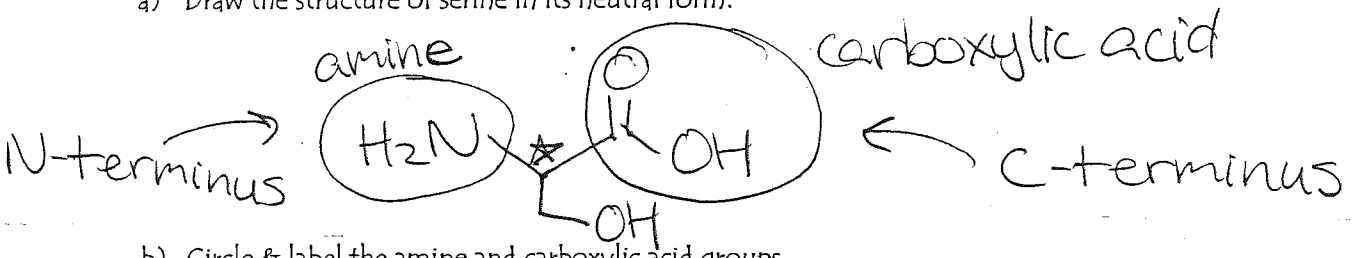
Key FB

Amino Acids, Proteins, & Enzymes Supplemental Homework

Amino Acids, Chirality, Protein Structure and Function, Enzymes, Reaction Catalysis, Enzyme Inhibition

1. Proteins are polymers of α-amino acids.

   a) Draw the structure of serine in its neutral form.



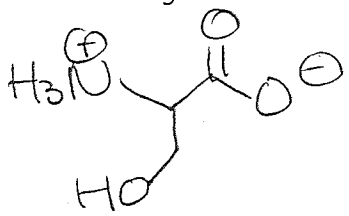
   b) Circle & label the amine and carboxylic acid groups. ✓

   c) Label the N-terminus and C-terminus of the amino acid. ✓

   d) Star the α-caarbon. ✓

   e) What is the name for the stereochemistry of this carbon? chirality

2. At physiological pH, serine exists in its ionized state, forming a zwitterion (a molecule with ionized groups, but neutral in overall charge). Draw the zwitterionic structure of serine.



3. When two amino acids are arranged N-terminus to C-terminus, the carboxylic acid of first amino acid reacts with the amine of the second amino acid to form an amide bond.

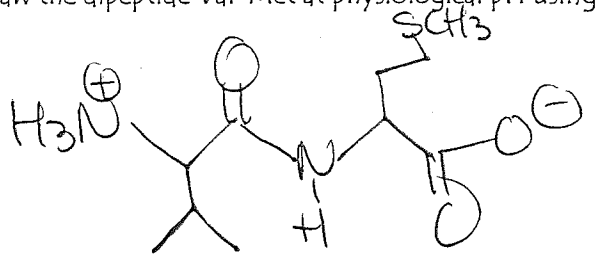
   a) What are the 3 different names for this reaction?

   synthetic dehydration, condensation, or acyl derivative formation

   b) What is the other name for the bonds that form?

   peptide bond

4. Draw the dipeptide Val-Met at physiological pH using skeletal-line structures.



5. Amino acids differ from one another by their particular R-groups. 19 of the 20 amino acids are chiral. Proteins are chiral molecules because they are composed of chiral amino acid building blocks. Which 2 characteristics need to be true for a carbon atom to be chiral?

tetrahedral carbon bonded to 4 different grps

6. The Fisher projection of glycine is shown. Draw its mirror image and answer the subsequent questions.

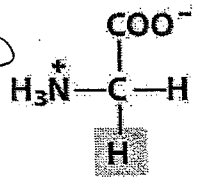
a) Is the α-carbon in glycine tetrahedral? yes

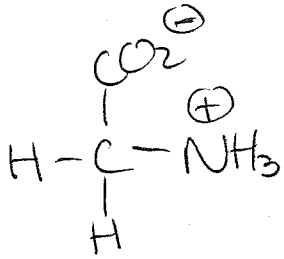
b) Is the α-carbon in glycine connected to 4 different groups? NO

c) Is the α-carbon in glycine chiral? NO

d) Is the carbonyl carbon in glycine tetrahedral? NO

e) Is the carbonyl carbon in glycine chiral? NO





f) Is glycine chiral? NO

g) Are the two glycine structures above the same molecule or two different molecules?

7. The Fisher projection of L-alanine is shown. Draw its mirror image & answer the subsequent questions.

a) Is the α-carbon in alanine tetrahedral? yes

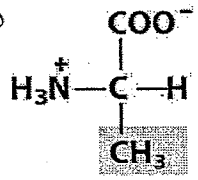
b) Is the α-carbon in alanine connected to 4 different groups? yes

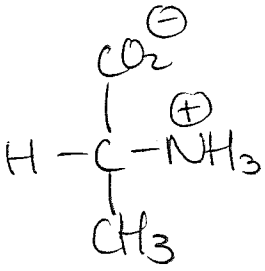
c) Is the α-carbon in alanine chiral? yes

d) Is the carbonyl carbon in alanine tetrahedral? NO

e) Is the carbonyl carbon in alanine chiral? NO

f) Is alanine chiral? yes





g) How are the two alanine structures above related to one another?

enantiomers

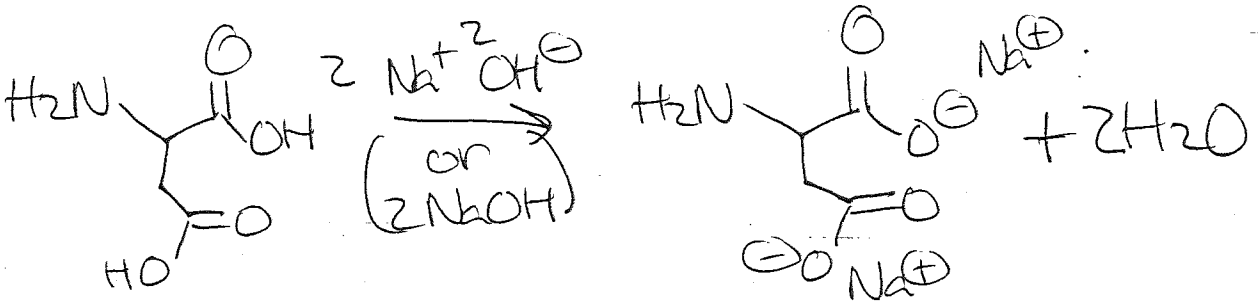
8. In your own words, define the following:

Enantiomers: non-superimposable mirror images

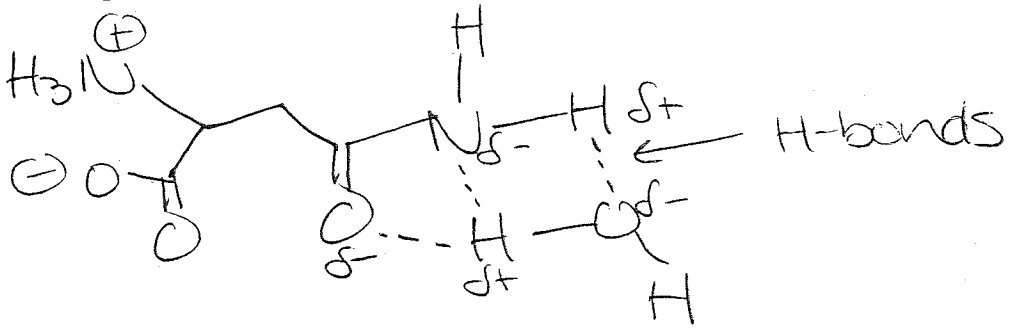
Racemic Mixture:: 50:50 mixture of a pair of enantiomers

Diastereomers: stereoisomers that are NOT non-superimposable mirror images.

9. Acidic amino acids are named due to their R-groups ability to donate a proton at physiological pH. The two acidic amino acids are aspartic acid and glutamic acid.
Write the reaction of aspartic acid with excesss sodium hydroxide to form sodium aspartate and water using skeletal-line structures.



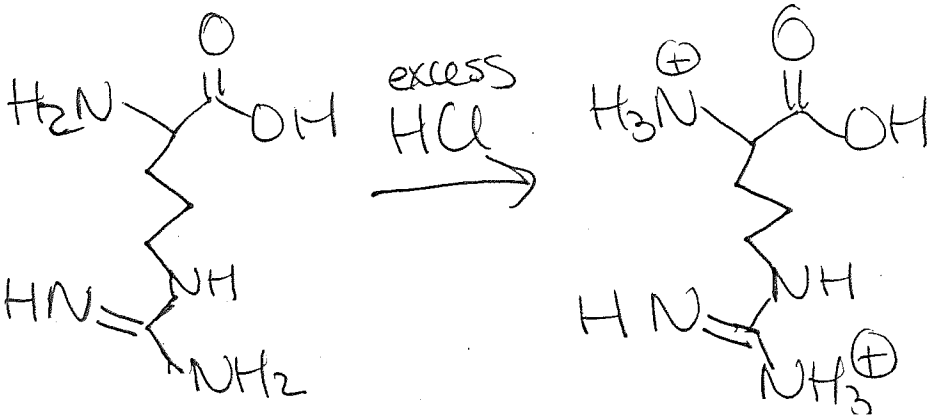
10. Two of the main hydrogen bonding-capable amino acids contain R-groups with either an amide or an alcohol.
Draw the skeletal-line structure for asparagine and then add a water molecule to show how they interact. Indicate any partial charges and add dashed lines for the H-bonds.



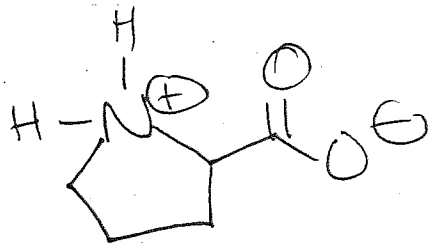
11. A majority of R-groups are composed solely or mostly of carbon and hydrogen atoms.
a) What is the predominant IMF that would be exhibited by these R-groups? List at least three different synonyms for this interaction.
London, vander Waals, hydrophobic

b) Would these particular amino acids more likely be found at the surface of a globular protein or within the core? Explain.
within core b/c they are repelled by H_2O of aqueous body fluids

12. Three amino acids (histidine, lysine, and arginine) are termed basic, as they have the ability to abstract a proton from solution at physiological pH. Show the reaction of arginine with excess hydrochloric acid to form the fully protonated form.



13. There is one amino acid whose R-group connects to its own N-terminus. Which amino acid is it? Draw its structure. proline



14. Within the ribosome, amino acids (AA) can join together forming peptide bonds.
    a) The linear sequence of amino acids (AA) in a polypeptide chain is defined as a protein's 1° structure.

    b) A protein's AA sequence is typically written from left to right, with the left-most AA called the N-terminus AA, and with the right-most AA called the C-terminus AA.

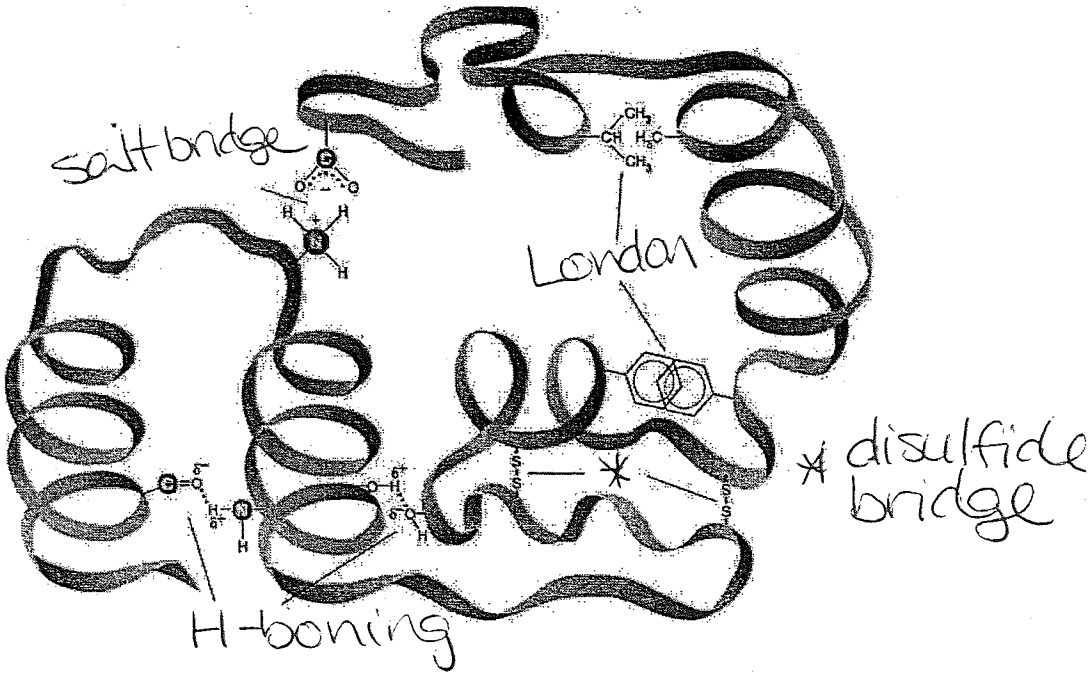
    c) Which non-covalent force is responsible for secondary structure formation? Between which functional groups does this interaction occur?
    H-bonding between the a.a. backbone.

    d) What are the two types of secondary structures that can occur?
    α-helix & β-sheet

    e) List the 5 different non-covalent interactions that form and stabilize the tertiary structure of proteins.
    salt bridge
    ion-dipole
    H-bond
    London
    Metal-ion complex

    f) Explain quaternary structure.
    protein comprised of 2or more polypeptide sub units.

15. In the diagram below,
    a) label the four types of tertiary structure.



    b) Which secondary structure element is shown numerous times?

α-helix

    c) Which secondary structure element is not shown at all?

β-sheet

16. Salt bridges, H-bonding, and London dispersion forces all help build the tertiary structure of proteins.

    a) Which 5 AAs can form ionic bonds/salt bridges with other charged R-groups?

Asp, Glu, Lys, Arg, His

    b) Of the 5 AAs listed above, which ones can interact with one another?

Asp, Glu > can interact with < Lys, Arg, His

    c) Which 6 AAs are capable of forming hydrogen bonds with one another or with water?

Ser, Thr, Tyr, Cys, Gln, Asn

    d) The remaining 9 AAs consist predominantly of C-C and C-H bonds and will exhibit which IMF between like R-groups?

Gly, Ala, Val, Leu, Ile, Pro, Trp, Phe, Met

17. There is one type of covalent bond found in tertiary structures. It is known as a disulfide bridge and occurs between two Cys (cysteine) residues.

18. Proteins generally fold into 3 different overall shapes. What are the 3 particular shapes for folded proteins and what is the general function for each shape type?

Fibrous: long fibers or sheets w/ structural role

Globular: spherical shape w/ roles as enzymes, hormones, antibodies, etc

Membrane: often have central channel for support role in transport across membranes

19. Proteins can be denatured by various treatments.

a) Define protein denaturation:

loss of 4°, 3°, &/or 2° structure

b) List 5 of the most common ways to denature a protein:

heat, pH, agitation, detergents, & some metals

20. As an enzyme is denatured, what is expected in regards to its activity?

as denaturation ↑ enzyme activity ↓

21. If a particular protein is non-enzymatic, but is responsible for binding/recognition of a specific molecule, how might denaturation affect its function?

It may no longer bind/recognize the specific molecule it was created to interact with

22. Enzymes may require cofactors or coenzymes to catalyze reactions.

a) What is the main distinguishing feature between cofactors and coenzymes?

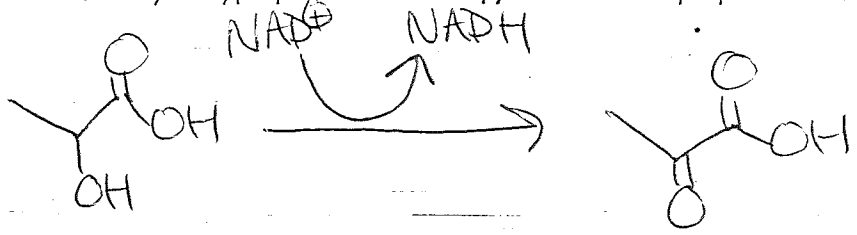
metal ions → ← organic cpds

b) How are cofactors and coenzymes obtained as nutrients?

Through our food
Coenzymes can also be synthesized in the body

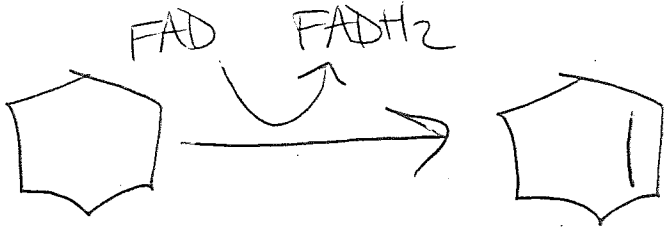
23. There are three coenzymes predominantly involved in electron and hydrogen-atom transfers in catabolism – NAD^+/NADH, NADPH/$NADP^+$, and FAD/$FADH_2$.

a) Add the coenzymes specialized for the oxidation of alcohols into carbonyls using the oxidation of lactic acid (2-hydroxypropanoic acid) into pyruvate (2-oxopropanoic acid).



b) Add the coenzyme specialized for the reduction of carbonyls to alcohols using the reduction of pyruvate into lactic acid.

c) Add the coenzyme specialized for the oxidation of alkanes into alkenes using cyclohexane to cyclohexene.



24. Enzyme activity can be attenuated through the activity of effector molecules. Effectors that decrease the activity of an enzyme are specifically referred to as inhibitors.

a) If an inhibitor binds within the active site of an enzyme, what type of inhibition is expected?

competitive

b) If an inhibitor binds to another site on the enzyme (allosteric site), what type of inhibition is expected?

non-competitive

c) Are the above types of inhibition usually specific for a particular enzyme, or non-specific?

d) Both examples above exhibit reversible inhibition. List 5 types of non-covalent enzyme-inhibitor interactions that allow for their reversibility?

salt bridge, ion-dipole, H-bonding, London, a metal-ion complexes

25. Two examples of non-specific enzymatic inhibition are temperature and pH effects.

a) How might extremely low/high temperatures affect the activity of an enzyme? Explain.

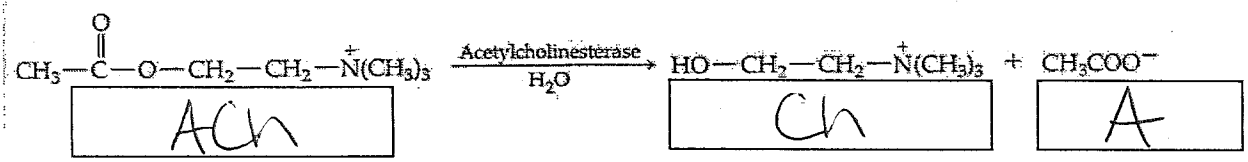
low or high temp can ↓ enzyme activity by causing the enzyme to denature.

b) List 2 ways that changing the pH might decrease the activity of an enzyme:

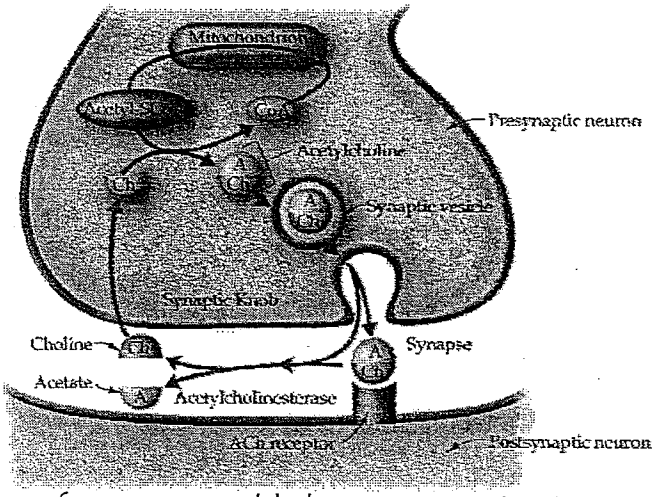
changing the pH can charge the charge on acidic or basic R grps which can disrupt the 4° & 3° structure

26. Acetylcholine is released to help muscles relax. Once it has triggered the next neuron, it is broken down by acetylcholinesterase to maintain muscle control.

a) Use the diagram below to label the reactants and products using ACh = Acetylcholine, Ch = choline, and A = acetate.



ACh | Ch | A



b) What classification of enzyme is acetylcholinesterase – oxidoreductase, isomerase, ligse, lyase, hydrolase, or transferase?

c) Atropine is found in plants call evening nightshades. Tomatoes, potatoes, and eggplants are all members of the evening nightshades. Atropine is used to accelerate a slow heart rate by activating the acetycholine receptors. Do you expect atropine interact at the active site or allosteric site of acetylcholinesterase? Explain.

The active site b/c it interacts w/ the same receptors indicating similar size, shape & polarity.