Question #4:
Proteins have four levels of structure:

**Primary structure**
The linear sequence of amino acids:
Amino-Gly-Asp-Arg-Val-Pro-Val-Gly-Carboxyl

**Secondary structure**
Regularly repeating local structures:
- α-helix
- β-strands, β-sheets and β-turns

**Tertiary structure**
The way that secondary structure elements orient in 3-d space to give rise to a fully-folded chain

**Quaternary structure**
Describes the arrangement of one polypeptide chain with respect to another in proteins that have multiple subunits.

What determines the primary sequence?

**Answer:**
The primary sequence is genetically determined. That is, DNA determines the sequence and more specifically one functional unit of DNA called a gene!

**Comments:**
It is important to note that protein primary structure generally determines higher levels of structure!!

*WHAT EXCEPTION DID WE DISCUSS IN LECTURE?*
Question #5:
The following protein is the *Escherichia coli (E. coli)* L-arabinose-binding protein. Notice that this protein contains both α-helix and β-sheet secondary structures. In the labeled α-helix, where would one be most likely to find the amino acid Glu?

![Image from the rcsb online protein databank](image)

Answer:
Glu (glutamate) is a hydrophilic amino acid and thus would be more likely to be found in region A.

Comments:
α-helices with one hydrophobic face and one polar face are termed **amphipathic**.

Question #6:
Which “kinky” amino acid is termed a helix breaker but is often found in β-turns?

Answer:
Pro
*Notice that Pro is the only amino acid in which the R group attaches to the nitrogen of the amino group.*
II. Carbohydrates

Question #1:
List two functions of carbohydrates
Answer:
1. Energy source
2. Energy storage
3. Components of cell walls and other protective structures
4. Recognition and signaling
5. Components of coenzymes and nucleic acids

Question #2
Fructose, galactose, and glucose are monosaccharides (simple sugars). The open chain form of glucose is drawn below:

\[
\begin{align*}
\text{H} & \text{C} \\
\text{H}^* & \text{C} - \text{OH} \\
\text{HO} & \text{C} - \text{H} \\
\text{H}^* & \text{C} - \text{OH} \\
\text{H}^* & \text{C} - \text{OH} \\
\text{CH}_2\text{OII} & \\
\end{align*}
\]

D-glucose
While this form exists in cells, it is not the predominant form. What other form predominates?
Answer:
The cyclic form

*Make sure you know how to number the carbons! Would you predict that monosaccharides would be soluble in water??
Question #3:
Two monosaccharides can be linked by a **glycosidic bond**. The picture below shows the disaccharide maltose which is composed of 2 glucose subunits.

![Maltose](image)

Lactose, the disaccharide in ____________ is composed of 1 galactose and 1 glucose subunit. Sucrose, or ________________, is made up of 1 glucose and 1 fructose subunit.

- a. fruit, sacchrine
- b. milk, table sugar
- c. candy, splenda
- d. coconut, maltose

**Answer:**

b

*Remember that this is a 1,4 glycosidic linkage because C-1 of the sugar on the left is linked to C-4 of the sugar on the right.*
Question #4:

**Oligosaccharides** are short chains of sugars containing between 2 and 10 subunits. **Polysaccharides** such as the starches and glycogen are long chains of sugars, often with branches.

![Diagram of 1, 6 linkage and 1, 4 linkage][1]

Both cellulose and glycogen are polysaccharides composed of glucose subunits. Some microorganisms can use cellulose as a food source but humans cannot. Why?

**Answer:**
The glucose subunits of cellulose are linked differently than those of glycogen. While humans have the enzyme that breaks the bonds between the glucose subunits of glycogen, we lack the enzyme that breaks the bonds between the glucose subunits of cellulose.

*NOTE - Page 724 in your text book has more info on ruminants! How is it that they can degrade cellulose while we can not?*

*If you are interested in earning some extra credit, check out the discussion on eCompanion.*
III. Nucleic Acids (RNA and DNA)

Question #1:
Nucleotides are the building blocks of nucleic acids. Is the nucleotide shown here a building block for RNA or DNA?

Answer:
This nucleotide contains a 2-deoxyribose sugar and is thus a deoxyribonucleotide. It is therefore a building block for DNA. RNA, in contrast, is built from ribonucleotides that contain ribose sugars.

*Don’t forget that it is the 2’ carbon that makes the difference. In this case, it has no hydroxyl!
Question #2:
Of the nitrogenous bases shown below, which are purines? which is generally only found in DNA? RNA?

Answer:
A and G are purines, T, C and U are pyrimidines.
*trick to remember: All Good Girls are Pure!
Thymine is generally only found in DNA and uracil in RNA.
Question #3:
Nucleotide subunits can be joined via a covalent bond as follows:

What is the name of the linkage that connects these residues?

a. β-O-glycosidic linkage
b. 3’-5’ phosphodiester linkage
c. 3’-5’ phosphoanhydride linkage
d. β-N-dinucleoside linkage

Answer:
b
Question #4:
It was in 1953 that Watson and Crick marched into a pub and announced that they had determined the structure of DNA.

a. Do the two strands of DNA run parallel to one another?
b. What type of bonds hold the two strands of DNA together? What is it called when these bonds are broken?
c. What are the base pairing rules? The bond between which base pair is stronger?
d. Because of the base pairing rules, one strand of DNA can always serve as the template for the synthesis of another. What is the correct complimentary DNA strand to 3’GCTTAATCGCA5’?

Answer:

a. No, the two strands of DNA have opposite directionality, they are antiparallel
b. H-bonds, denaturation or melting

c. G pairs with C and A with T. Three H-bonds hold the GC pair together and only two hold the AT pair together thus the GC bond is stronger.
d. 5’CGAATTAGCGT3’

The following cartoon is a simple way to depict DNA where the sugar-phosphate backbone is implied but only shown as dark lines. The bases are abbreviate by letters and the H-bond are shown by dashed lines. Notice that there are 3 H-bonds between G and C but only 2 between A and T.
See also Fig. 11.6 in your text book! Practice labeling the 5’ and 3’ ends of the portion of the DNA molecule shown above!

Comment:
The above molecule has polarity (directionality)!!
The top (left) is termed the 5’ end and the phosphate the 5’ phosphate. The bottom (left) is the 3’ end (3’ hydroxyl). No matter how long this chain of nucleotides grows, the chain will always have a 5’ end and a 3’ end.
IV. Lipids

Question #1:
List two functions of lipids

Answer:
1. Components of biological membranes
2. Energy storage
3. Thermal insulation and padding
4. Surface protection
5. Cell signaling and recognition

Question #2:
Triacylglycerols, phospholipids, steroids and waxes are all lipids. Triacylglycerols (TAGs) are the storage form of fatty acids. Based on the following structure, speculate as to why these molecules are so efficient at energy storage.

Answer:
The fatty acyl side chains of a TAG are highly reduced and thus have lots of high energy C-C and C-H bonds. They are packed with power!! Also, because TAGs are highly hydrophobic and uncharged, they can be stored in an anhydrous (unsolvated) form in cells - very efficient packing.
FATS ARE LIKE BACKPACKING FOOD - They are high energy and dehydrated so they are light weight (efficient fuel)!

Question #3:
Phospholipids are the most abundant type of lipid in membranes. Based on the following structure, predict the orientation of these molecules within a membrane. Draw a sketch.

Answer:

Which is the inner leaflet? the outer leaflet?