

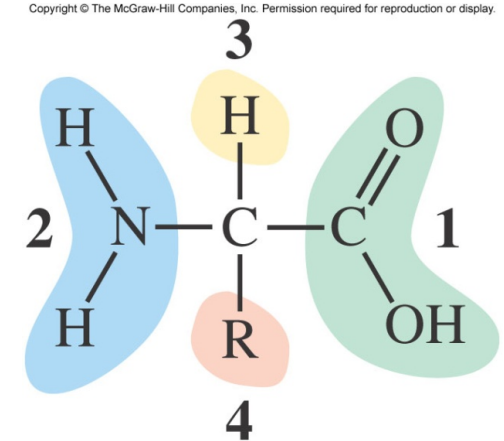


Proteins

Amino Acids (Ch. 11.4)

Amino acids are the building blocks for proteins:

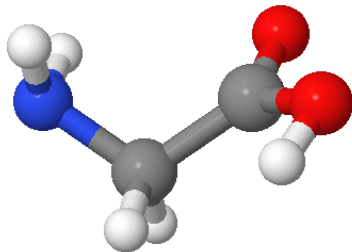
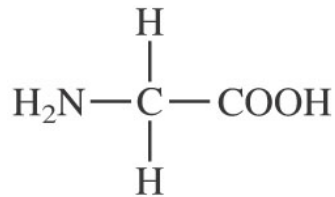
1. carboxylic acid
2. amino group
3. H atom
4. side chain (what makes amino acids different from each other)



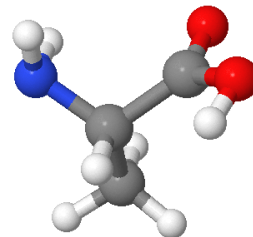
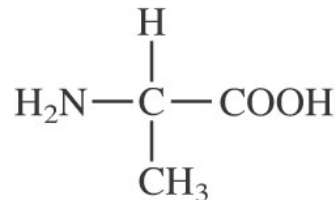
Examples:

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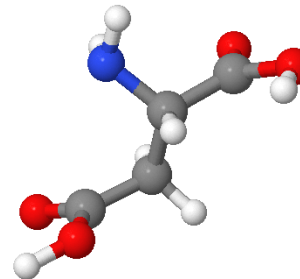
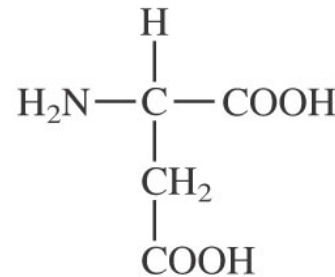
glycine



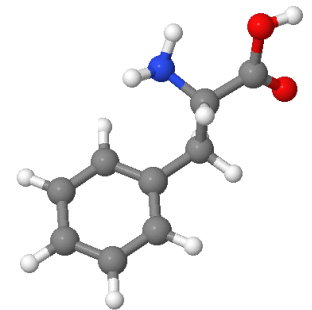
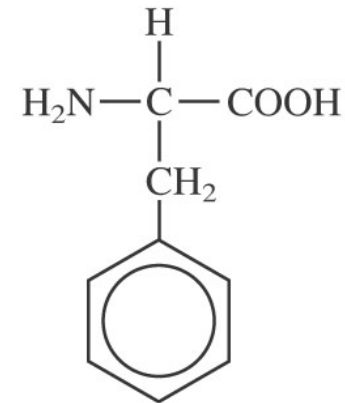
alanine



aspartic acid



phenylalanine

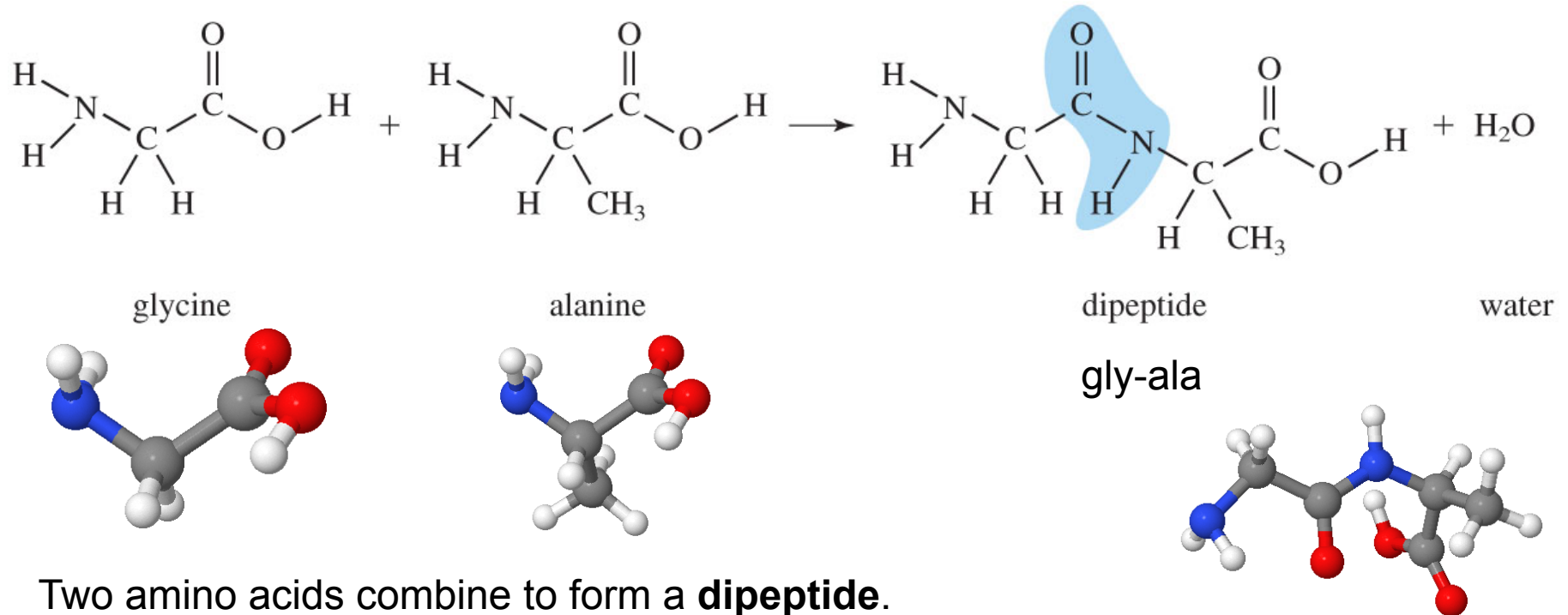


20 naturally occurring amino acids; our bodies can make only 11 of them...

Proteins from Amino Acids (Ch. 11.4)

Yet another example of a condensation reaction:

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Two amino acids combine to form a **dipeptide**.

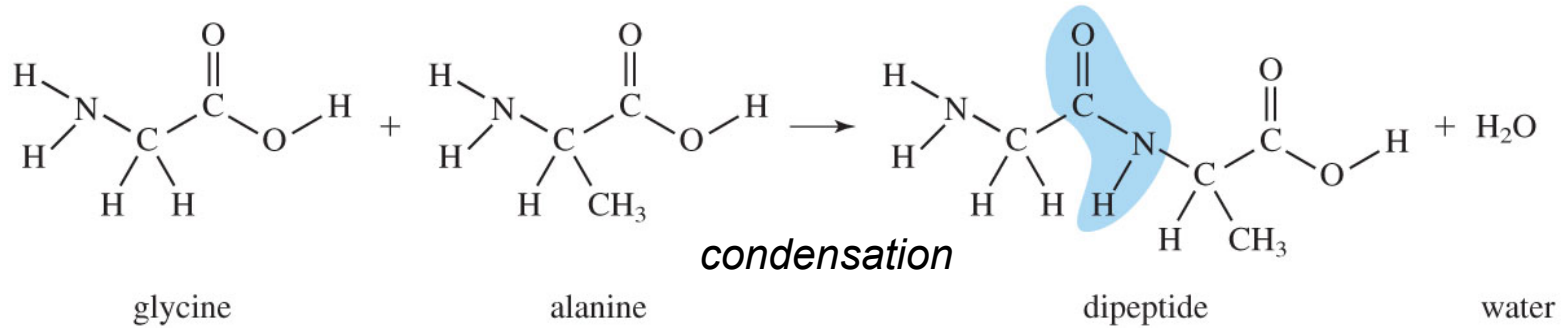
The order matters: gly-ala is not the same molecule as ala-gly.

A **protein** is a polypeptide built up from 100s-1000s of amino acids.

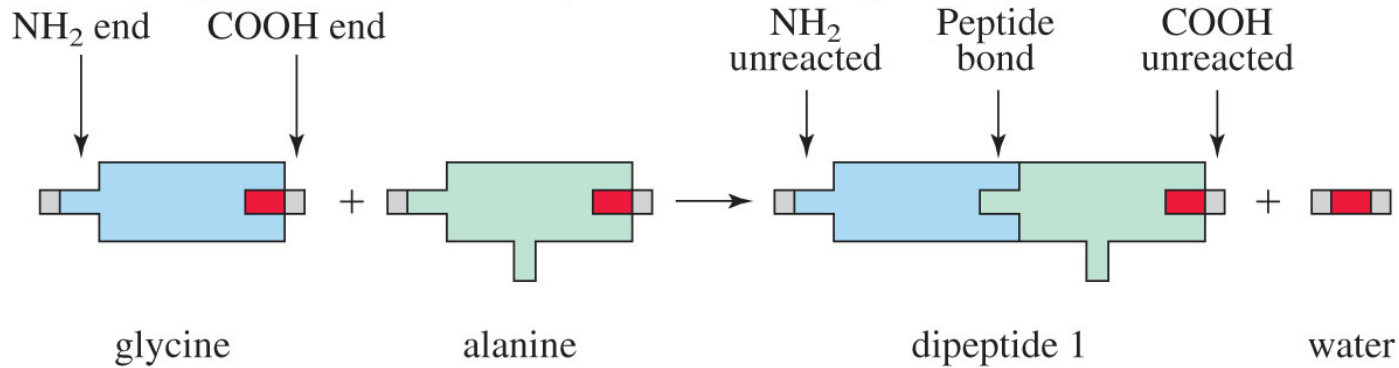
An **enzyme** is a protein that can act as a catalyst.

Active Sites: Protein Synthesis (Ch. 11.4)

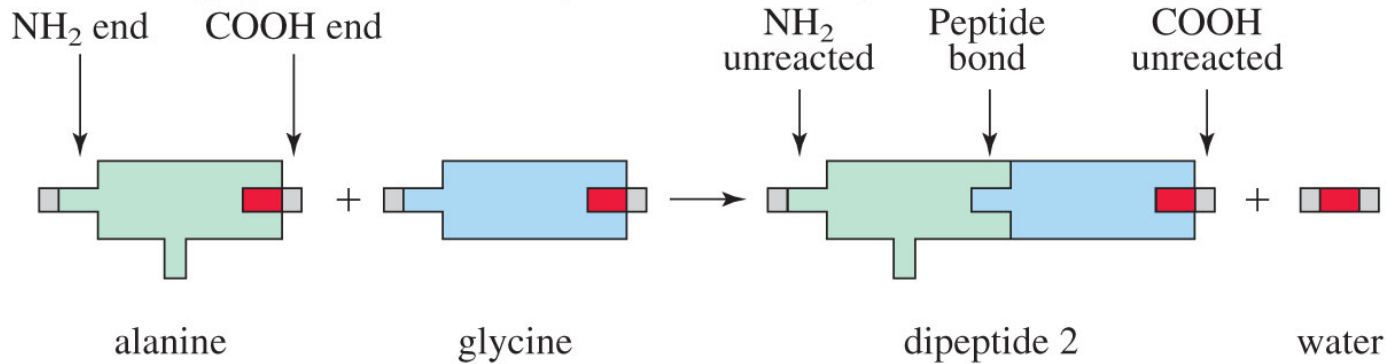
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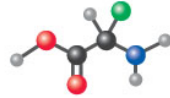


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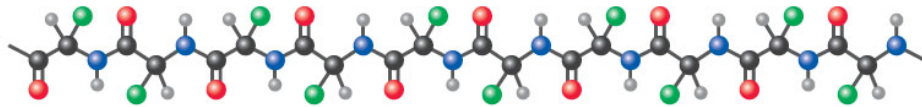


Active Sites: Protein Structure (Ch. 12.4)

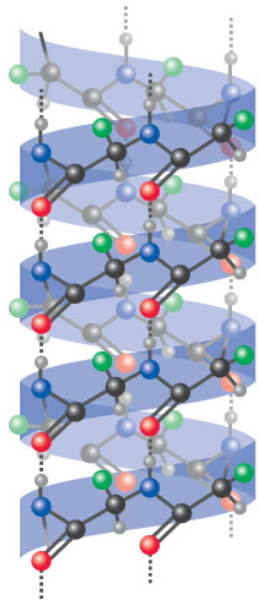
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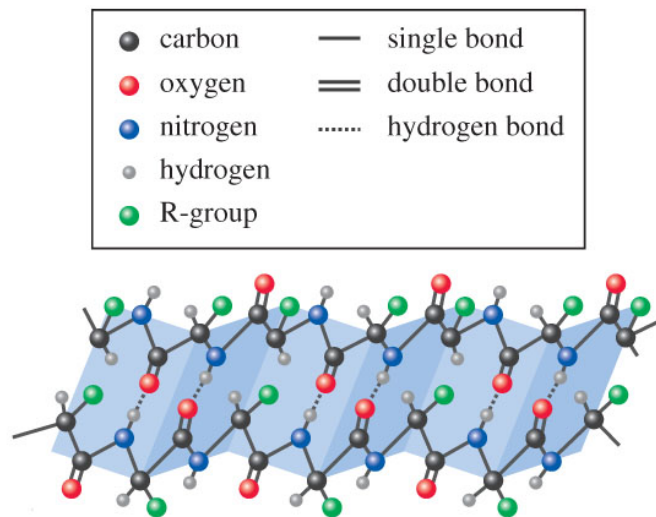
Amino acid monomer



Primary structure



α -helix



β -pleated sheet

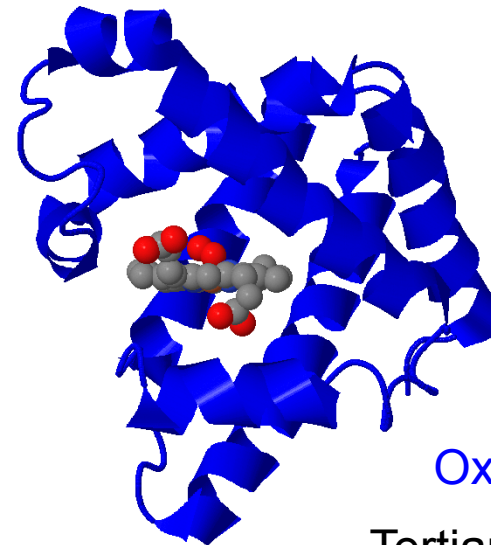
Secondary structures

Primary Structure: sequence of amino acids (comes from DNA)

Secondary Structure: alpha helix, beta sheet, ... (close interactions)

Tertiary Structure: 3-D arrangement of chain (distant interactions within chains)

Quaternary Structure: 3-D arrangement of chains (interactions between chains)



Oxymyoglobin

Tertiary Structure

Protein Sequence: Primary Structure

Myoglobin contains 153 amino acids:

VAL LEU SER GLU GLY GLU TRP GLN LEU
VAL LEU HIS VAL TRP ALA LYS VAL GLU
ALA ASP VAL ALA GLY HIS GLY GLN ASP
ILE LEU ILE ARG LEU PHE LYS SER HIS
PRO GLU THR LEU GLU LYS PHE ASP
ARG PHE LYS HIS LEU LYS THR GLU ALA
GLU MET LYS ALA SER GLU ASP LEU LYS
LYS HIS GLY VAL THR VAL LEU THR ALA
LEU GLY ALA ILE LEU LYS LYS LYS GLY
HIS HIS GLU ALA GLU LEU LYS PRO LEU
ALA GLN SER HIS ALA THR LYS HIS LYS
ILE PRO ILE LYS TYR LEU GLU PHE ILE
SER GLU ALA ILE ILE HIS VAL LEU HIS
SER ARG HIS PRO GLY ASP PHE GLY
ALA ASP ALA GLN GLY ALA MET ASN LYS
ALA LEU GLU LEU PHE ARG LYS ASP ILE
ALA ALA LYS TYR LYS GLU LEU GLY TYR
GLN GLY

Primary Structure: sequence of amino acids (comes from DNA)

Secondary Structure: alpha helix, beta sheet, ... (close interactions)

Tertiary Structure: 3-D arrangement of chain (distant interactions)

Quaternary Structure: 3-D arrangement of chains (interactions between chains)

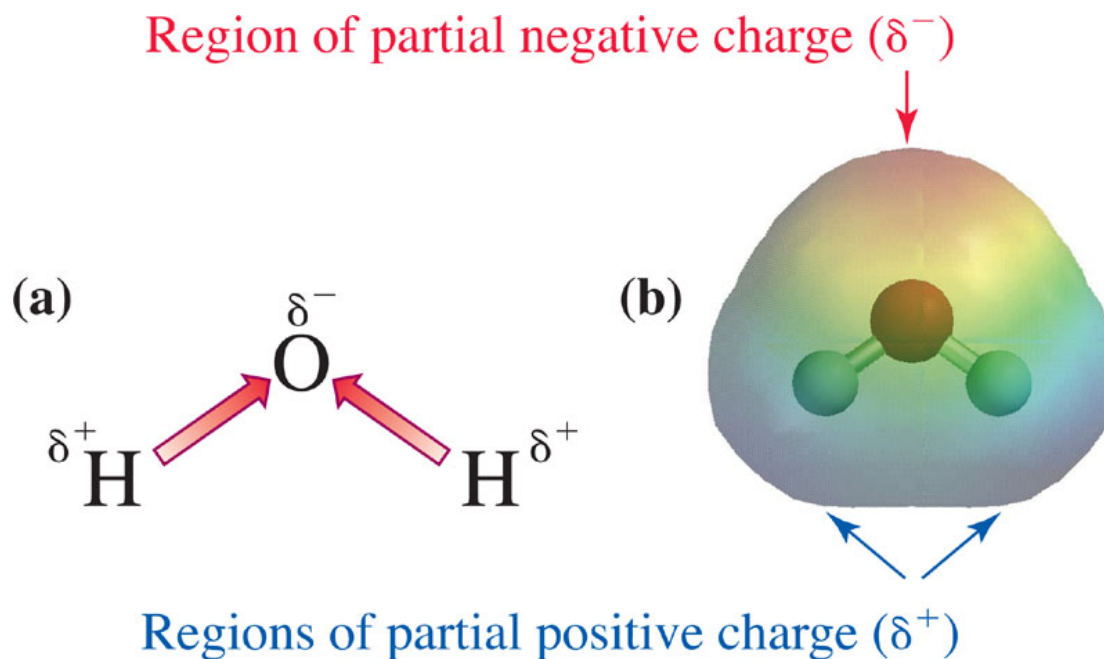
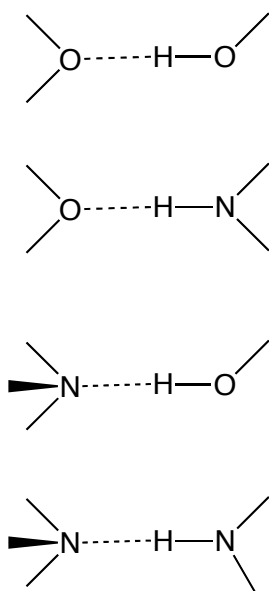
Hydrogen Bonding (5.5 & 5.6)

So far, we've talked about shared pairs of electrons

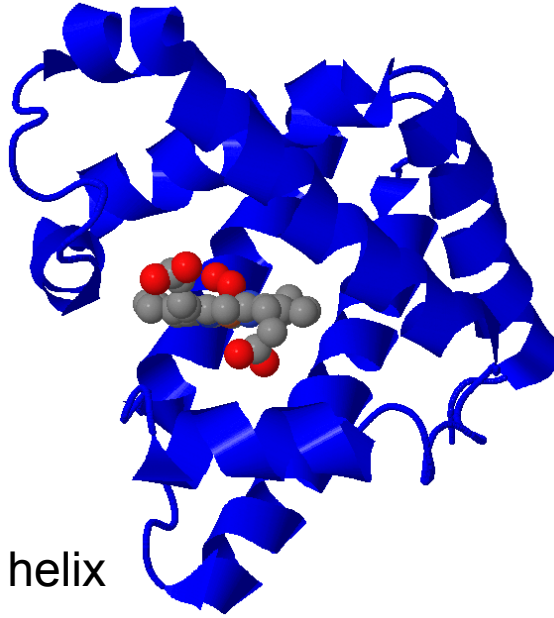
The sharing doesn't have to be equal

later electronegativity will tell us which atoms have the stronger pull

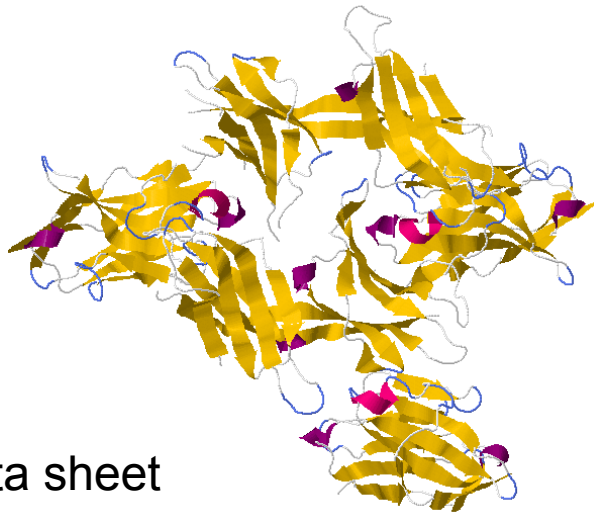
For now: N-H and O-H bonds are polarized to make the H partially positive & the O or N partially negative



Secondary structure



Alpha helix



Beta sheet

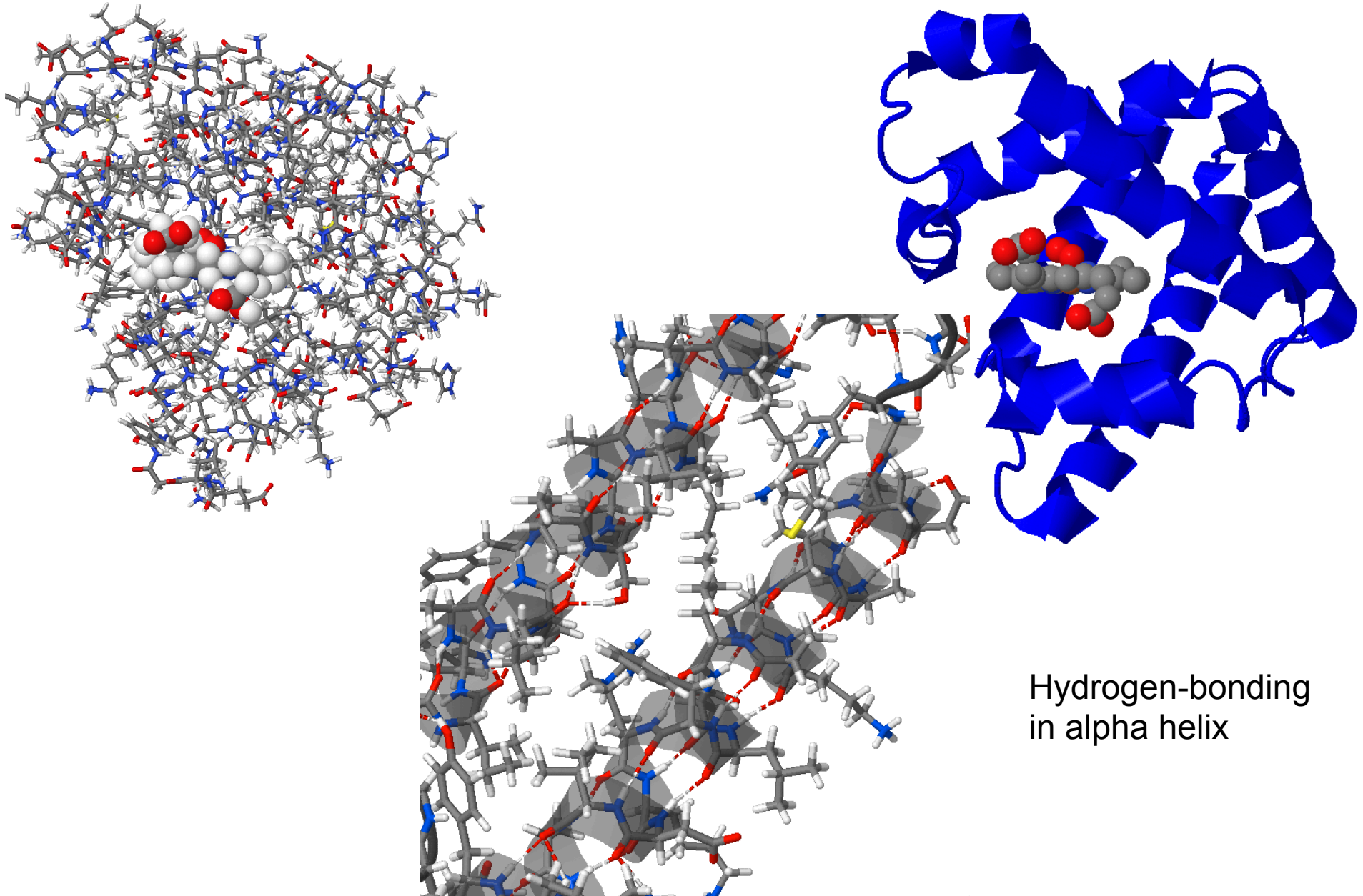
Primary Structure: sequence of amino acids (comes from DNA)

Secondary Structure: alpha helix, beta sheet, ... (close interactions)

Tertiary Structure: 3-D arrangement of chain (distant interactions)

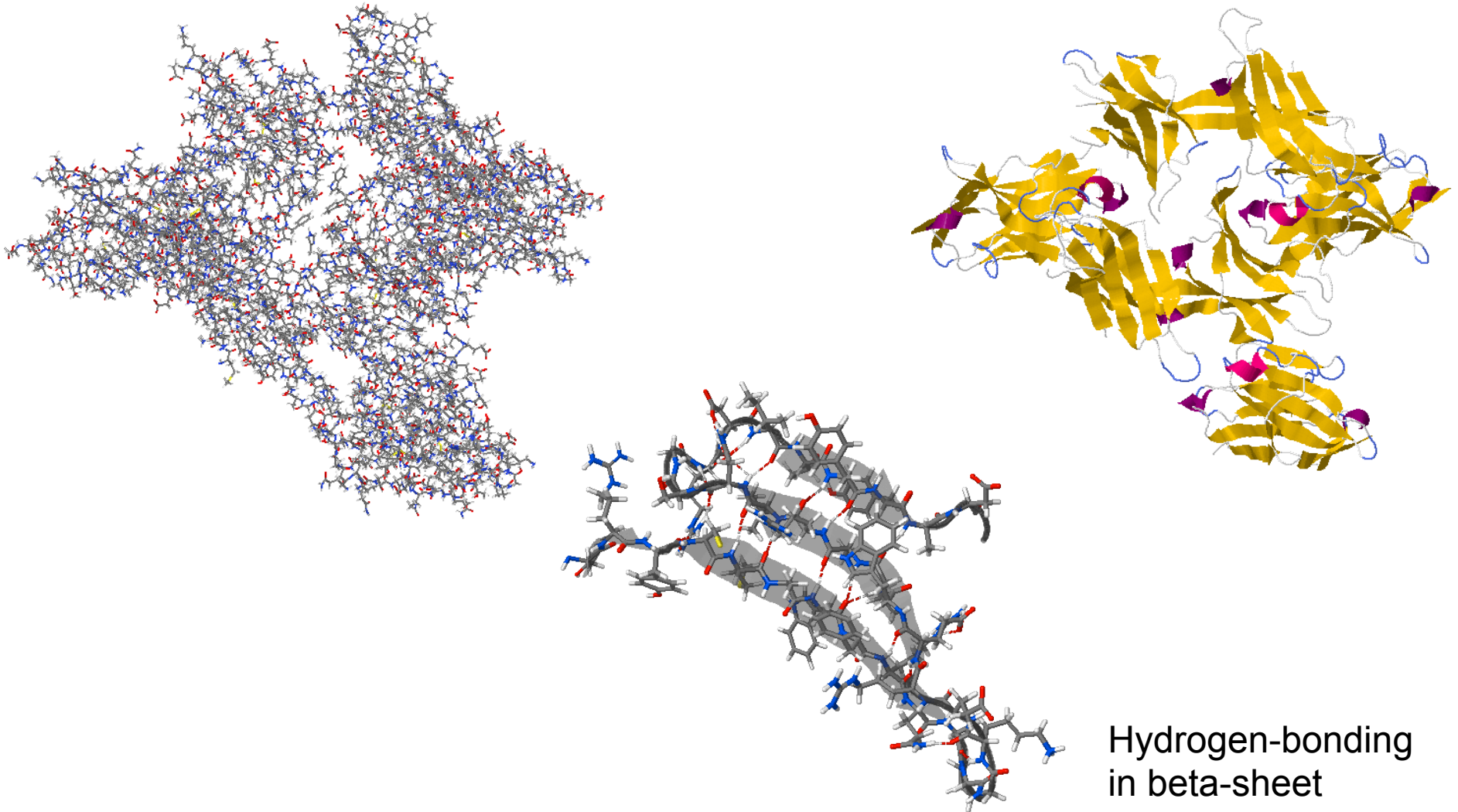
Quaternary Structure: 3-D arrangement of chains (interactions between chains)

Myoglobin, representations



Hydrogen-bonding
in alpha helix

Beta-Sheets



Beta2-microglobulin, thought to be involved in amyloid formation (Alzheimer's disease, Prion disease (Mad Cow))

Binding Sites: Quaternary Structure in Hemoglobin

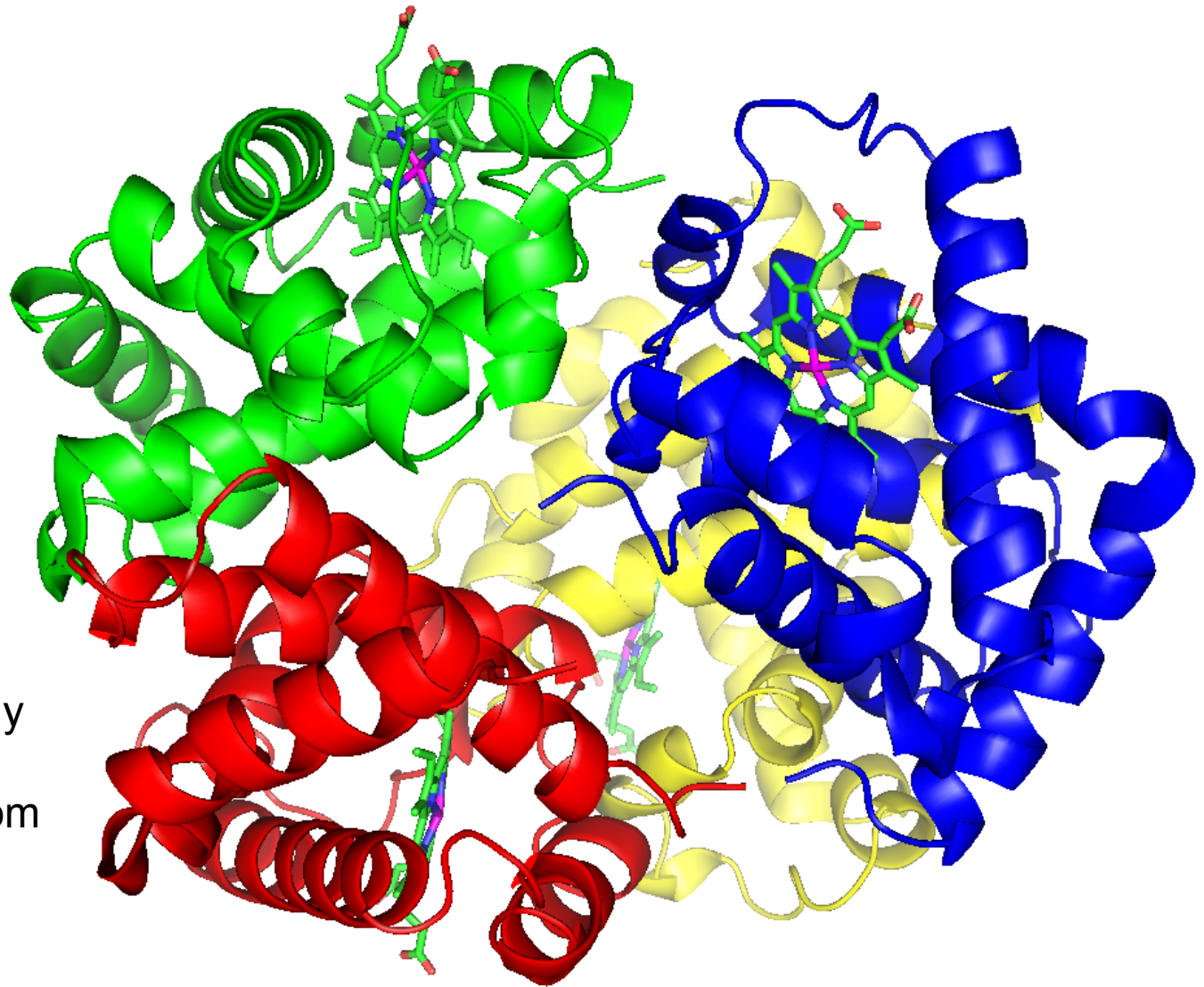
Hemoglobin

4 subunits

4 O₂ binding sites

Binding of 1 molecule of O₂ is slow, but causes the other 3 sites to open up

CO binds more slowly than O₂, but is more difficult to remove from the Fe-containing binding site



Protein Folding

So far we've talked about the role that hydrogen bonding plays in protein structure

Primary Structure: sequence of amino acids
(comes from DNA)

Secondary Structure: alpha helix, beta
sheet, ... (close interactions)

Tertiary Structure: 3-D arrangement of chain
(distant interactions within chain)

Quaternary Structure: 3-D arrangement of
chains (interactions between chains)

Remember: General rule: Like dissolves like

Hydrocarbon dissolves in Hydrocarbon

C-H bonds

oils, fats

Nonpolar

Hydrophobic

Hydroxyl dissolves in Hydroxyl

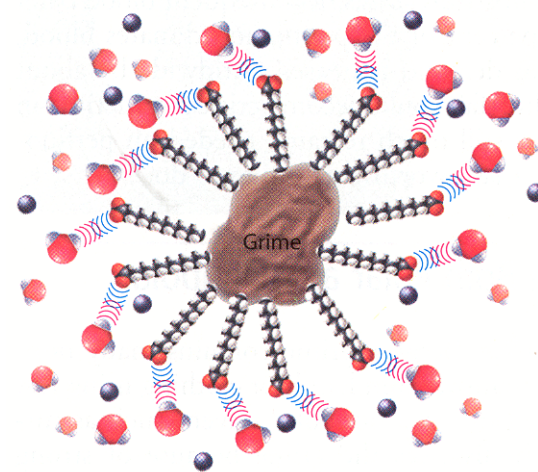
O-H bonds

water, alcohols, sugars

Polar

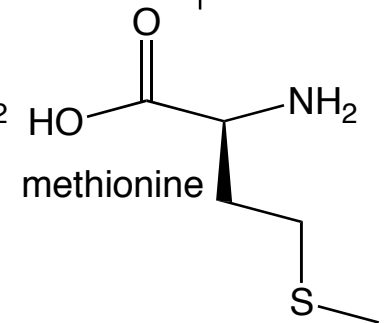
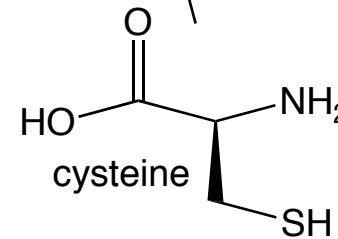
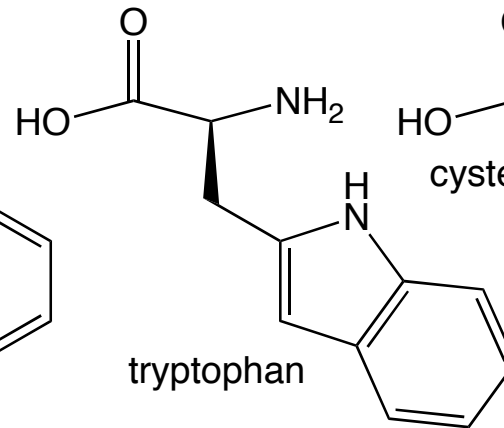
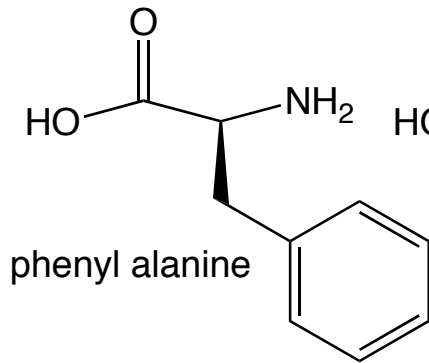
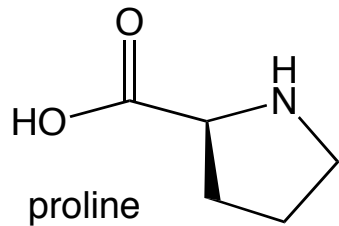
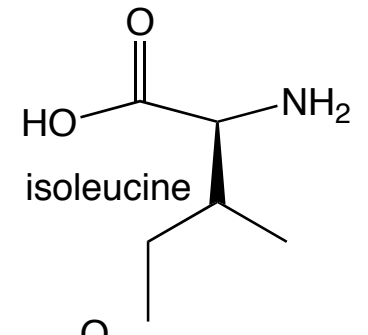
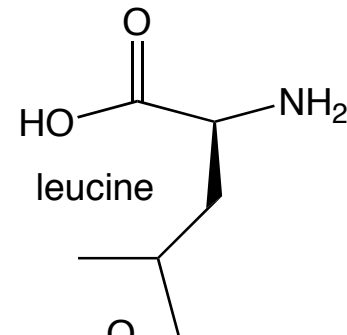
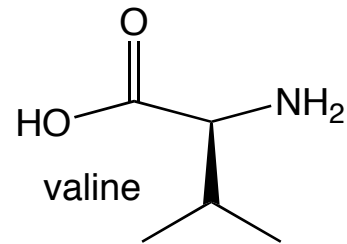
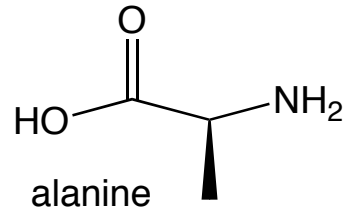
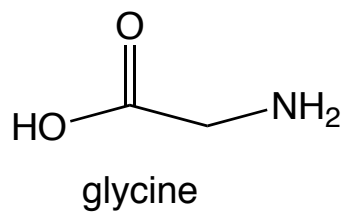
Hydrophilic

& how soap works

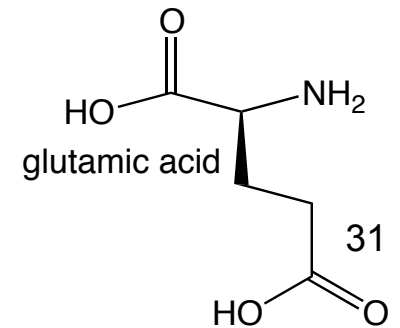
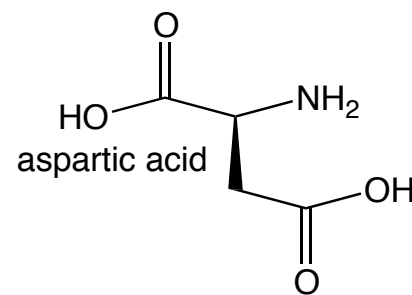
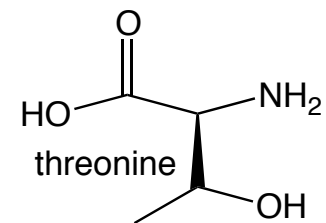
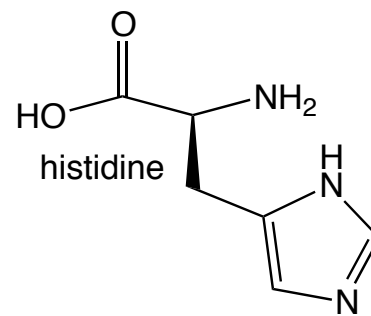
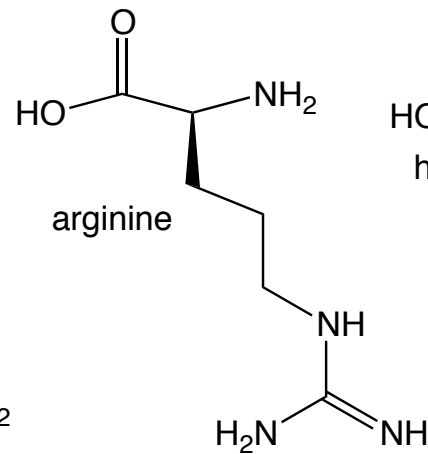
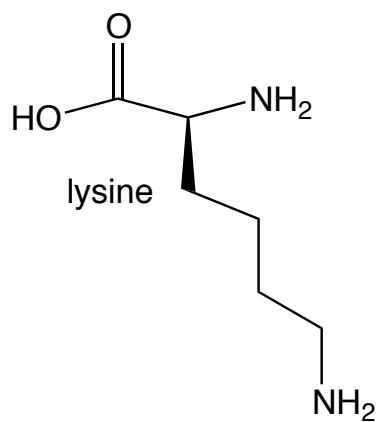
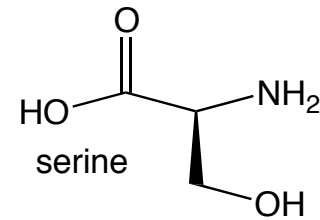
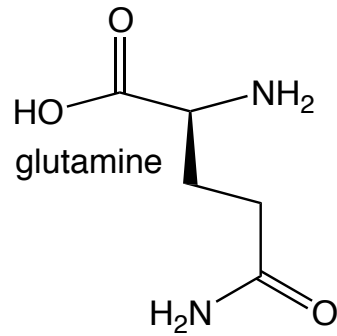
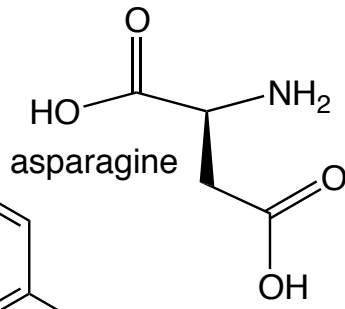
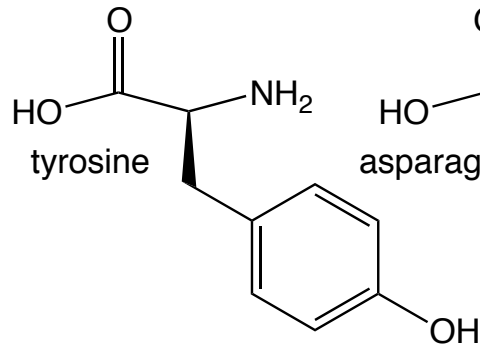


Some amino acid side chains are hydrophobic & some are hydrophilic

Hydrophobic amino acids



Hydrophilic amino acids



Essential amino acids

Essential amino acids for adults

Chemical structures shown:

- Methionine: CSCC[C@@H](N)C(=O)O
- Valine: CC(C)[C@@H](N)C(=O)O
- Threonine: CC(O)[C@@H](N)C(=O)O
- Phenyl alanine: c1ccc(cc1)[C@@H](N)C(=O)O
- Leucine: CC(C)C[C@@H](N)C(=O)O
- Isoleucine: CC[C@H](C)[C@@H](N)C(=O)O
- Tryptophan: C1=CN2C(=C1)C=C[C@H]2[C@@H](N)C(=O)O
- Lysine: CCCC[NH2][C@@H](N)C(=O)O
- Histidine: C1=CN=C(N1)[C@@H](N)C(=O)O

Food sources:

- Corn (maize) and other grains:** Methionine, Valine, Threonine, Phenylalanine, Leucine, Isoleucine
- Beans and other legumes:** Tryptophan, Lysine

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Table 11.5

The Essential Amino Acids

histidine

isoleucine

leucine

lysine

methionine

phenylalanine

threonine

tryptophan

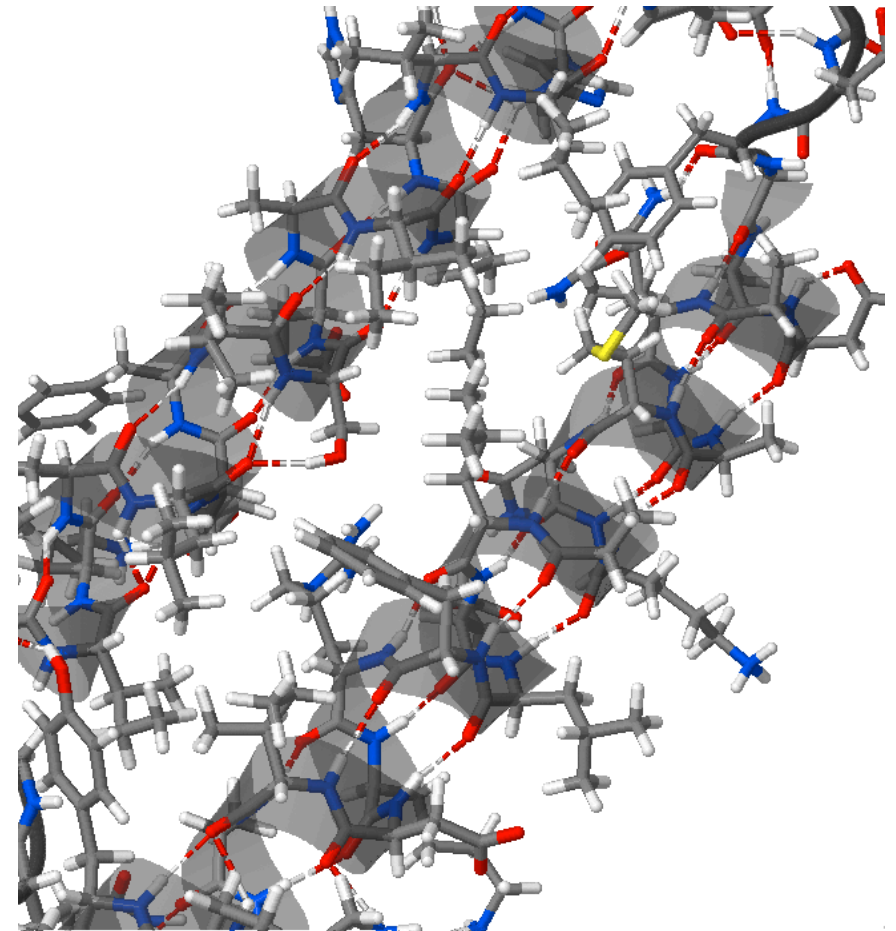
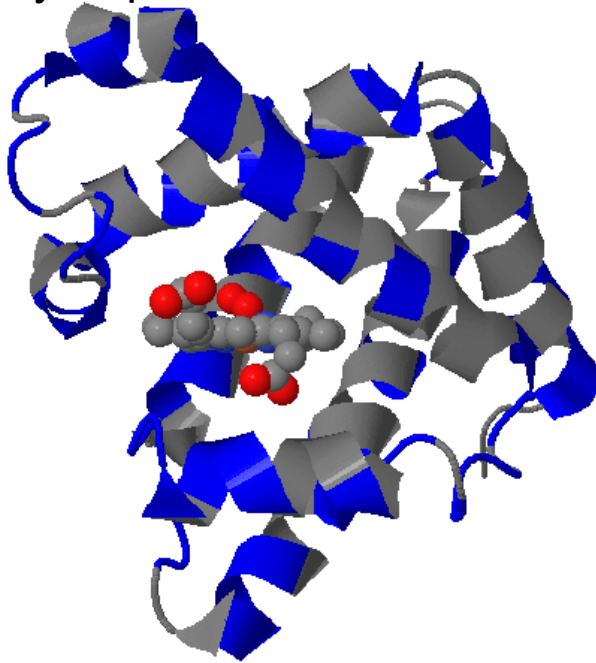
valine

Myoglobin—solution phase protein

Primary oxygen carrier in muscle tissue

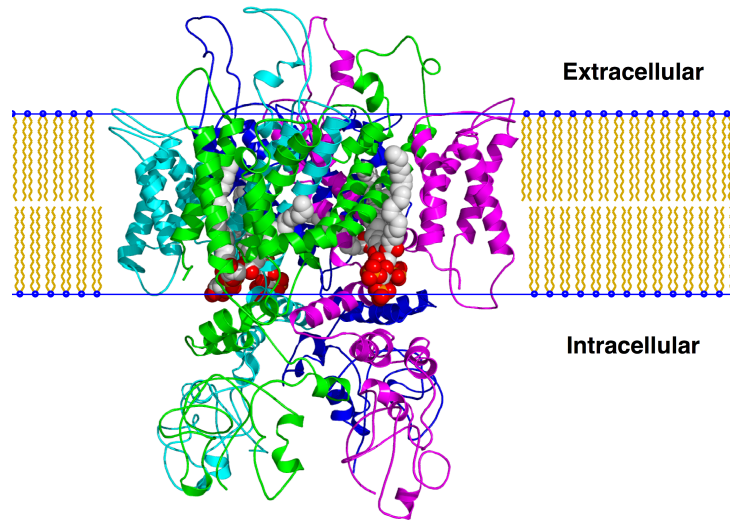
Hydrophobic in grey

Hydrophilic in blue



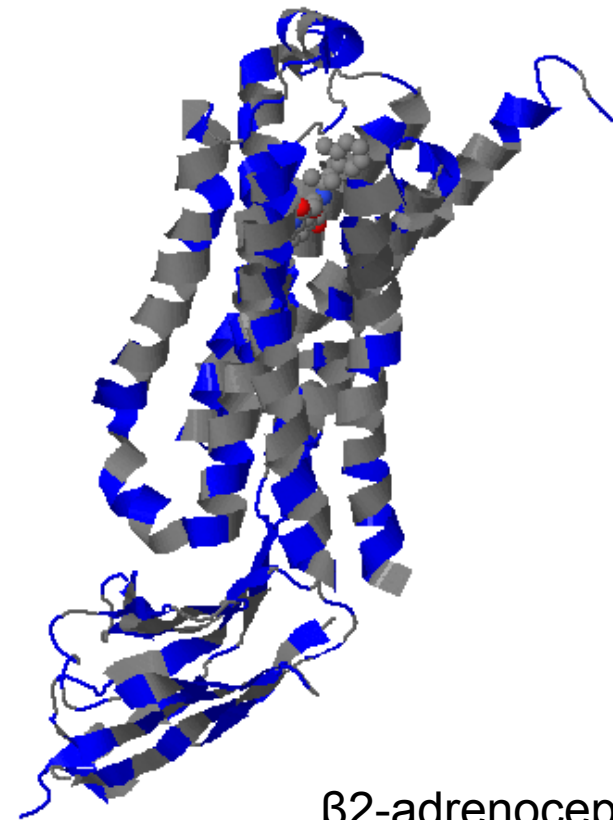
Hydrophobic side chains are on the inside
Hydrophobic interactions contribute to folding
Non-polar \leftrightarrow non-polar
polar \leftrightarrow polar

Trans membrane receptor



Hydrophobic in grey
Hydrophilic in blue

Non-polar membrane \leftrightarrow non-polar protein



Receptor for adrenaline (fight-or-flight response)