Introduction in Fatty Acids

Question 1
Which of the following are major physiologic functions of free fatty acids?

☐ They stabilize the structure of membranes
☐ They serve as precursors of phospholipids and glycolipids
☐ They serve as fuel molecules
☐ They are precursors of triacylglycerols
☐ They are precursors of certain hormones and intracellular messengers

Question 2
These are naturally occurring fatty acids. Give the systematic name, the common name, the abbreviation and the position of the double bond closest to the methyl end of the chain.

A. \( \text{CH}_3(\text{CH}_2)_{14}\text{CO}_2\text{H} \)
   - Systematic name:
   - Common name:
   - Abbreviation:
   - Double bond:

B. \( \text{CH}_3(\text{CH}_2)_{7}\text{CH}=\text{CH}(\text{CH}_2)_{7}\text{CO}_2\text{H} \)
   - Systematic name:
   - Common name:
   - Abbreviation:
   - Double bond:
C. \( \text{CH}_3(\text{CH}_2)_4(\text{CH}=	ext{CHCH}_2)_2(\text{CH}_2)_6\text{CO}_2\text{H} \)

Systematic name:

Common name:

Abbreviation:

Double bond:

D. \( \text{CH}_2\text{CH}_2(\text{CH}=	ext{CHCH}_2)_3(\text{CH}_2)_6\text{CO}_2\text{H} \)

Systematic name:

Common name:

Abbreviation:

Double bond:

**Question 3**

Arrange the fatty acids in the order of increasing melting point.

1.

2.

3.

4.

5.
Question 4

A. Which processes occur during fatty acid degradation and synthesis?

<table>
<thead>
<tr>
<th>Degradation</th>
<th>Synthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. How many carbon atoms are minimally added or removed from a fatty acid during its synthesis or degradation, respectively?

Synthesis: 

Degradation:

Triacylglycerols

Question 5

Triacylglycerols are more efficient than glycogen for the storage of metabolic energy. What two properties of triacylglycerols cause this?

1. 

2.
Using fatty acids as fuel

Question 6
The following questions are about the triacylglycerols stored in adipose tissue.

A. Are they hydrolized to form fatty acids and dihydroxyacetone?

B. Are they hydrolized by a lipase that is activated by a covalent modification?

C. Do they release fatty acids that can be oxidized to \( \text{CO}_2 \) and \( \text{H}_2\text{O} \) to provide energy to the cell?

D. Can they yield a precursor of glucose?

E. By which hormones are they mobilized?

Question 7
The following 7 questions are about the thioester bond.

A. Acyl CoA and acetyl CoA both contain a thioester bond. What drawing depicts a thioester bond?

B. Fatty acids are first activated through the formation of a thioester linkage to coenzyme A. Why is it needed to activate fatty acids?
C. How does the $\Delta G^\circ$ value for the hydrolysis of acetyl coenzyme A compare with that for the hydrolysis of ATP?

$\Delta G^\circ$ ATP $\rightarrow$ ADP hydrolysis = kJ/mol

$\Delta G^\circ$ acetyl CoA hydrolysis = kJ/mol

D. The $\Delta G^\circ$ for the hydrolysis of ATP to ADP and acyl CoA do not differ much. What is the significance of the relatively large and negative $\Delta G^\circ$ value with respect to fatty acid metabolism?

E. Acyl CoA is formed from a fatty acid. What are the steps by which the synthesis takes place?

F. Which enzyme catalyzes both reactions?

G. How is pyrophosphatase involved in the activation of fatty acids for $\beta$ oxidation?
Question 8
This is an (incomplete) list of reactions and compartments relevant to the β oxidation of fatty acids.
Put the reactions and compartments in the proper order.

1.
2.
3.
4.
5.
6.
7.
8.

Question 9
Carnitine in the β oxidation of fatty acids acts as a transmembrane carrier.

A. What is translocated over the membrane by carnitine?

B. Over which membrane, and in what direction of the mitochondrion is it translocated?

Question 10
The fatty acids below in the mitochondrion are completely oxidized and respired. Calculate the approximate yield in ATP molecules.

<table>
<thead>
<tr>
<th>Fatty Acid</th>
<th>ATP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testradecanoic acid (C14:0)</td>
<td>ATP</td>
</tr>
<tr>
<td>Hexadecanoic acid (C16:0)</td>
<td>ATP</td>
</tr>
<tr>
<td>Octadecanoic acid (C18:0)</td>
<td>ATP</td>
</tr>
<tr>
<td>Icosanoic acid (C20:0)</td>
<td>ATP</td>
</tr>
</tbody>
</table>
Question 11
Depending on what you eat, levels of acetyl CoA, ketone bodies and oxaloacetate can be low or high.

A. Which levels rise when you eat a meal rich in carbohydrates?
   - Ketone bodies
   - Oxaloacetate
   - Acetyl CoA

B. Which levels rise when you eat a meal only rich in fats and have exhausted your glycogen storage?
   - Ketone bodies
   - Oxaloacetate
   - Acetyl CoA

Question 12
In diabetes oxaloacetate levels are low, and acetyl CoA is diverted to form ketone bodies. Examples of these bodies are acetoacetate and 3-hydroxybutyrate.

A. Which of these are normal fuels for heart muscle and renal cortex?
   - Acetoacetate
   - 3-hydroxybutyrate

B. Which of these are synthesized in the liver?
   - Acetoacetate
   - 3-hydroxybutyrate

C. What are the differences between these two molecules?
D. Which of these can give rise to acetone?

- Acetoacetate
- 3-hydroxybutyrate

E. How many carbon atoms do they contain?

<table>
<thead>
<tr>
<th>Compound</th>
<th>Carbon Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetoacetate</td>
<td>3</td>
</tr>
<tr>
<td>3-hydroxybutyrate</td>
<td>3</td>
</tr>
</tbody>
</table>

F. How many acetyl CoA molecules do they require for their synthesis?

<table>
<thead>
<tr>
<th>Compound</th>
<th>Acetyl CoA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetoacetate</td>
<td></td>
</tr>
<tr>
<td>3-hydroxybutyrate</td>
<td></td>
</tr>
</tbody>
</table>

G. Which of these can be regarded as water-soluble, transportable forms of citrate in the blood?

- Acetoacetate
- 3-hydroxybutyrate

Question 13
Methylmalonyl CoA mutase catalyses a very unusual process.

A. What process does it catalyze?

B. What special molecule does it contain?
Synthesis and degradation

Question 14
The oxidation and synthesis have partly different characteristics and reactants. Put the reactant or characteristic in the column with the appropriate pathway.

<table>
<thead>
<tr>
<th>Oxidation</th>
<th>Synthesis</th>
</tr>
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<tbody>
<tr>
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</table>

Question 15
In the synthesis of fatty acids bicarbonate is required. What is the role of this bicarbonate?

Question 16
Citrate plays an important part in the synthesis of fatty acids. One of the roles is to transport necessary molecules over the membrane of the mitochondrion.

A. What does it carry, and which way?

B. There is also a second role. What other role does it have?
**Question 17**
The fatty acid synthase of mammals is a dimer consisting of identical subunits. Each of these contains all the activities necessary to synthesize fatty acids from malonyl CoA and acetyl CoA.

Why is a single subunit unable to carry out the reactions?

**Question 18**
The fatty acid synthase of mammals is a dimer of two long multifunctional polypeptide chains.

Write below the four possible advantages of polypeptide chains with more than one active site.

1. 
2. 
3. 
4. 

**Question 19**
What is the major product of the fatty acid synthetase complex in mammals?

**Question 20**
For the synthesis of a fatty acid ATP and NADPH is required. Calculate what is required for the synthesis of the fatty acids below from acetyl CoA.

- Aprylic acid (C8:0): ATP, NADPH
- Capric acid (C10:0): ATP, NADPH
- Lauric acid (C12:0): ATP, NADPH
- Myristic acid (C14:0): ATP, NADPH
- Palmitic acid (C16:0): ATP, NADPH
Elongation and Unsaturation

Question 21
By regulating acetyl CoA carboxylase the fatty acid synthesis is regulated, for it is the first (irreversible) step.

When is acetyl CoA carboxylase activated?

- When phosphorylated by a cAMP-dependent protein kinase
- When phosphorylated in the presence of citrate
- When dephosphorylated by protein phosphatase 2A
- When a high-energy charge occurs in the cell

Question 22
Endoplasmic reticulum systems introduce double bonds into long-chain acyl CoAs by a complex of three membrane-bound proteins.

A. Where can these double bonds be introduced?

- When phosphorylated by a cAMP-dependent protein kinase
- When phosphorylated in the presence of citrate
- When dephosphorylated by protein phosphatase 2A
- When a high-energy charge occurs in the cell

B. One of these membrane-bound proteins is desaturase.

Does desaturase use an isozyme of the FAD-dependent dehydrogenase also used by the beta oxidation cycle to form double bonds?

C. Where can these double bonds be introduced?

- linoleate to arachidonate
- palmitate to palmitoleate
- oleate to linoleate
- stearate to oleate
**Question 23**
Eicosanoid hormones are derived from polyunsaturated fatty acids.

A. What are the four major classes of eicosanoid hormones?

1. 
2. 
3. 
4. 

B. What is the major precursor for these hormones?

C. What is the systemic potency of these hormones?

- It stimulates the synthesis of leukotrienes
- It inhibits the synthesis of prostaglandins
- It inhibits the synthesis of leukotrienes
- It blocks the active site of prostacyclin synthase

**Question 24**
Aspirin is a potent anti-inflammatory agent. Why is that?