thought to be important to tissue function.



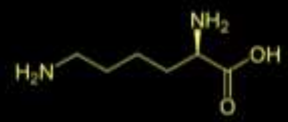
ISOLEUCINE

Named in 1904 by Felix Ehrlich, who observed that it was similar but not identical to leucine.



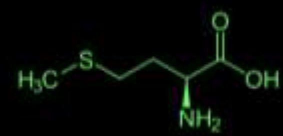
LEUCINE

First used in 1826 by chemist William Henry. Comes from the Greek word *leukós*, "white".



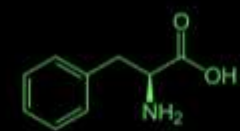
LYSINE

Named in 1889 from the Ancient Greek word *lúsis*, meaning "loosening".



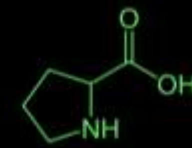
METHIONINE

Coined in 1926 by Barger and Coyne as a contraction of *γ-methiol-α-aminobutyric acid*.



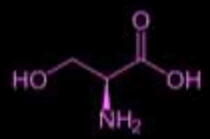
PHENYLALANINE

Named by Erlenmeyer and Lipp in 1883 because it looks like alanine with a phenyl group.



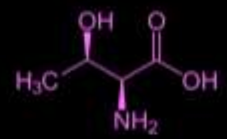
PROLINE

The name is a contraction of *pyrrolidine*, which makes up a side chain of the compound.



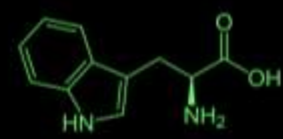
SERINE

From the Latin word *sericum*, meaning "silk", because it was first obtained from silk protein.



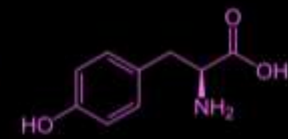
THREONINE

Named in 1936 after *threose*, a type of monosaccharide that it was thought to resemble.



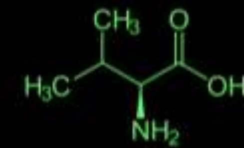
TRYPTOPHAN

Traces to the Greek roots *trípsis*, meaning "rubbing", and *phaínein*, meaning "to show".



TYROSINE

From Greek *tyrós*, meaning "cheese", because it was obtained from old cheese.



VALINE

Named in 1906 after a type of acid that occurs in the roots of the *valerian* plant.

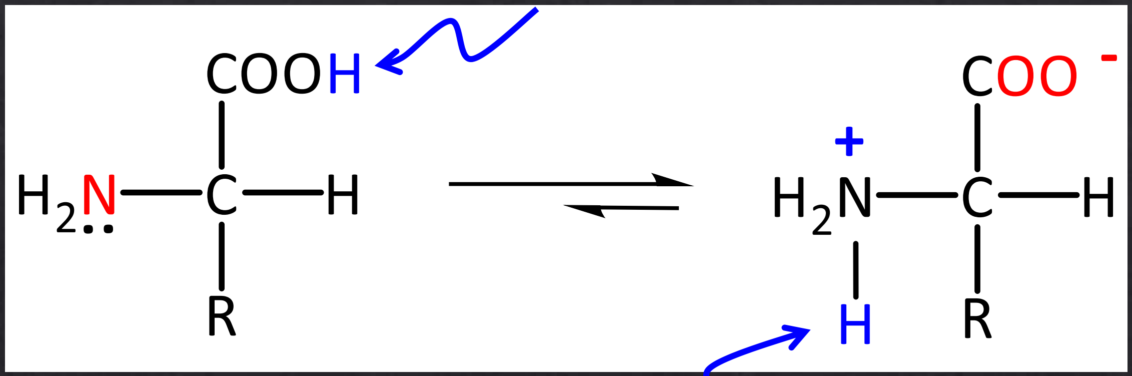
Sources: etymonline.com, wiktionary.org, merriam-webster.com, oed.com, chemtymology.co.uk, bioetymology.blogspot.com

Basic polar — Acidic polar — Nonpolar — Polar

TWITTER: @etymology_nerd
INSTAGRAM: @etymologynerd

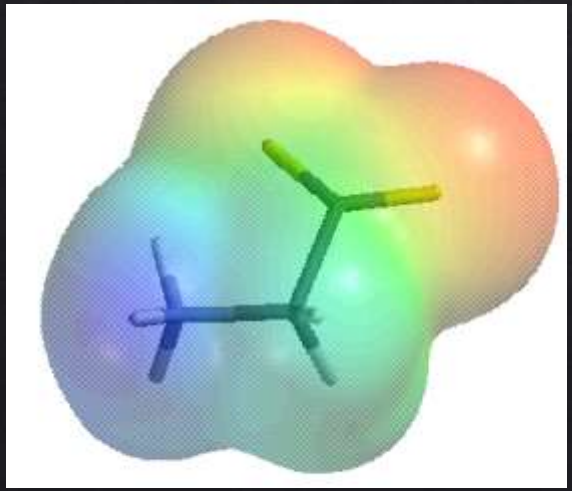
Amino acids are acidic and basic: Exist as zwitterions

pK_a = 2-3



Zwitterion

pK_a = 9-10



Pictures from Vollhardt & Schore

$\overset{+}{H_3N}CH_2COO^-$

Glycine as a zwitterion

Influence of pH

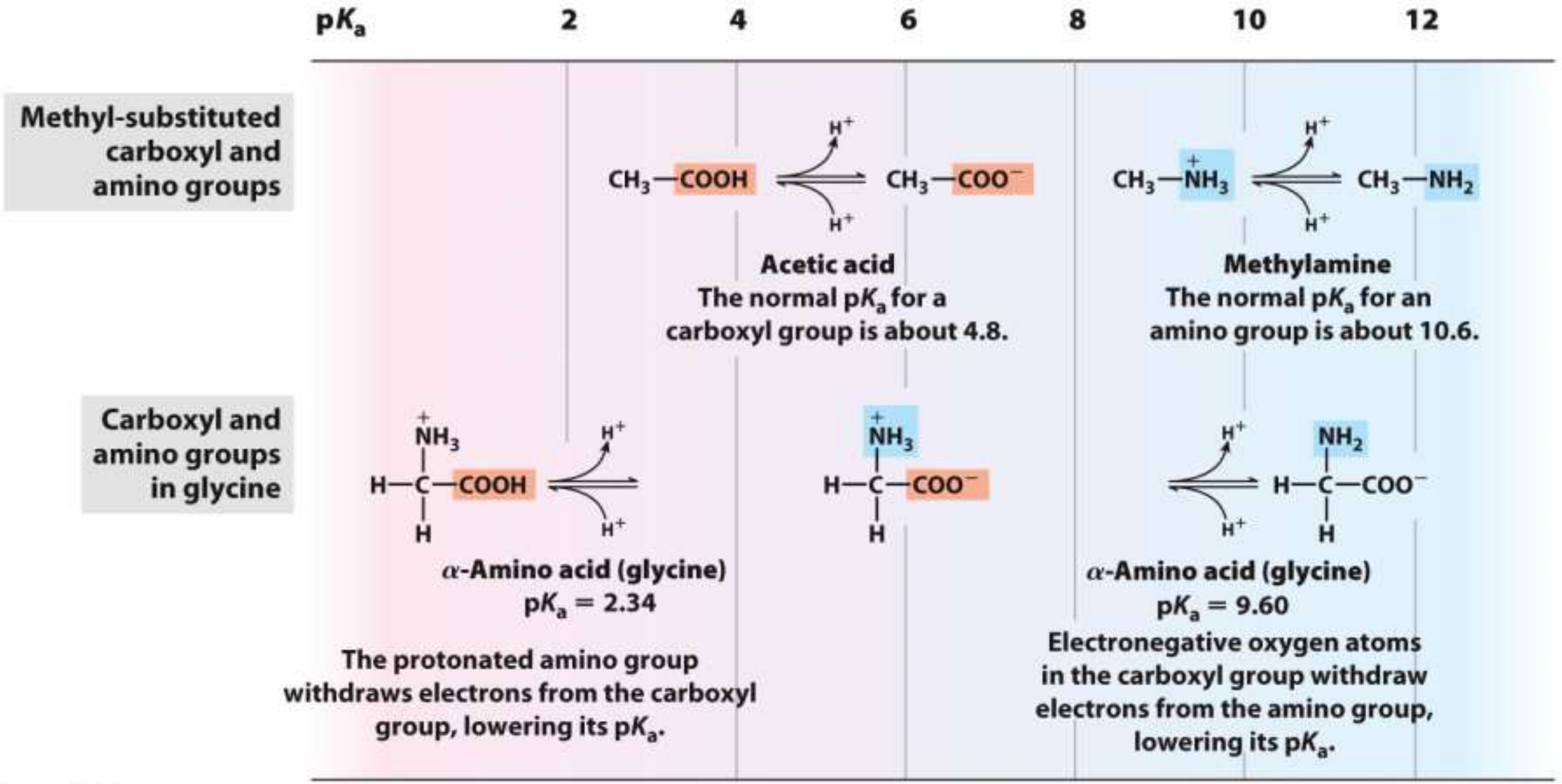


Figure 3-11
Lehninger Principles of Biochemistry, Seventh Edition

pI = **isoelectric point** or **pH**, the pH at which the net electric charge is 0

Amino Acids: Classification

Common amino acids can be placed in five basic groups depending on their R substituents:

- nonpolar, aliphatic (7)
- aromatic (3)
- polar, uncharged (5)
- positively charged (3)
- negatively charged (2)

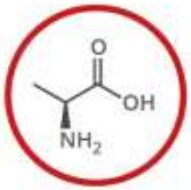
A GUIDE TO THE TWENTY COMMON AMINO ACIDS

AMINO ACIDS ARE THE BUILDING BLOCKS OF PROTEINS IN LIVING ORGANISMS. THERE ARE OVER 500 AMINO ACIDS FOUND IN NATURE - HOWEVER, THE HUMAN GENETIC CODE ONLY DIRECTLY ENCODES 20. 'ESSENTIAL' AMINO ACIDS MUST BE OBTAINED FROM THE DIET, WHILST NON-ESSENTIAL AMINO ACIDS CAN BE SYNTHESISED IN THE BODY.

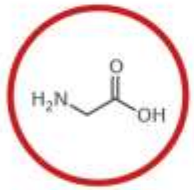
Chart Key: ALIPHATIC · AROMATIC · ACIDIC · BASIC · HYDROXYLIC · SULFUR-CONTAINING · AMIDIC · NON-ESSENTIAL · ESSENTIAL

Chemical Structure
single letter code

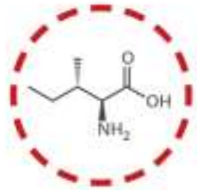
NAME A
three letter code
DNA codons



ALANINE A
Ala
GCT, GCC, GCA, GCG

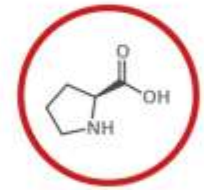


GLYCINE G
Gly
GGT, GGC, GGA, GGG



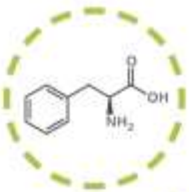
ISOLEUCINE I
Ile
ATT, ATC, ATA

LEUCINE L
Leu
CTT, CTC, CTA, CTG, TTA, TTG

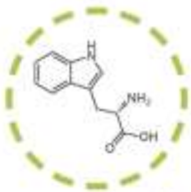


PROLINE P
Pro
CCT, CCC, CCA, CCG

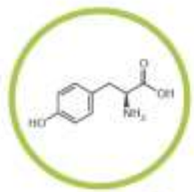
VALINE V
Val
GTT, GTC, GTA, GTG



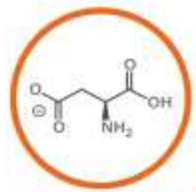
PHENYLALANINE F
Phe
TTT, TTC



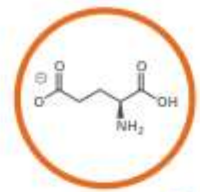
TRYPTOPHAN W
Trp
TGG



TYROSINE Y
Tyr
TAT, TAC

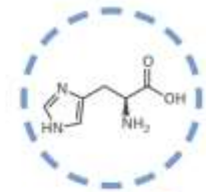


ASPARTIC ACID D
Asp
GAT, GAC



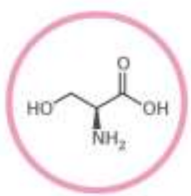
GLUTAMIC ACID E
Glu
GAA, GAG

ARGININE R
Arg
CGT, CGC, CGA, CGG, AGA, AGG

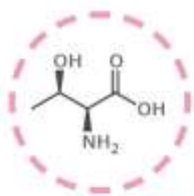


HISTIDINE H
His
CAT, CAC

LYSINE K
Lys
AAA, AAG

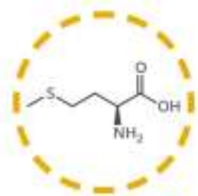


SERINE S
Ser
TCT, TCC, TCA, TCG, AGT, AGC



THREONINE T
Thr
ACT, ACC, ACA, ACG

CYSTEINE C
Cys
TGT, TGC



METHIONINE M
Met
ATG

ASPARAGINE N
Asn
AAT, AAC

GLUTAMINE Q
Gln
CAA, CAG

Note: This chart only shows those amino acids for which the human genetic code directly codes for. Selenocysteine is often referred to as the 21st amino acid, but is encoded in a special manner. In some cases, distinguishing between asparagine/aspartic acid and glutamine/glutamic acid is difficult. In these cases, the codes asx (B) and glx (Z) are respectively used.

Nonpolar, aliphatic R groups

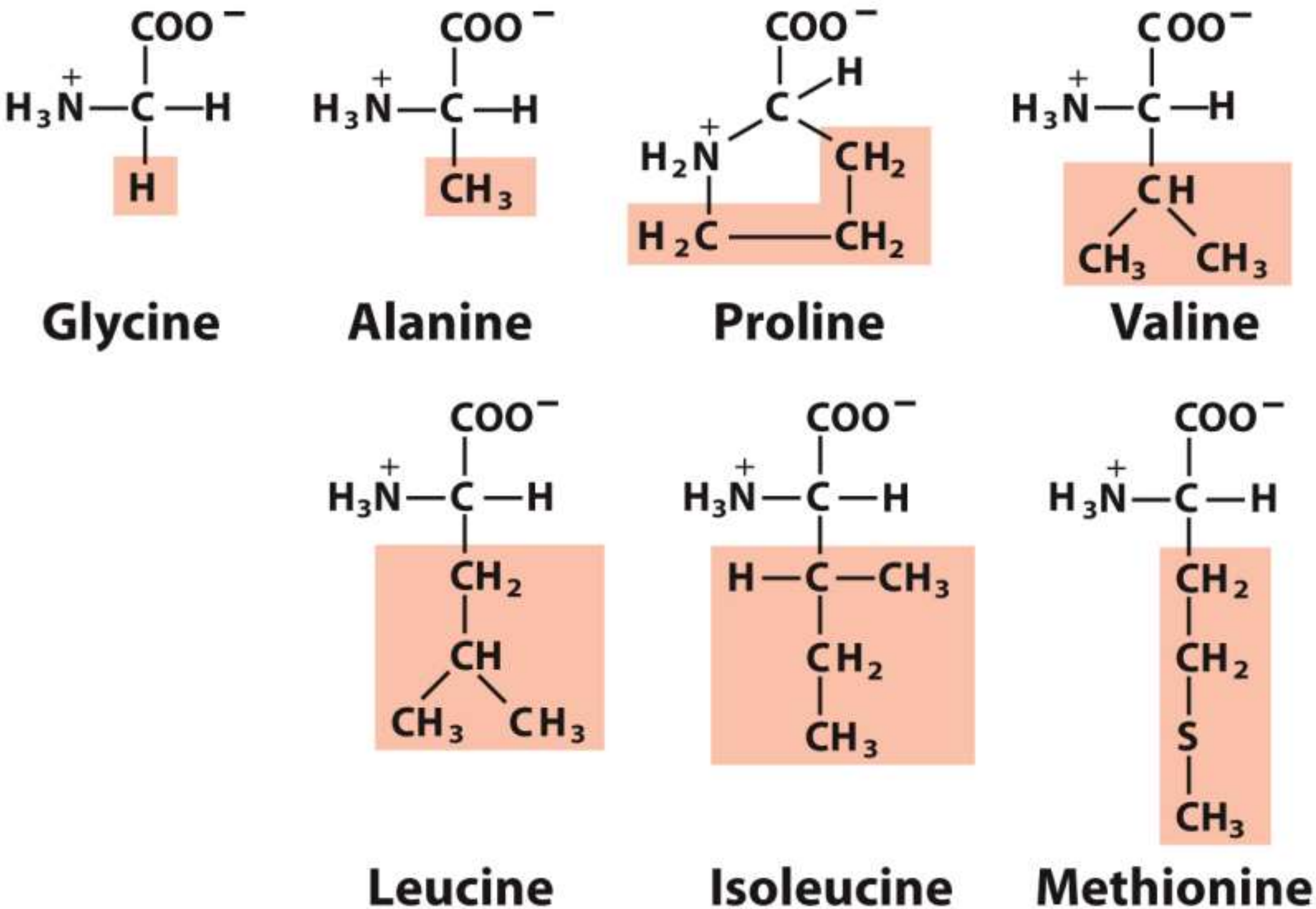


Figure 3-5 part 1
Lehninger Principles of Biochemistry, Seventh Edition

Aromatic R groups

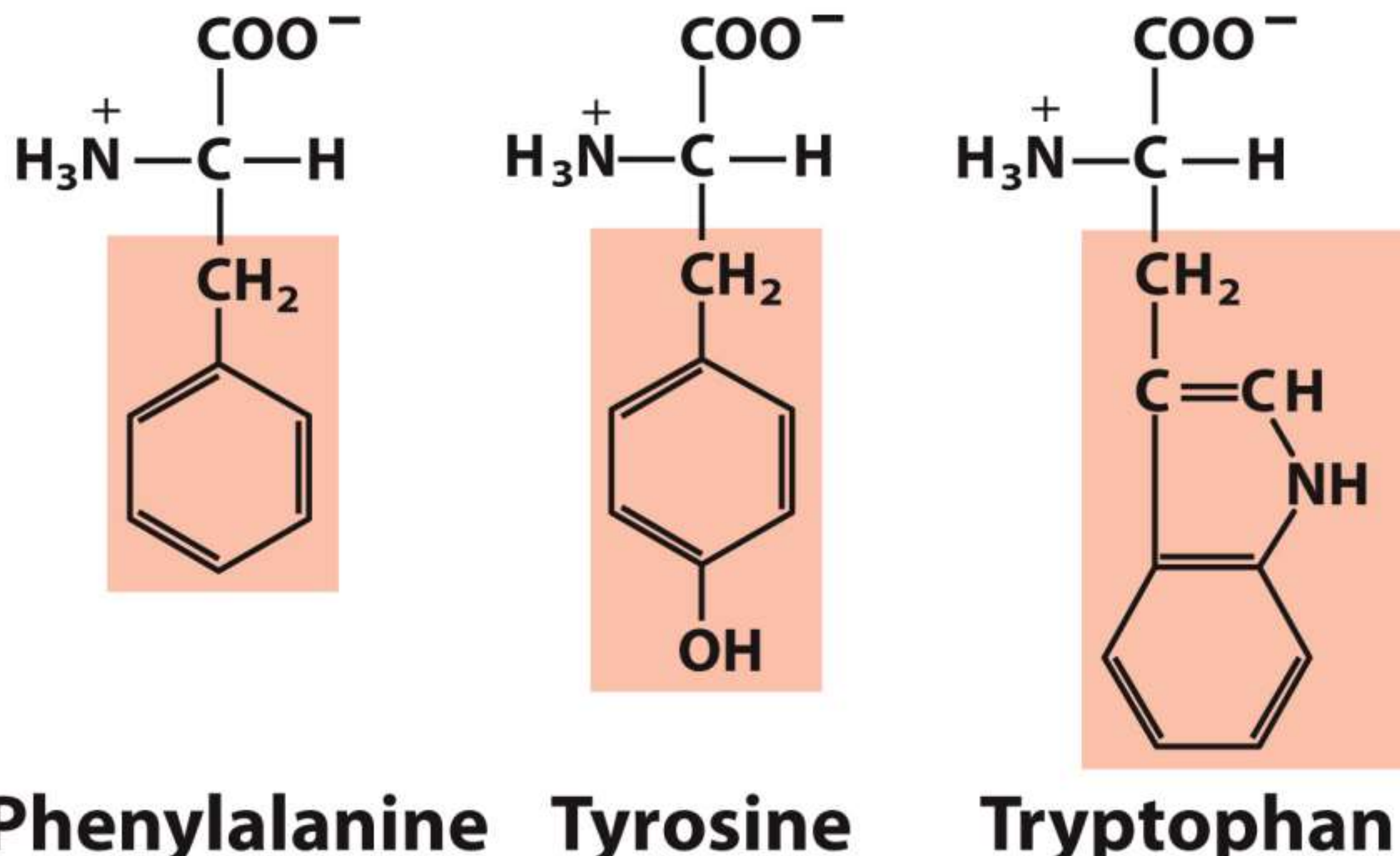


Figure 3-5 part 2
Lehninger Principles of Biochemistry, Seventh Edition

Polar, uncharged R groups

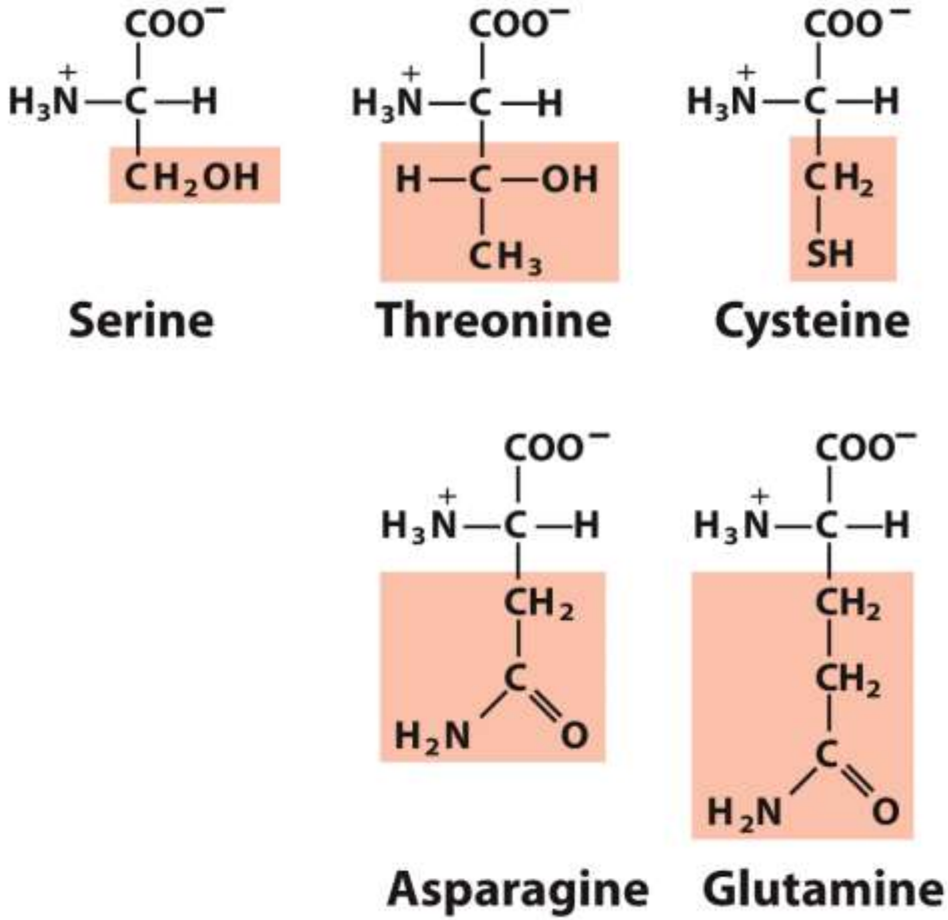


Figure 3-5 part 3
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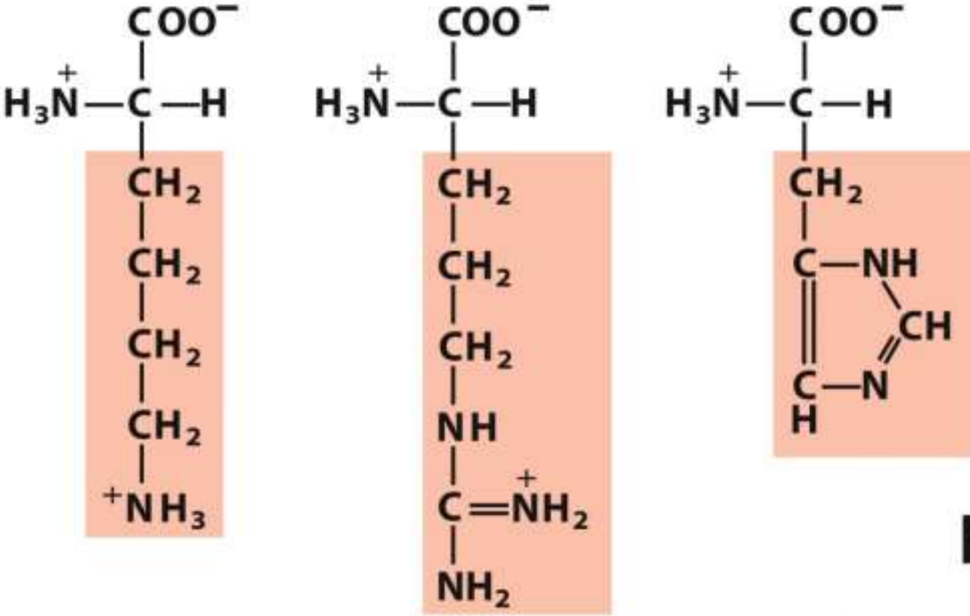
Positively charged R groups



Lysine Arginine Histidine

Figure 3-5 part 4
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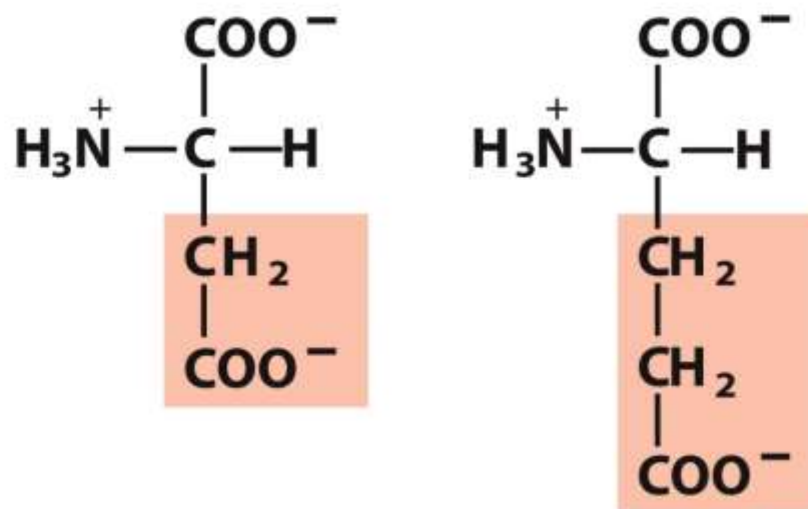
Negatively charged R groups



Aspartate Glutamate

Figure 3-5 part 5
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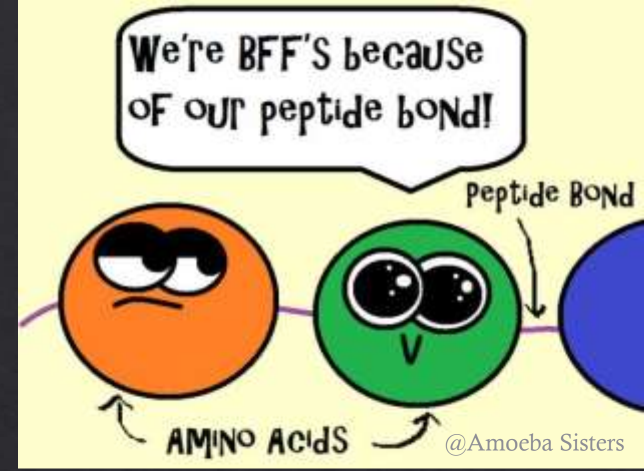
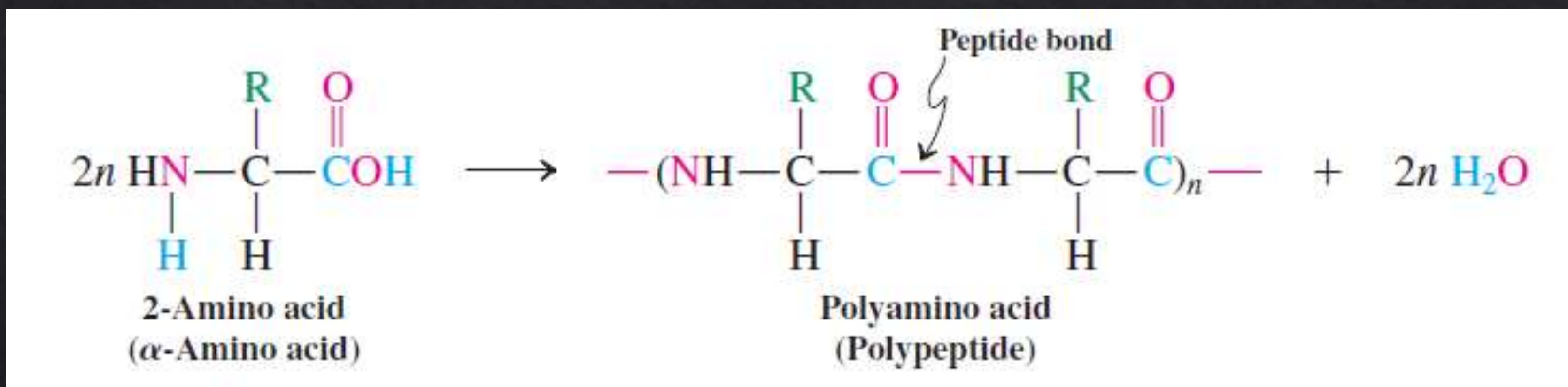
Peptides & Proteins



Peptide = > 1 AA

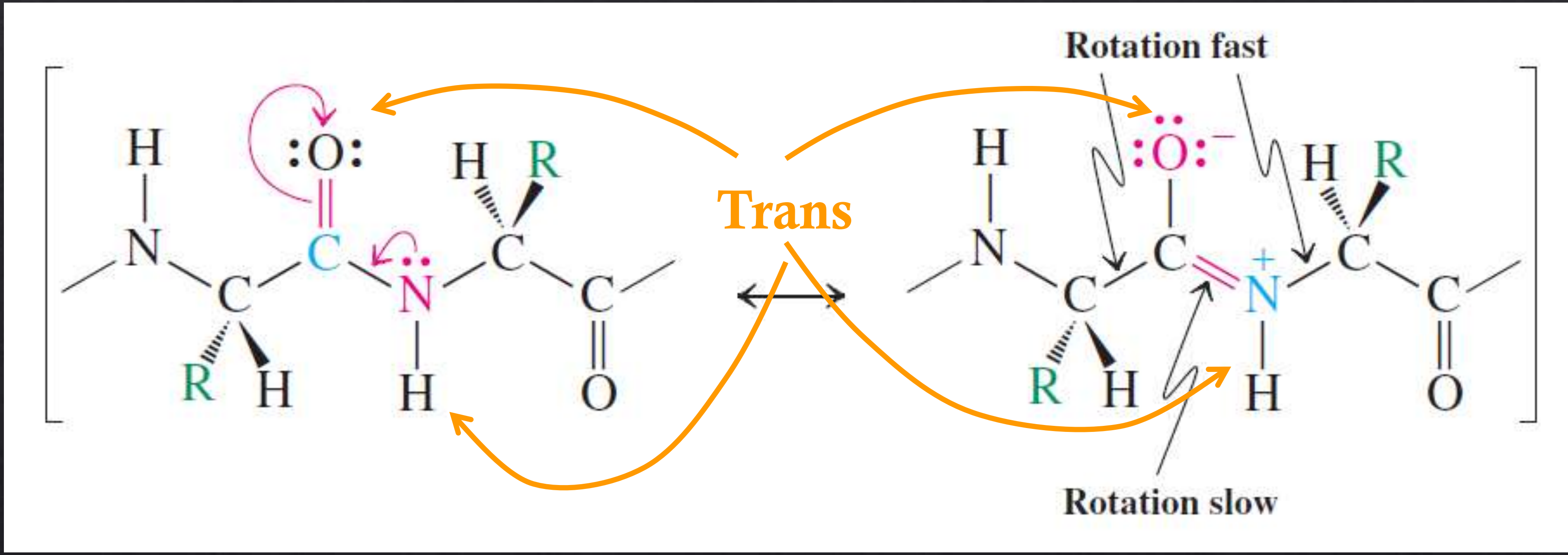
Polypeptides with > 50 AA = protein



Picture from Vollhardt & Schore

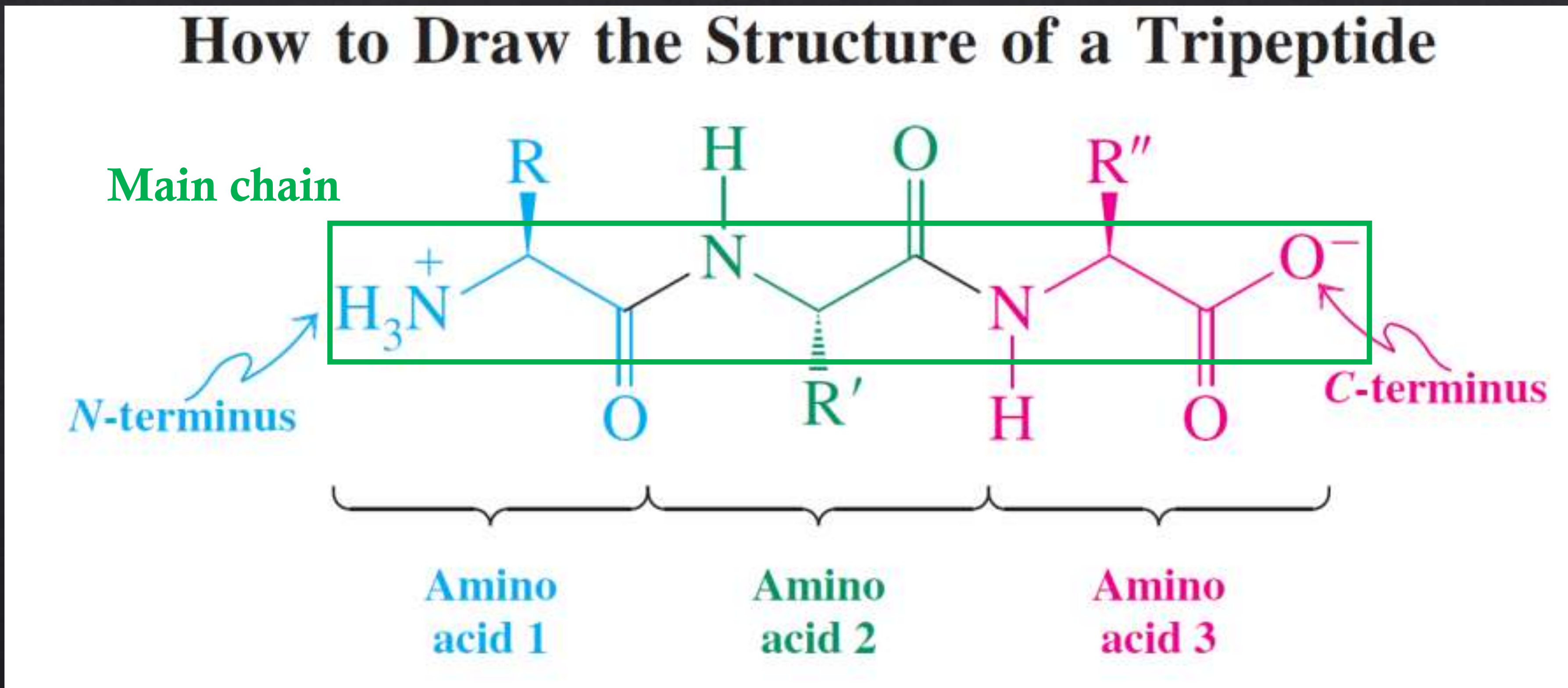
AA in a peptide are usually referred to as residues

The peptide bond



Picture from Vollhardt & Schore

The peptide bond



Picture from Vollhardt & Schore

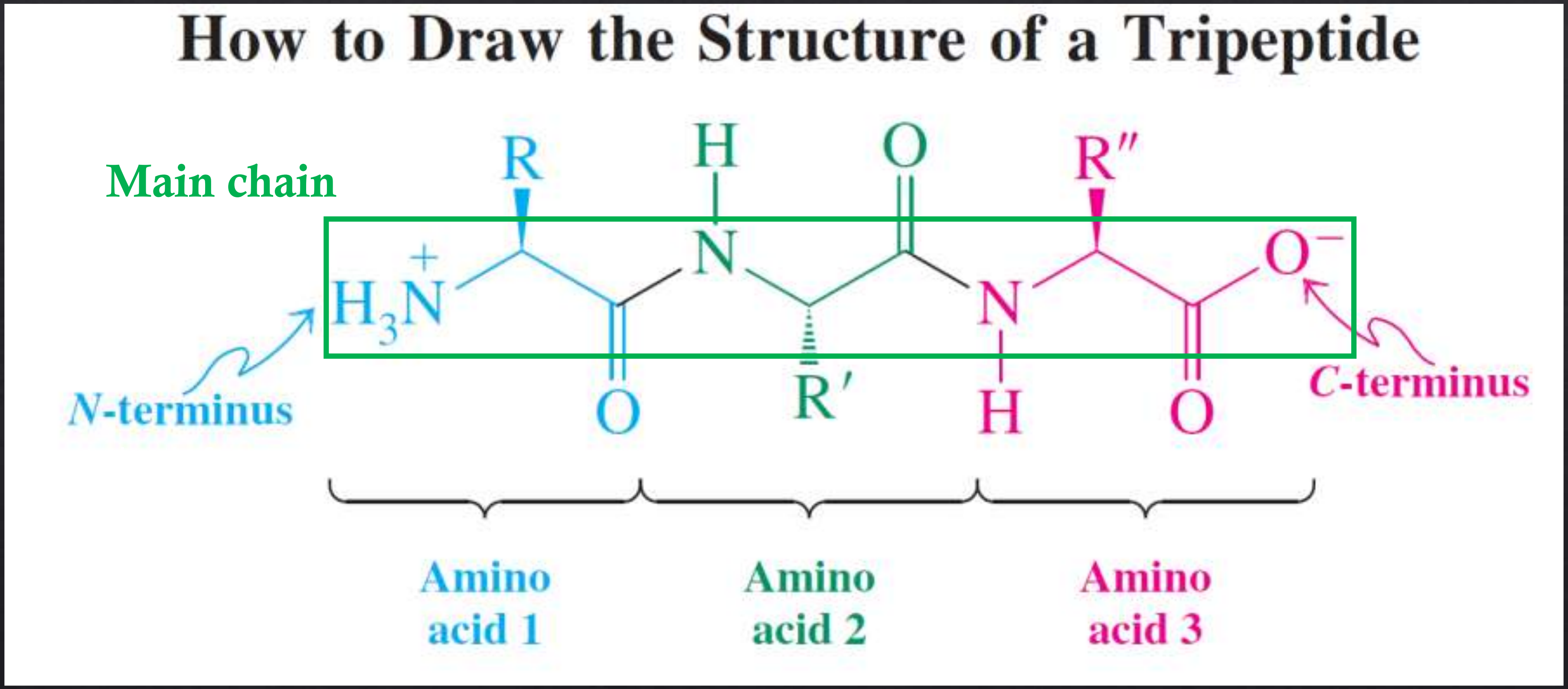
R, R’, R”, etc. are called the side chains. All stereocenters are assumed to be *S*.


5 minute

Proteins:
Main Agents of Biological Function

- Catalysis
  - enolase (in the glycolytic pathway)
  - DNA polymerase (in DNA replication)
- Transport
  - hemoglobin (transports O_2 in the blood)
  - lactose permease (transports lactose across the cell membrane)
- Structure
  - collagen (connective tissue)
  - keratin (hair, nails, feathers, horns)
- Motion
  - myosin (muscle tissue)
  - actin (muscle tissue, cell motility)

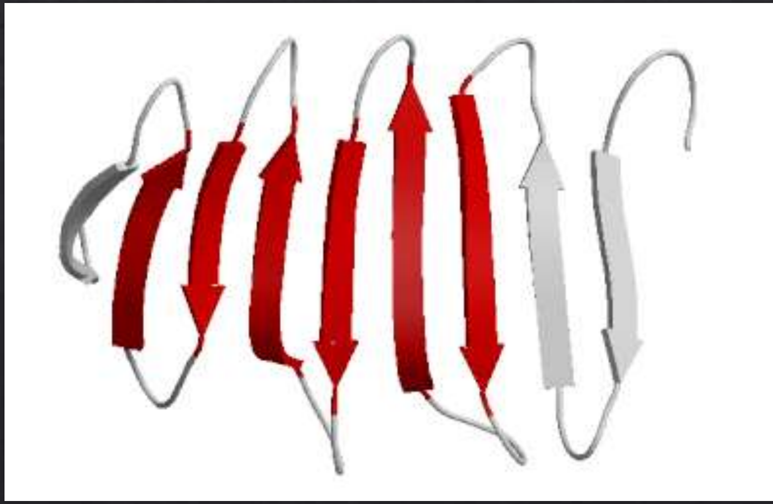
Primary structure



Picture from Vollhardt & Schore

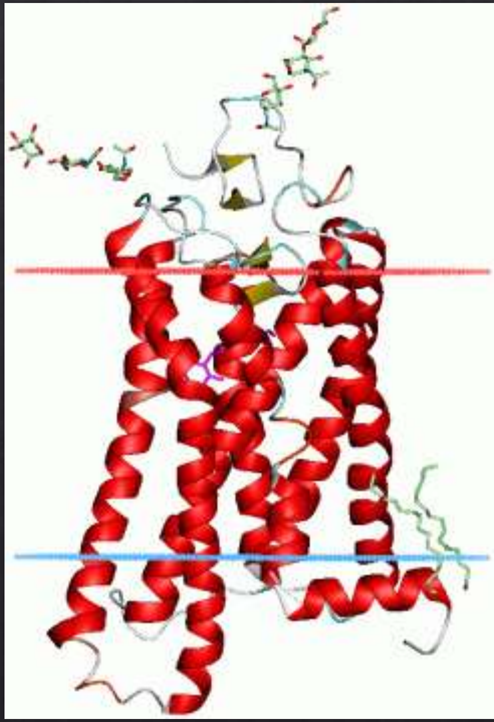
Secondary structure

Pleated sheets



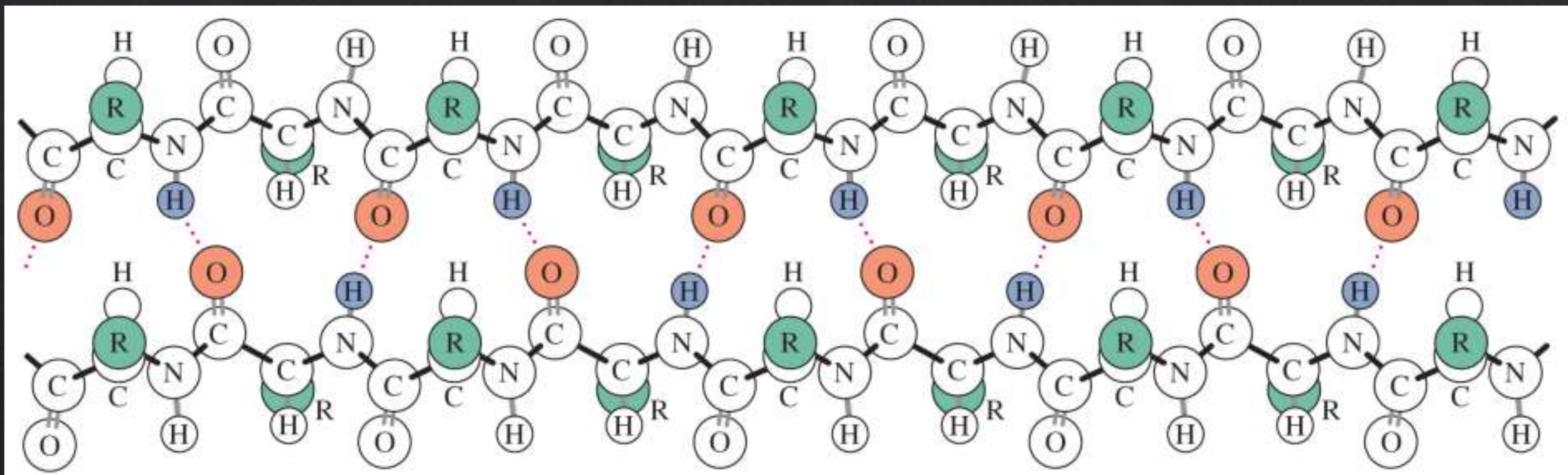
Picture from Wikipedia

α helix



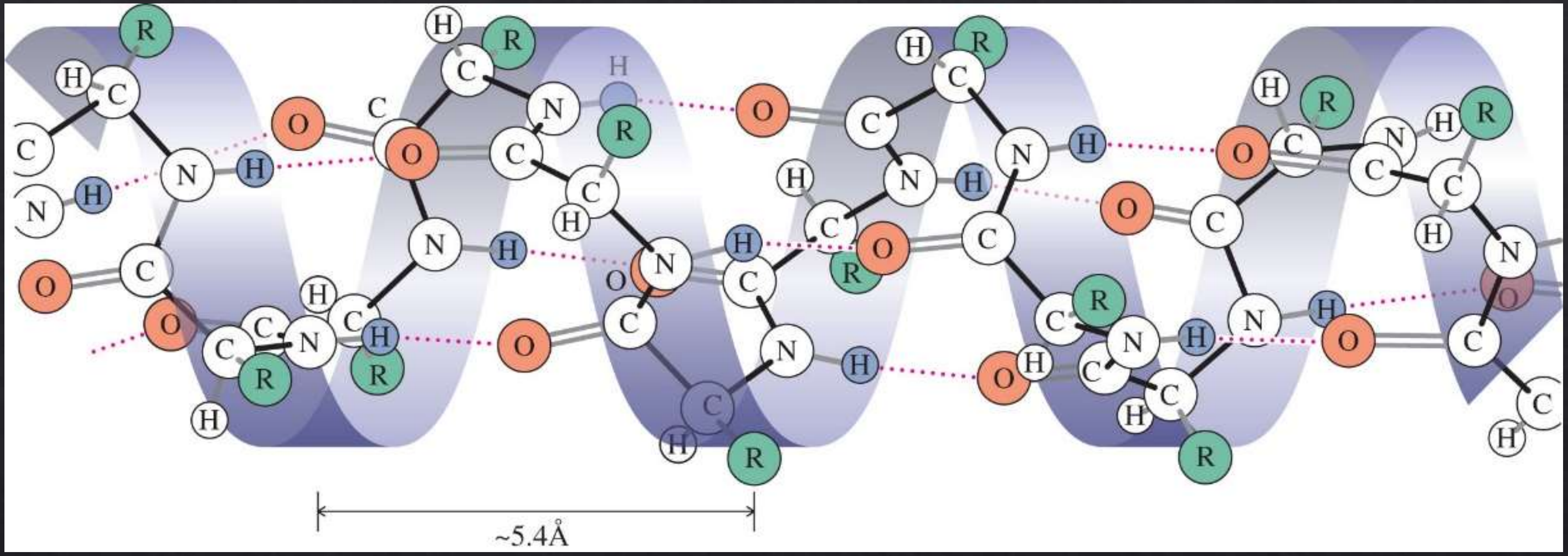
Picture by A. Lomize

Pleated sheets – β configuration



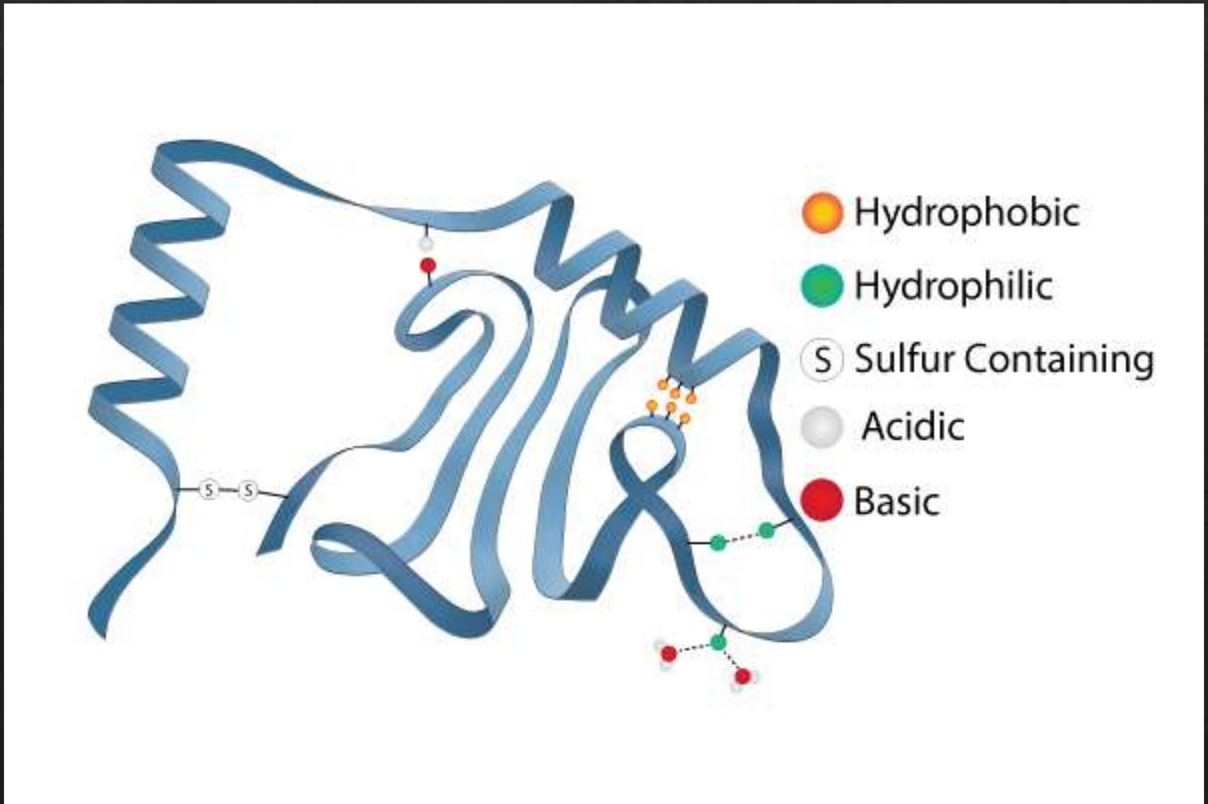
Picture from Vollhardt & Schore

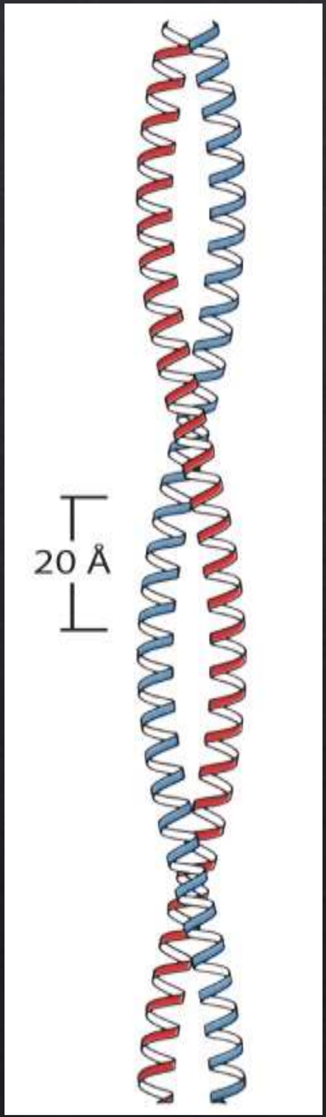
α helix



Picture from Vollhardt & Schore

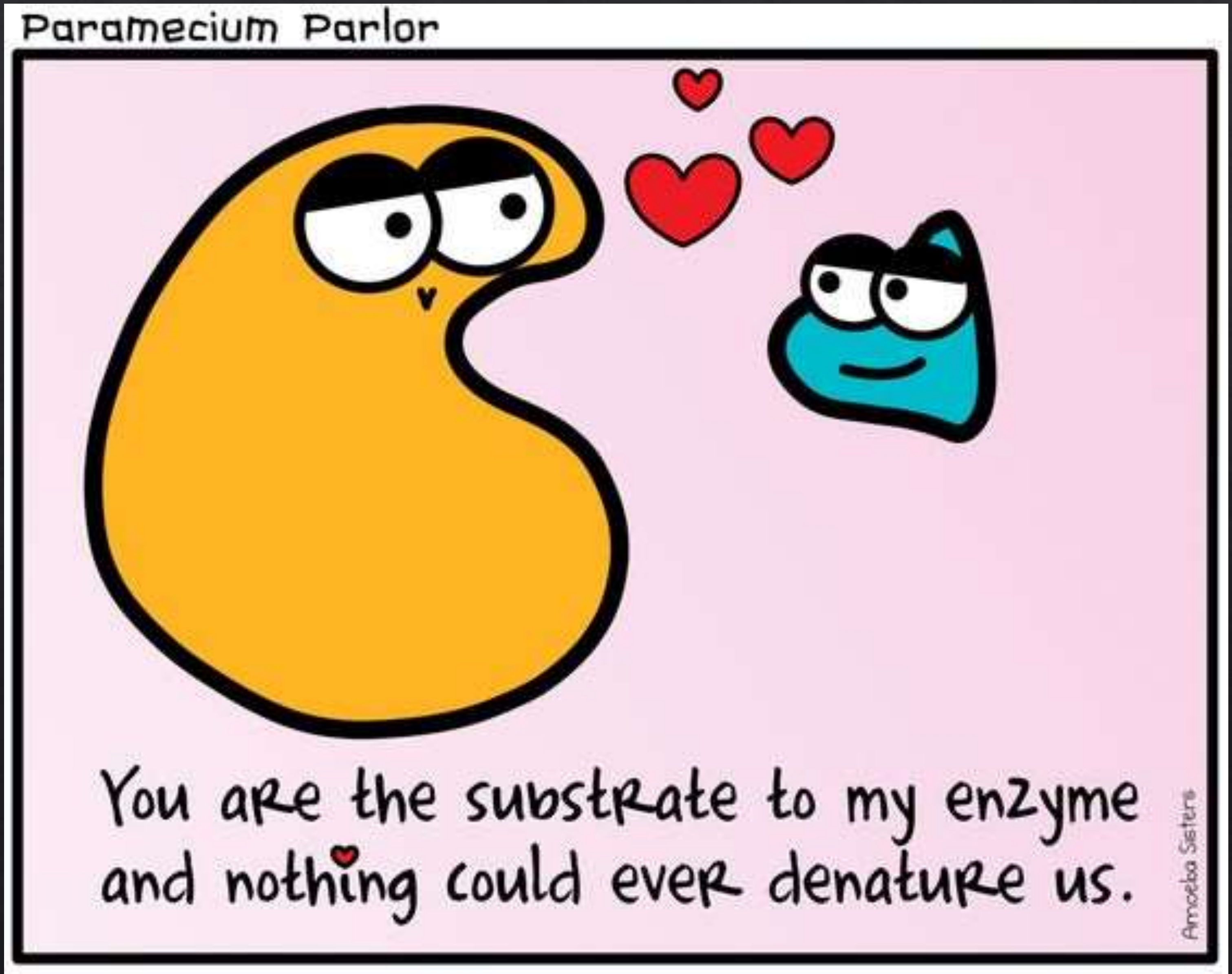
Tertiary structure



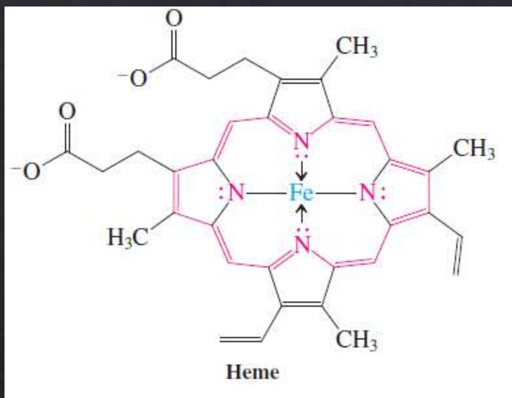


Pictures from Vollhardt & Schore

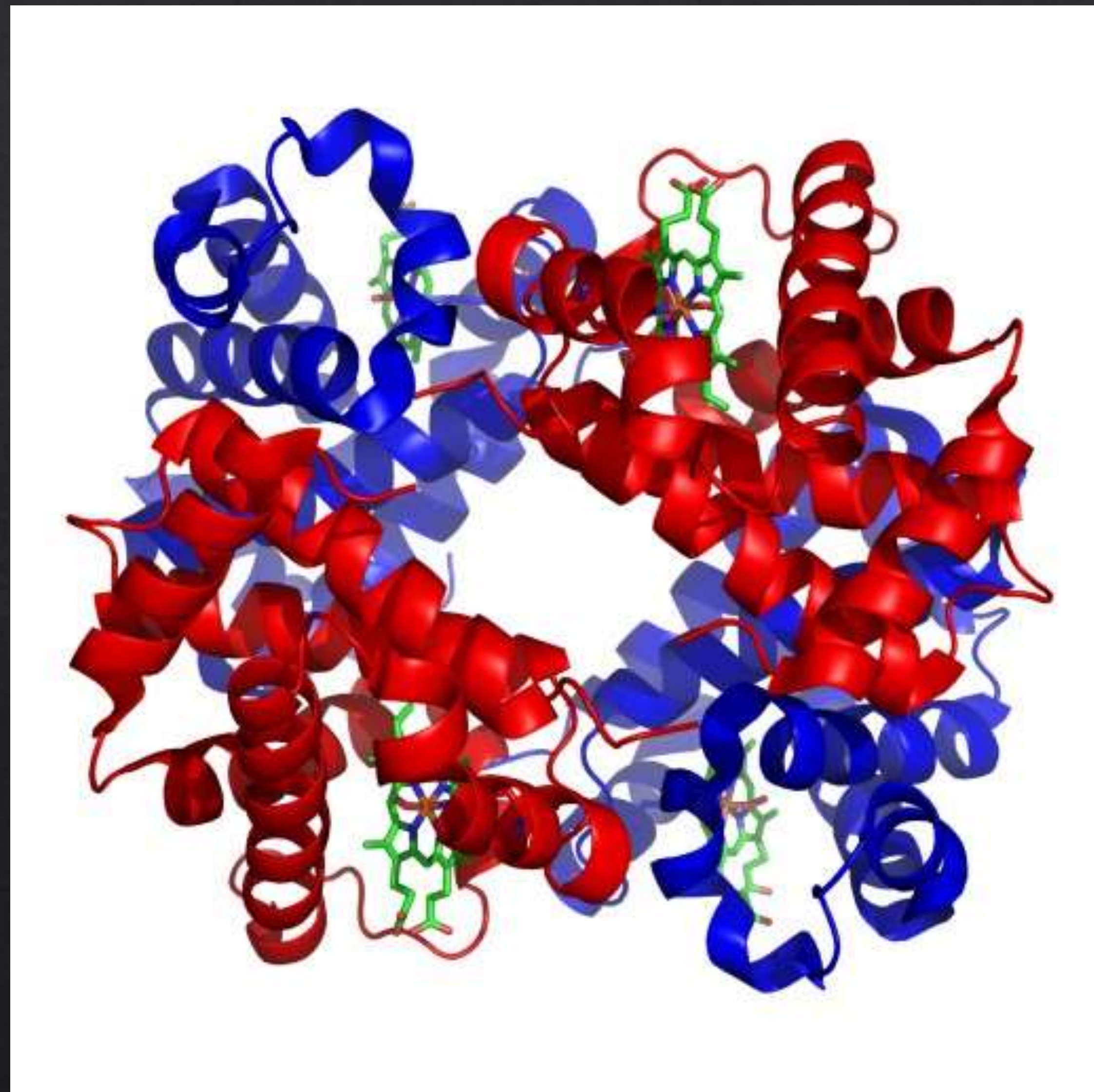
Tertiary structure



Quaternary structure

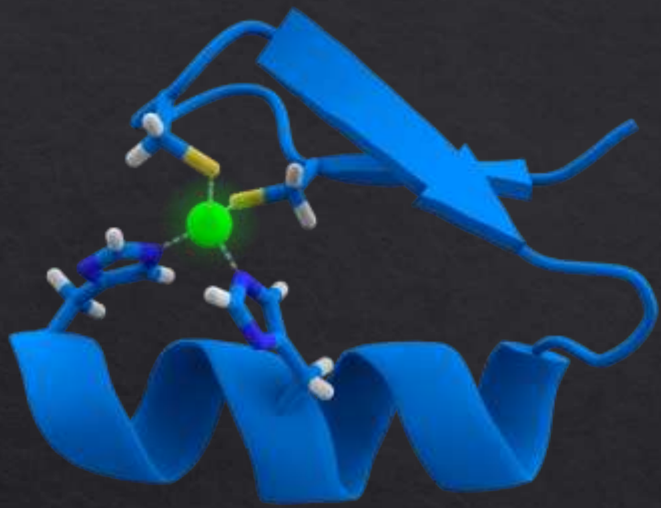


Picture from Nelson&Cox

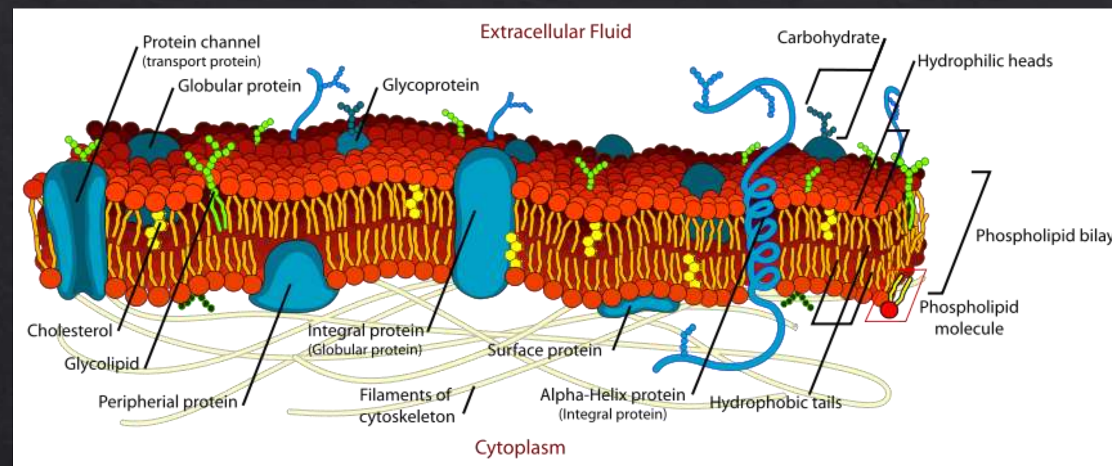


Picture by Zephyris

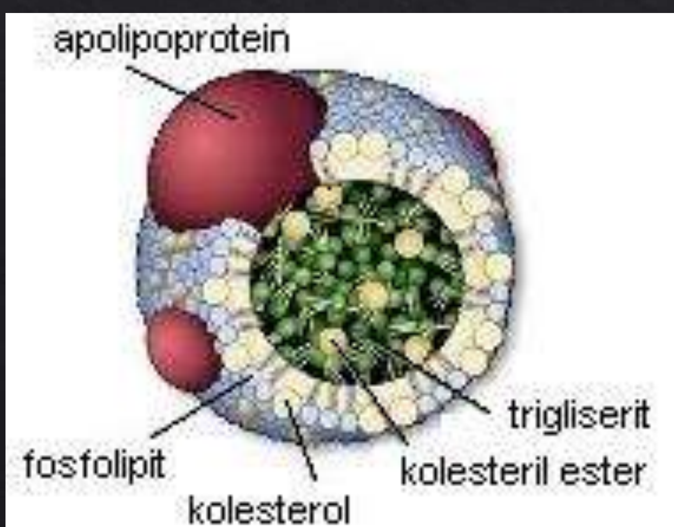
Conjugated proteins



Picture by T. Splettstoesser



Picture by Alokprasad84



Picture by Mutlutopuz

Protein structure and function

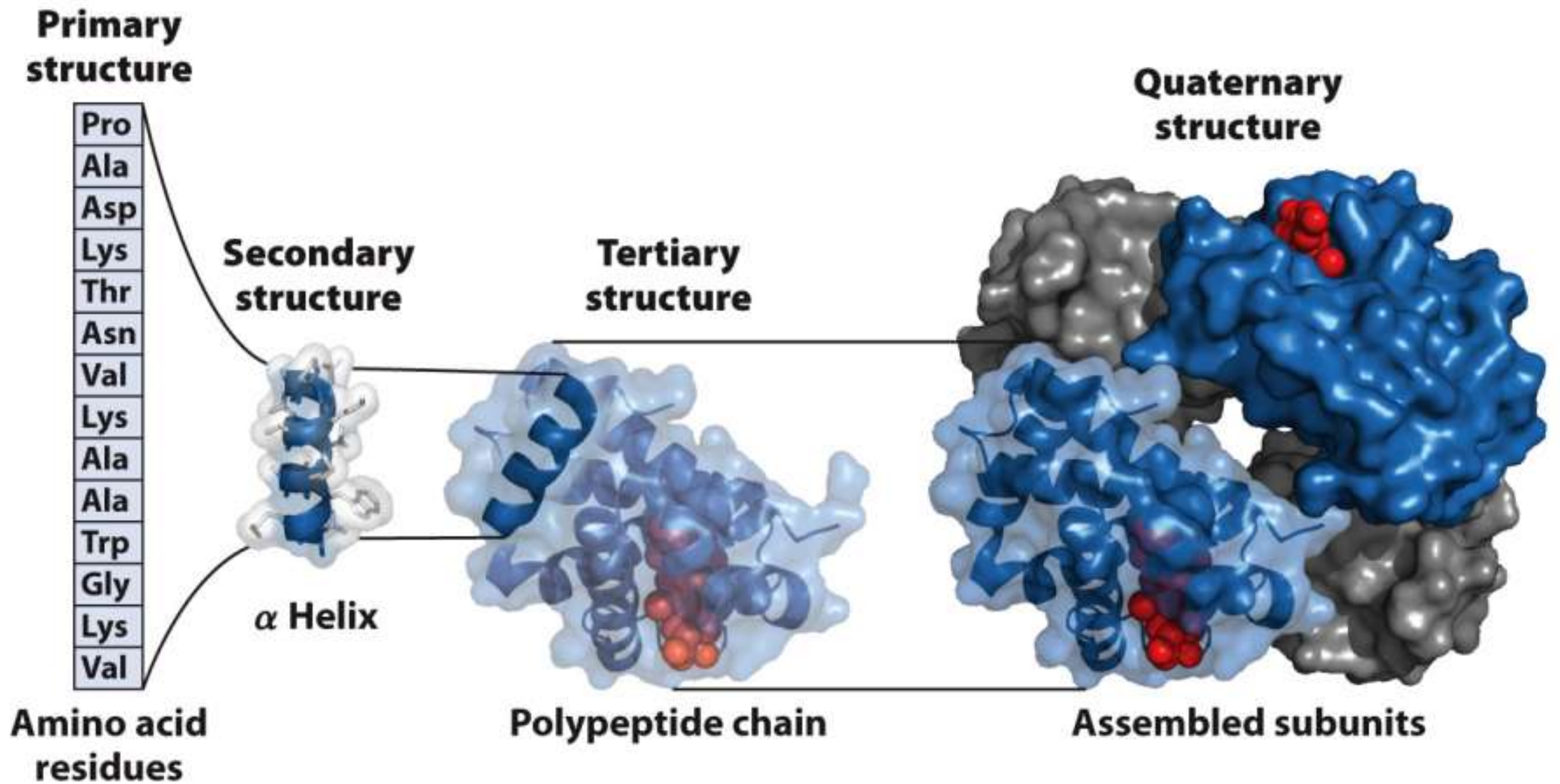
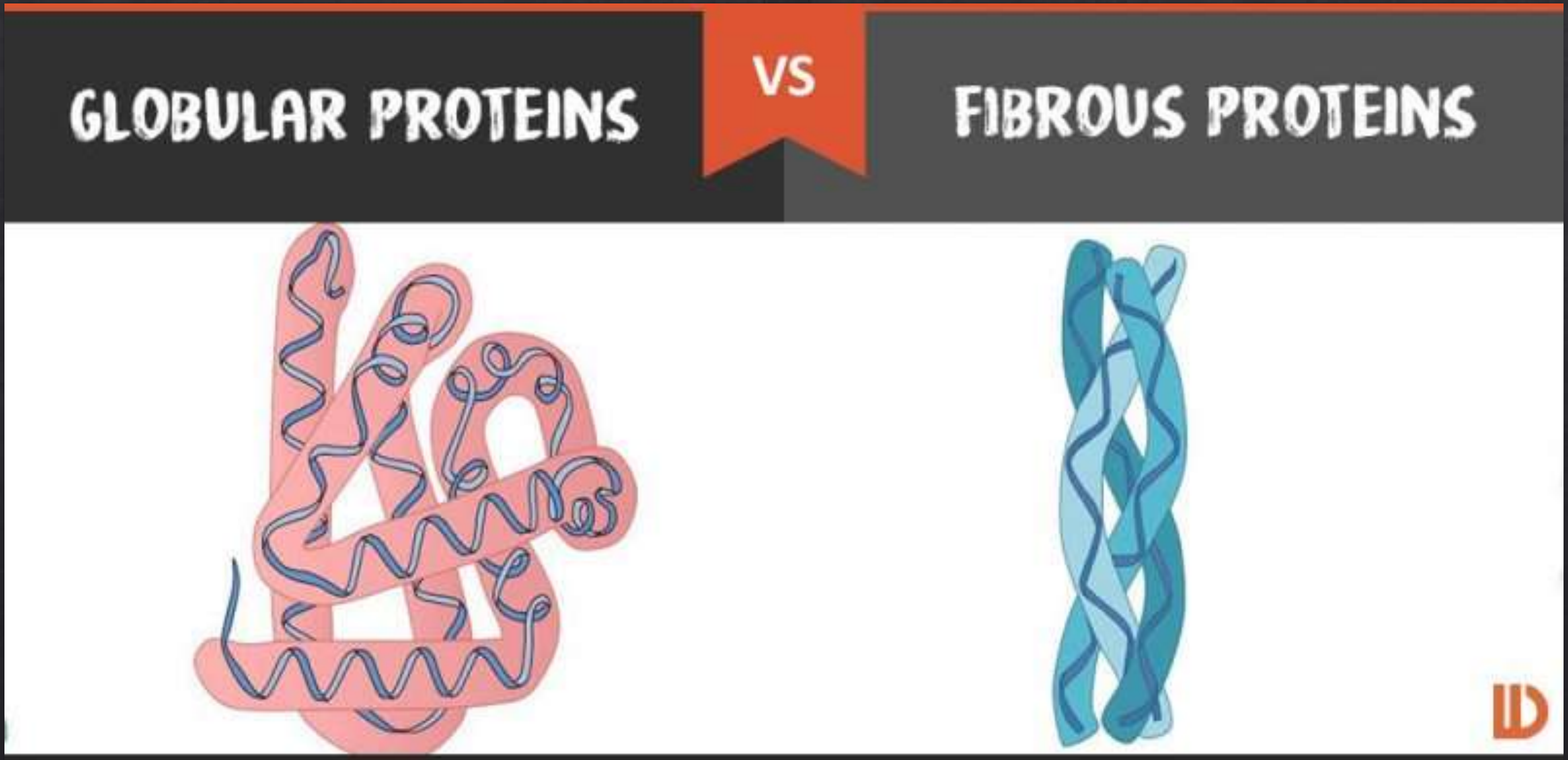


Figure 3-23
Lehninger Principles of Biochemistry, Seventh Edition

Major classes of proteins



Picture from Mr Green

Fibrous protein – Collagen

- Collagen is an important constituent of connective tissue: tendons, cartilage, bones, cornea of the eye.
- Each collagen chain is a long Gly- and Pro-rich left-handed helix.
- Three collagen chains intertwine into a right-handed superhelical triple helix.
- The triple helix has higher tensile strength than a steel wire of equal cross section.
- Many triple-helices assemble into a collagen fibril.

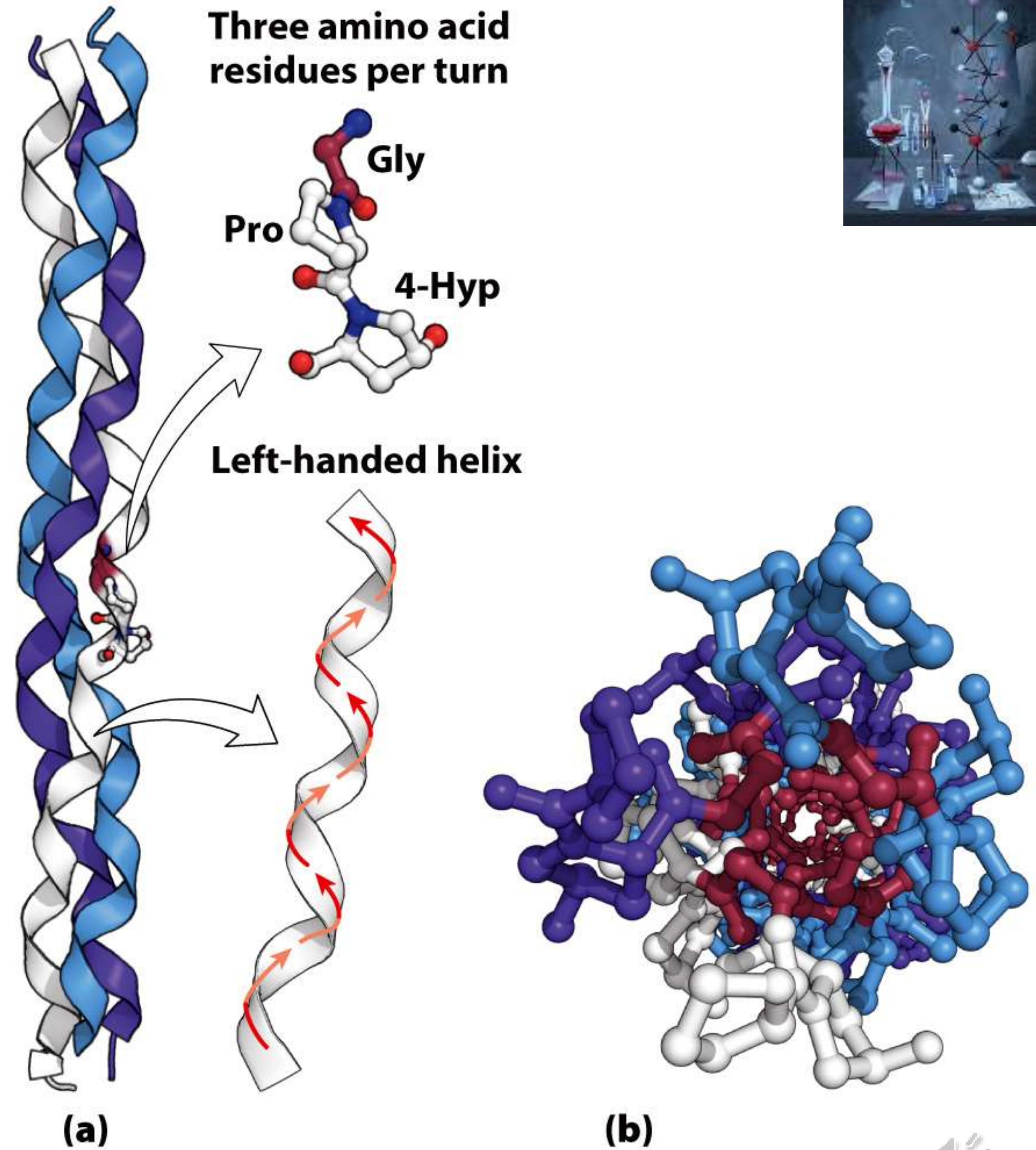


Figure 4-12
Lehninger Principles of Biochemistry, Seventh Edition

Fibrous protein – Silk Fibroin

- AA sequence prevents folding, elongated form
- Antiparallel β sheet structure
- Small side chains (Ala and Gly) allow the close packing of sheets.
- Structure is stabilized by:
  - hydrogen bonding within sheets
  - London dispersion interactions between sheets

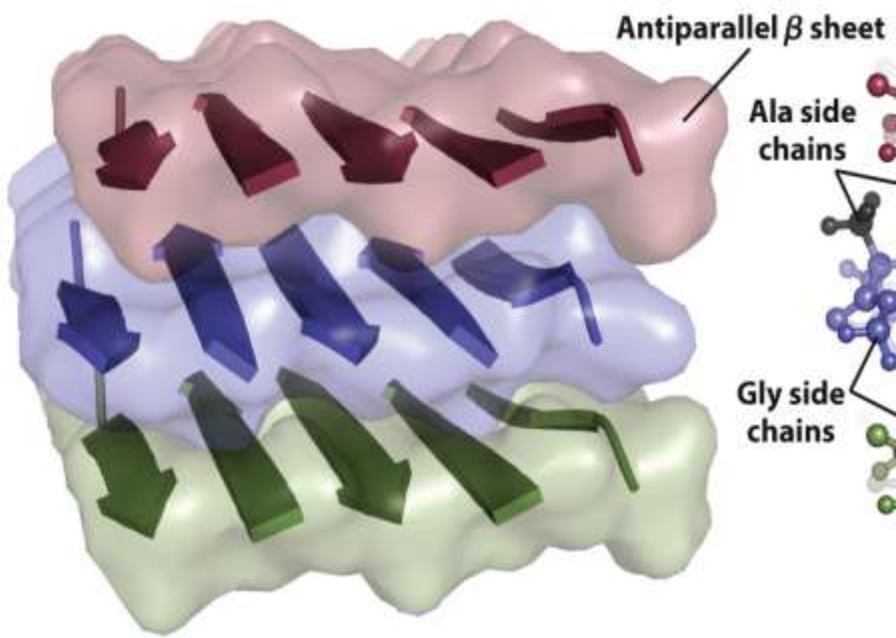


Figure 4-14a
Lehninger Principles of Biochemistry, Seventh Edition

Globular Proteins

- Specific arrangement of several secondary structure elements
  - all α helix
  - all β sheet
  - both
- Motifs can be found as recurring structures in numerous proteins.
- Globular proteins are composed of different motifs folded together.

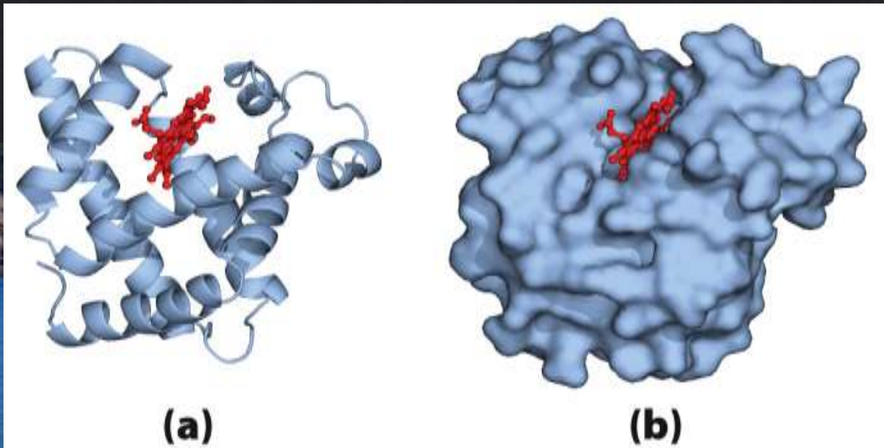


Figure 4-16
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Motifs (folds)

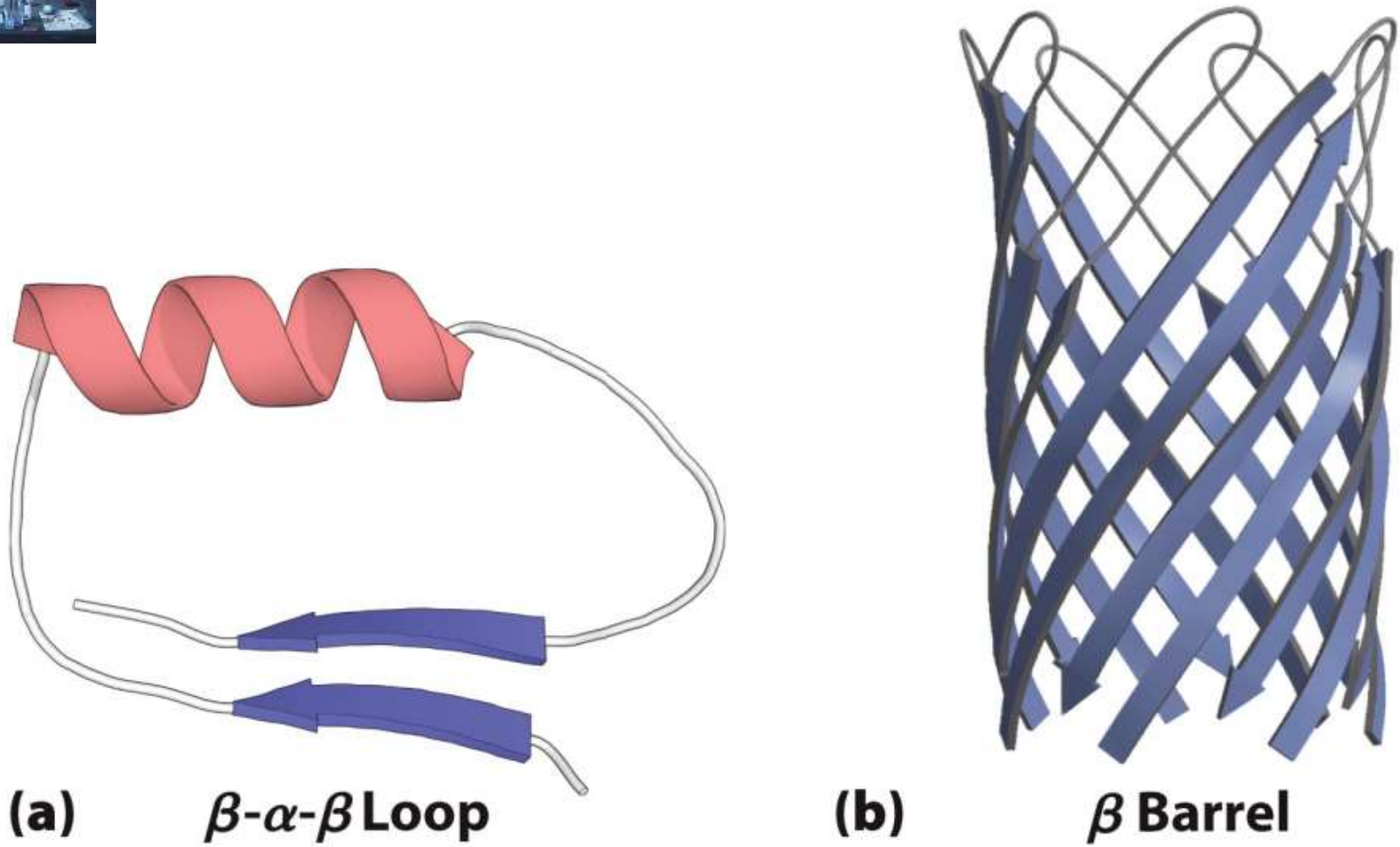

Figure 4-18
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Polypeptide folding

- Hydrophobic effect stabilises protein structure. It requires at least 2 levels of secondary structure.
- When together α-helices and β-sheets are generally found in different structural layers.
- Segments adjacent in the primary structure are usually close in the folded structure.
- β conformations are more stable when slightly twisted in a right-handed sense.
- Some proteins (or parts of them) lack ordered structure – disordered proteins.

Life cycle of a protein

- A protein's function depends on its 3D structure.
- Loss of structural integrity with accompanying loss of activity is called denaturation.
- Proteins can be denatured by:
  - heat or cold
  - pH extremes
  - organic solvents
  - chaotropic agents: urea and guanidinium hydrochloride

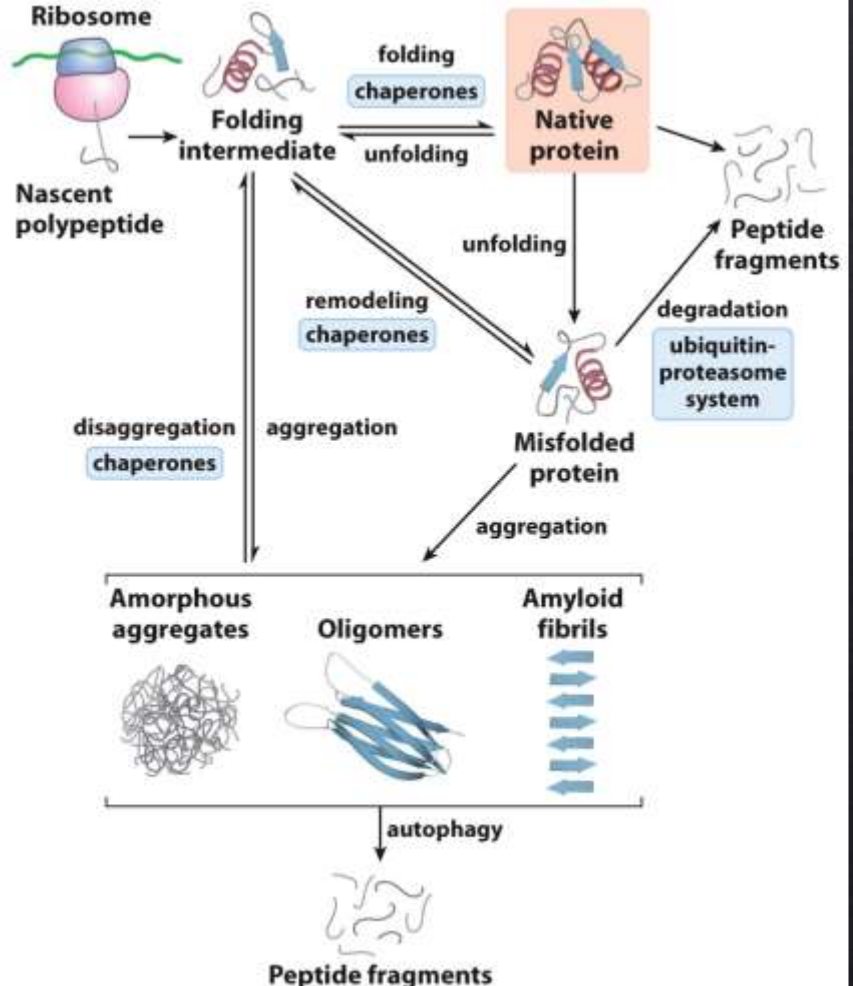

Figure 4-25
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