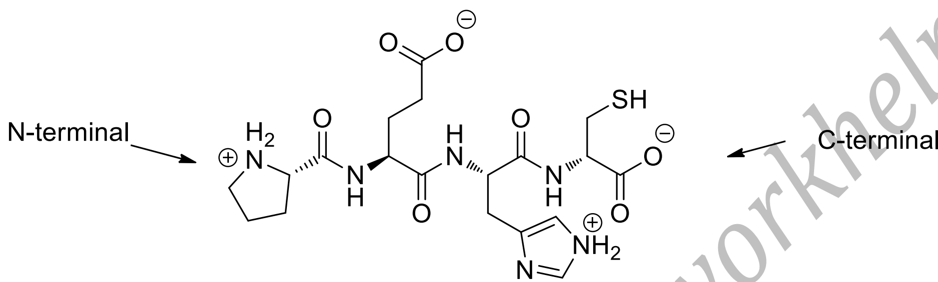
Biochemistry I: Metabolism and Its Regulation
Problem Set

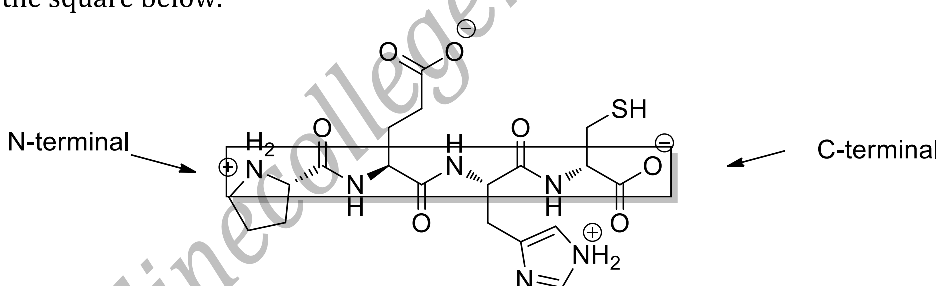
1. Draw the tetra-peptide Pro—Glu—His—Cys. Draw the structure that would exist at physiological pH. For the peptide bond between Glu and His, identify in your drawing all the atoms that are co-planar. The drawing also clearly indicates the C- terminal amino acid and the N-terminal amino acid. Use the format shown for the dipeptide in Fig. 4.14 of your textbook.

Answer:



Pro-Glu-His-Cys
(Proline-Glutamine-Histidine-Cystine)

At physiological pH, the N terminus is charged positively, and the C terminus is charged negatively.
Co-planar atoms are +NH2-CH-CO-NH-CH-CO-NH-CH-CO-NH-CH-CO_2- and are highlighted in the square below.



Pro-Glu-His-Cys
(Proline-Glutamine-Histidine-Cystine)

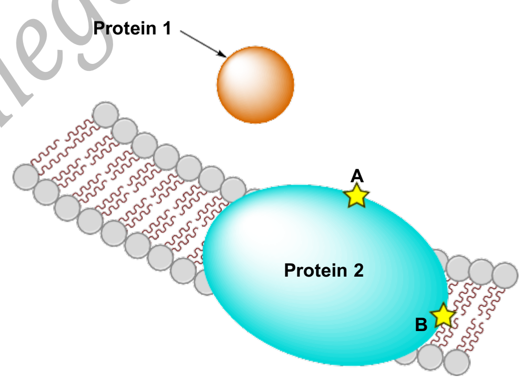
N-terminal (Nitrogen end) –Pro
C-terminal (Carboxylic end)-Cys

2. For each of the following pairs of amino acids, identify the strongest type of intermolecular forces involved when their side chains interact. Use the following list: disulfide bridge, hydrogen bonding, hydrophobic interaction, or salt bridge (ionic bond).
    a. Tyr and Asp
    b. Asn and Arg
    c. Phe and Thr
    d. His and Trp
    e. Glu and Trp

Answer:

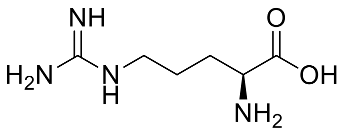
a. Hydrogen bond
b. Hydrogen bond
c. Hydrophobic interaction
d. Hydrogen bond
e. Salt bridge (ionic bond)

3. In the figure below, protein one is located in the cytosol, and protein two is membrane-bound. Give 3 specific examples from Figure 4--3 of amino acids that you might expect to find on the surface of protein 1. For protein 2, give three specific amino acids you would expect to be on the surface near points**A** and **B** (labelled with stars). To clarify, you should choose three amino acids for point **A** and also list three amino acids for point **B**. Rationalize your choices by discussing the amino acids you chose and their properties in a few sentences.

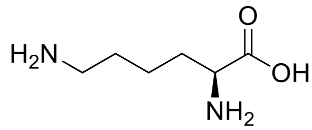


Answer:

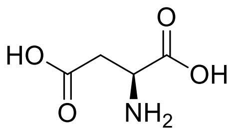
The phospholipid bilayer has a hydrophilic portion outside and inside the membrane, whereas the hydrophobic part remains internal.
Protein1, which is found in the cytosol, is a cytosolic protein. The cytosol is mainly composed of water, so at this point1, it has hydrophilic residues such as basic AA such as Lys (Lysine) and Arg (Arginine); acidic AA such as Asp (Apartic acid) and Glu (Glutamic acid); and polar AA such as Ser (Serin) and Asn (Asparagine).



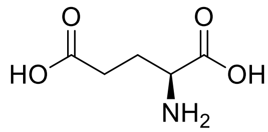
Arginine



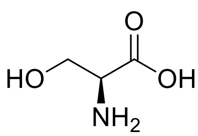
Lysine



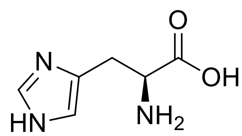
Aspartic acid



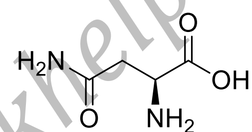
glutamic acid



Serine



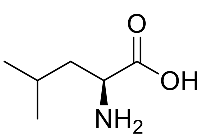
Histidine



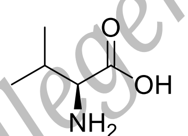
Asparagine

Protein2 is integral and called embedded protein. It contains residues with hydrophobic side chains containing amino acids at site B, which interacts with fatty acyl groups of the membrane phospholipids, thus anchoring the protein to the membrane.

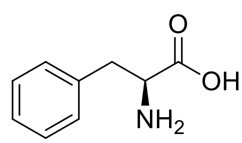
So, at site B, the amino acids (AA) may be hydrophobic, such as Leu (Leucine), Val (Valine), and Phe (Phenylalanine).



Leucine

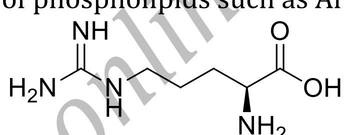


Valine

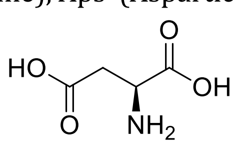


Phenylalanine

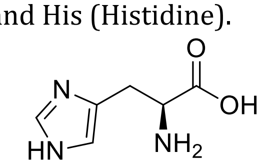
At site A, hydrophilic amino acids (AA) may present, which interact with the hydrophilic part of phospholipids such as Arg (Arginine), Aps (Aspartic acid), and His (Histidine).



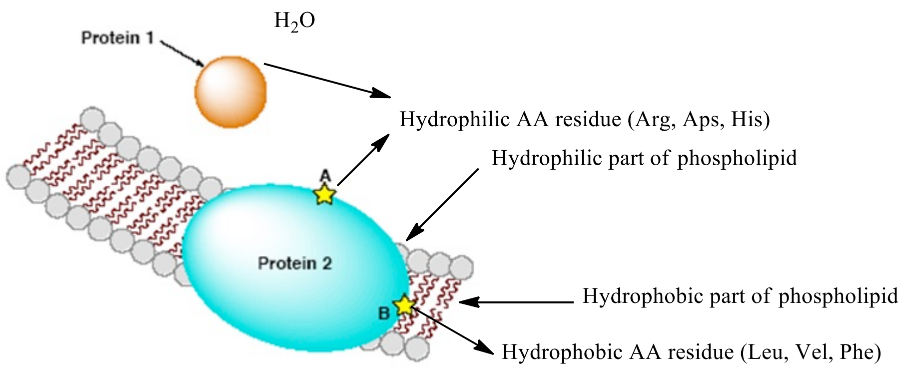
Arginine



Aspartic acid

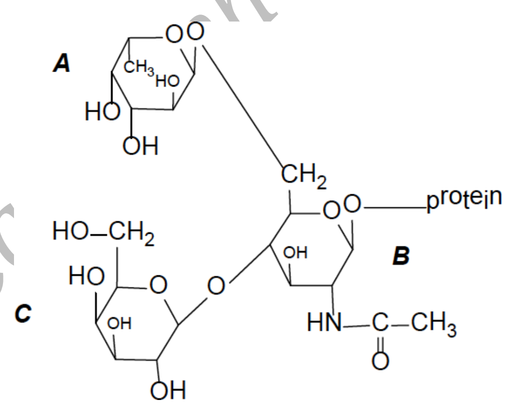


Histidine



4. The oligosaccharide shown below is one of four attached to the protein hormone erythropoietin, which stimulates red blood cell production and is alsoused to treat anemia.

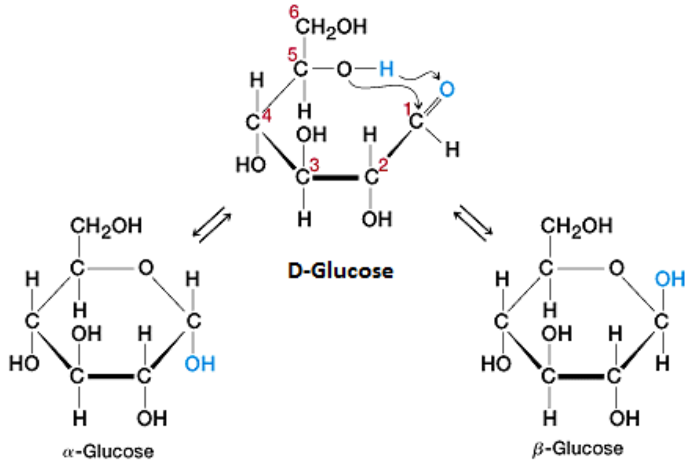
   a. Is ring A a D-- or an L--sugar? How do you know?
   b. Is the ring B a glucose derivative? How do you know?
   c. Describe the linkage between the monosaccharide moieties ring B to ring C.
   d. Redraw the molecule showing each of the six--membered rings in the most stable chair conformation.



Answer:

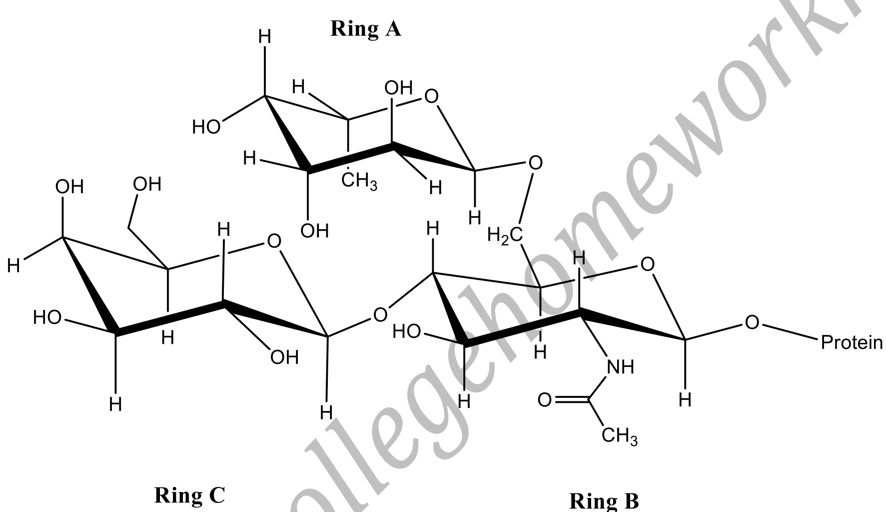
a: Ring A is L-sugar because the substituent is LEFT of the anomeric carbon, and the nonring carbon C6 is "down" relative to C5 hydrogen.

b: Yes, ring B is a glucose derivative because glucose forms the six-membered pyranose ring. The pyranose can have two anomers based on the orientation of hydroxyl above the plane (β anomer) or below the plane (α-anomer). B is in the form of β-glucose with D stereochemistry in the ring. Hence, it is β-D-Glucose derivatives.

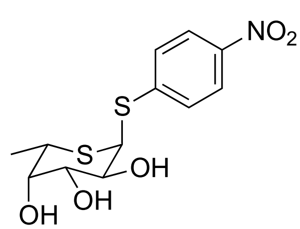


c: Ring B and C have β (1, 4) glycosidic linkage.

d: The most stable chair conformations are given below

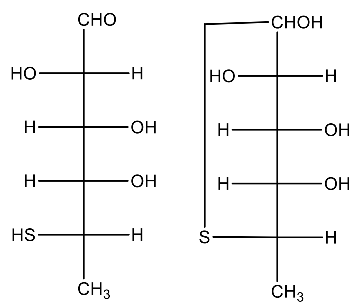


5. The following compound is a thiosugar, a potent inhibitor of fucosidase. Draw the Fischer projection for the free, open-chain form of the sugar alone, i.e. not bonded to the aromatic ring.



Answer:

Fisher projection of thiosugar

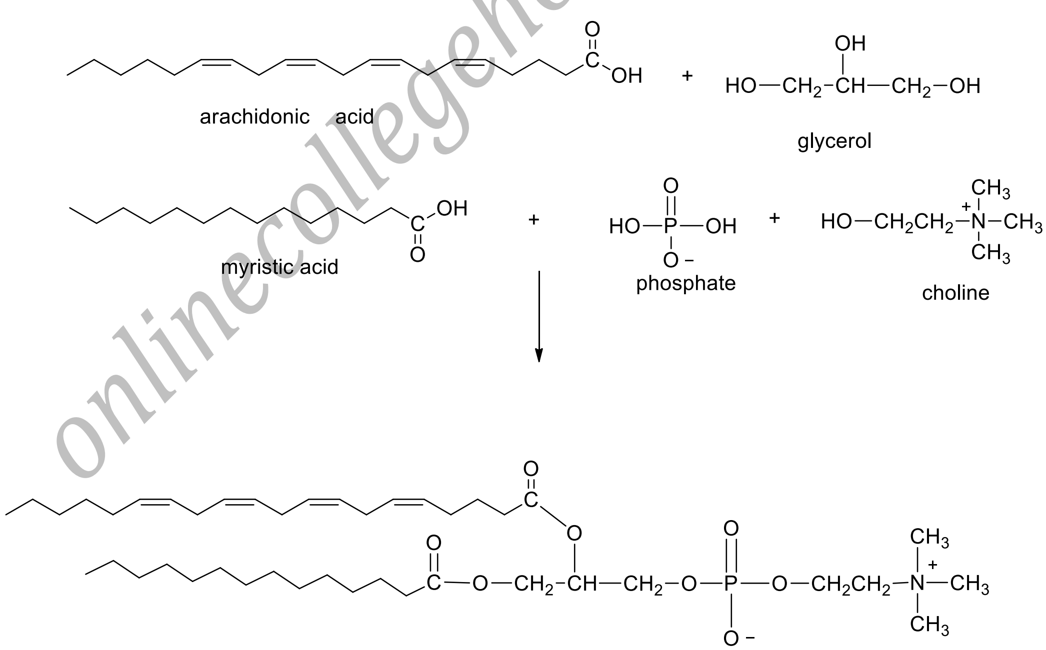


Fisher Projection

6. Draw a phosphoglyceride formed by the reaction of glycerol, 1 molecule of arachidonic acid, 1 molecule of myristic acid, 1 phosphate and 1 molecule of choline. Your drawing should be the form found at physiological pH and should be in the same format as that of phosphatidylcholine in Figure 8.6 of your text (i.e., use a line drawing for the fatty acids). Be careful of the geometry.

Answer:

The line diagram of phosphatidylcholine is depicted below. It is composed of arachidonic acid, glycerol, myristic acid, phosphate, and choline molecules.

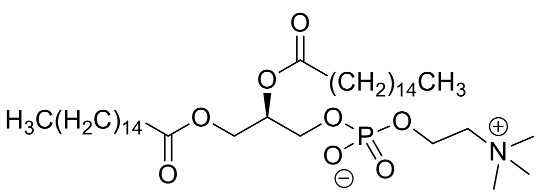


phosphatidylcholine

7. Mayonnaise is made from vegetable oil, lemon juice, and eggs. The oil and the juice would normally separate into two layers, but the lecithin in the egg yolksprevents separation by keeping the mixture emulsified (mixed). The structureof lecithin (phosphotidylcholine) is shown in figure 8.6 of your text.

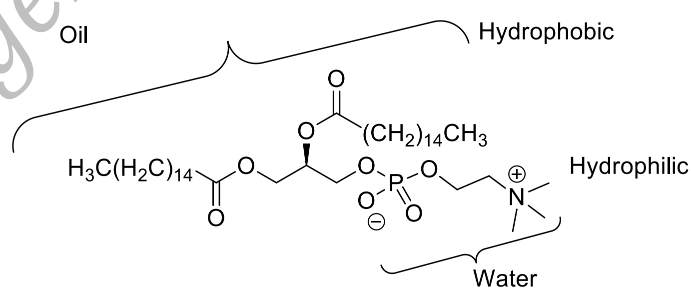
   a. Explain how lecithin can interact with both the oil and the water. Be specific in using the structure of this compound in your answer. (Remember that the juice is mostly water.)

Answer:

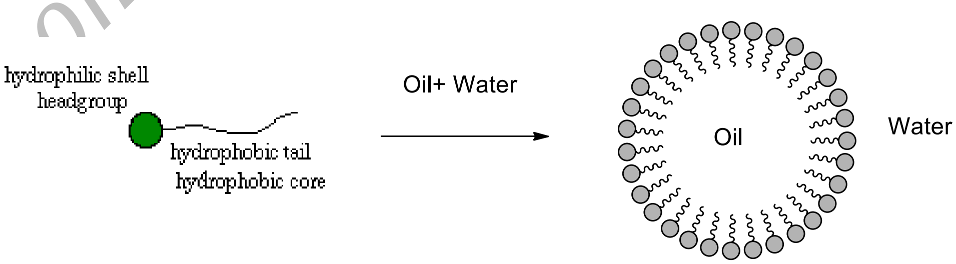


Lecithin

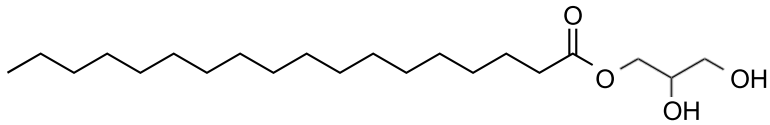
The molecular structure of lecithin makes it an effective emulsifier for the interaction of water and oil. Phospholipids, the major component of lecithin, are partly hydrophilic phosphate and choline (attracted to water) and partly hydrophobic alkyl chain (repelled from water and attracted to oil). Lecithin's ability to simultaneously interact with oil and water makes it such an effective and stable emulsifier. It has a strong hydrophilic nature and is used to prepare o/w emulsion.



Lecithin



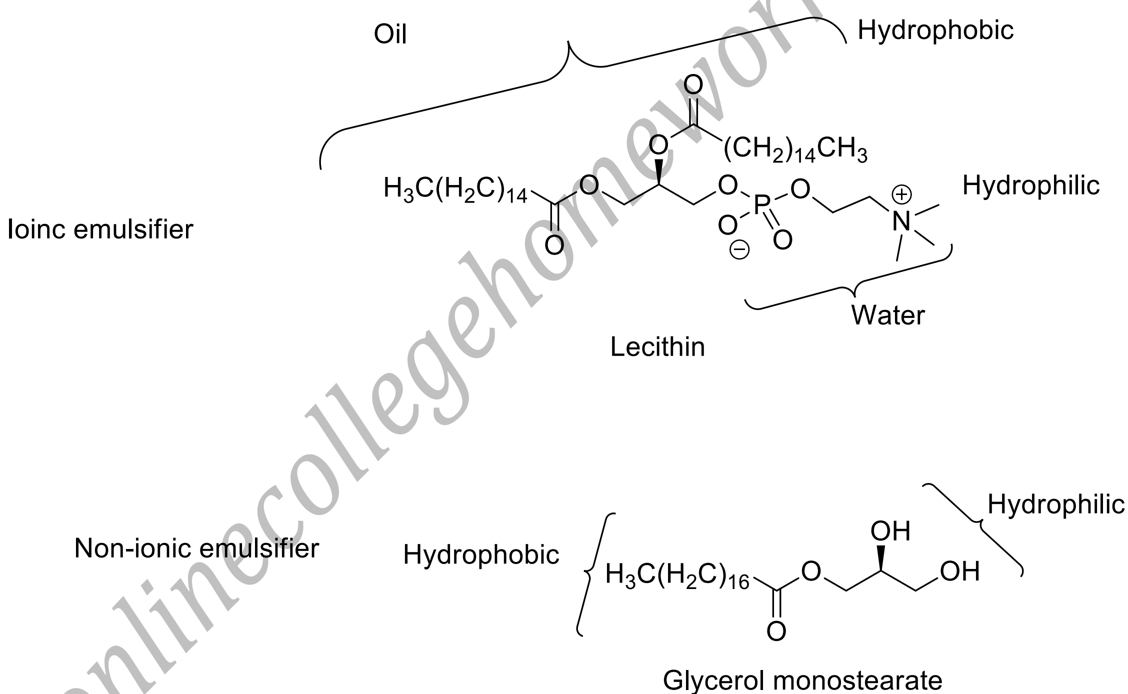
b. Compare this with the emulsifier glycerol monostearate (shown below). Which do you think is a more effective emulsifier? Explain by discussing specific structural features.



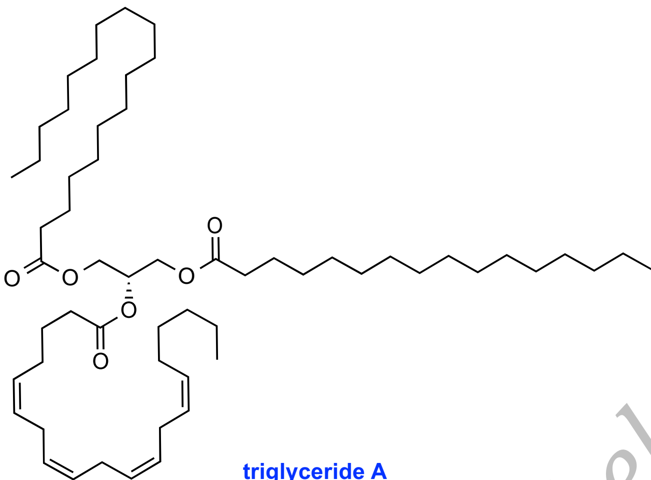
Glycerol monostearate

Answer:

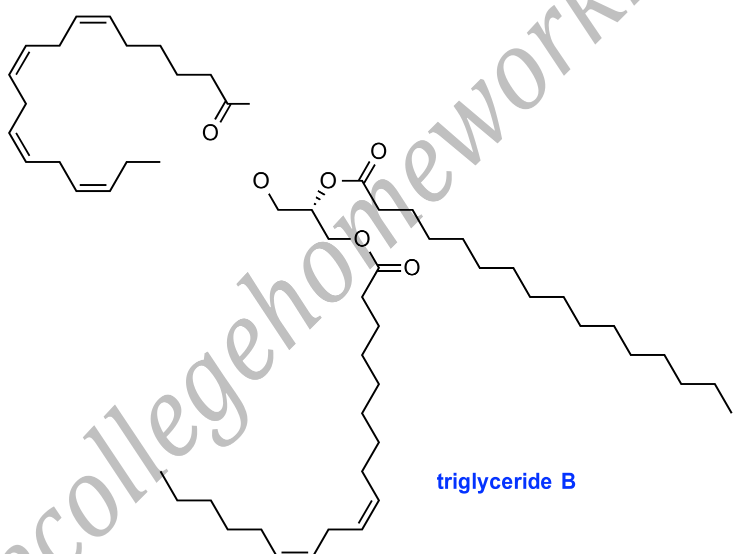
Glyceryl monostearate is less effective than lecithin because it is a nonionic emulsifier with weak emulsifying properties. It serves as an emulsifier to stabilize emulsions through its ability to thicken the emulsion.



8. Which triglyceride is more likely to be isolated from a plant source and which from an animal source? Explain in terms of their structures and substructures.



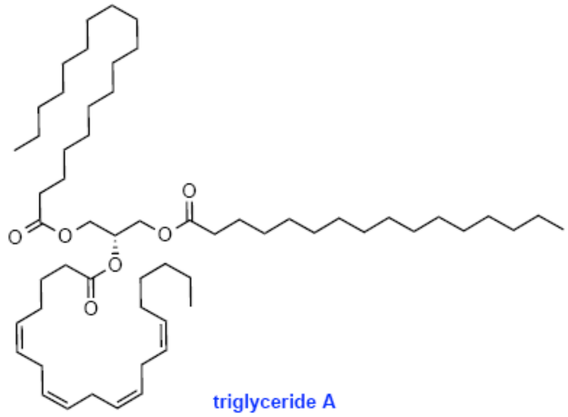
triglyceride A



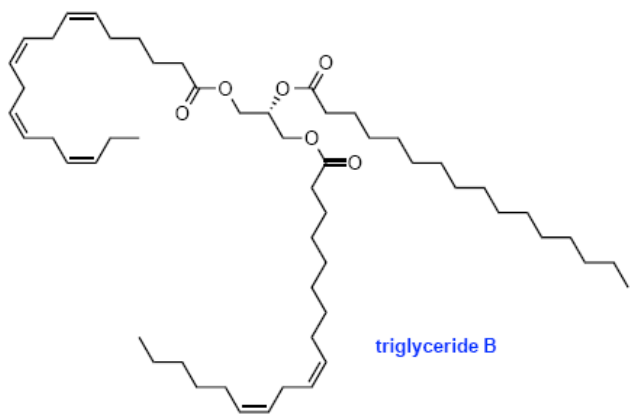
triglyceride B

Answer:

Triglycerides are formed by combining glycerol with three fatty acid molecules. Vegetable oil typically has more unsaturated fatty acids, and animal fats typically have more saturated fatty acids.



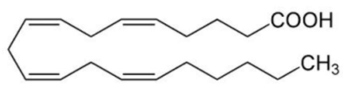
triglyceride A



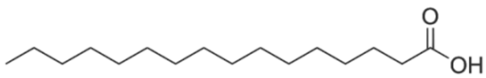
triglyceride B

Triglyceride A: Less unsaturated, it is more likely to be isolated from animals. It has two saturated fatty acids (palmitic acid and stearic acid) and one unsaturated fatty acid (arachidonic acid), which are esterified by glycerol.

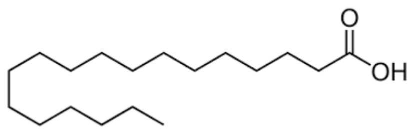
TGA = 1 palmitic acid+ stearic acid+ arachidonic acid + 1 Glycerol



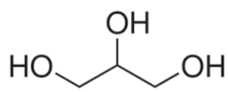
Arachidonic Acid



Palmitic acid



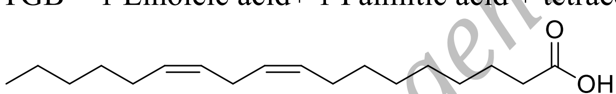
Stearic Acid



Glycerol

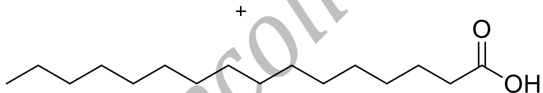
Triglyceride B is more unsaturated, making it more likely to be isolated from the plant. It has two unsaturated fatty acids (one linoleic acid and one tetraecosanoic acid) and one saturated fatty acid (palmitic acid), which are esterified with glycerol.

TGB = 1 Linoleic acid+ 1 Palmitic acid + tetraecosanoic acid+ 1 Glycerol

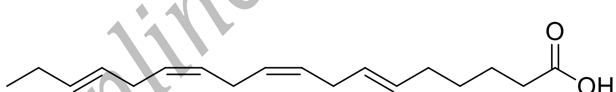


Linoleic acid

+

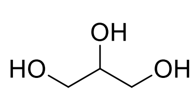


Palmitic acid



(6*E*,9*Z*,12*Z*,15*E*)-octadeca-6,9,12,15-tetraenoic acid

+



Glycerol