

Fatty Acid and Triacylglycerol Metabolism

This is the first part of lipid metabolism It includes 5 lectures

Mobilization of stored fats

Lippincott's Chapter 16

This is a good reading source for today's lecture

Our first lecture describes how the fat stored in adipose tissue is converted to fatty acids and transported to tissues

What is the first lecture about

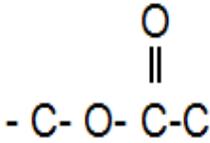
- What is triacylglycerol
- Fatty acids structure
- The most common fatty acids
- TAG as the major energy source and reserve
- Mobilization of TAG in response to hormonal signal

181-182

189-192

193-197

**G
L
Y
C
E
R
O
L**



FATTY ACID

This represents the structure of triacyl glycerol

Glycerol is joined to each fatty acids by an ester bond

FATTY ACID

Glycerol is a three carbon compound with three hydroxyl groups

FATTY ACID

(Same or different FA) As the name implies it is formed from glycerol (alcohol) joined to three fatty acids(FA)

TRIACYLGLYCEROL



The carbon atoms can be numbered starting with carboxyl carbon (red) as number 1

Fatty acid

The carbon atoms can be designated by Greek letters with α (alpha) given to the first carbon in the chain (green) after carboxyl carbon i.e. carbon number 2

The pK_a of carboxyl group in fatty acids ≈ 4.8

So, at physiological pH fatty acid exists as anion

ω

ω (omega) carbon is the last carbon regardless of its number

β

α



Unprotonated carboxyl group, so it is negatively charged

Or



This is the structure of a fatty acids
It is a long hydrocarbon chain with a carboxyl group

Another simple way to show the structure of fatty acid

What is the number of β (beta) carbon in the previous fatty acid?



Answer
It is carbon 3

What is the number of γ (gamma) carbon?

Answer
It is carbon 4

If you didn't get the write answer then go back to the previous slide

The hydrocarbon chain can be saturated or it may contain one or more double bonds

Now count the location of the first double bond from the ω end

This fatty acid contains 2 double bonds in its hydrocarbon chain



Unsaturated Fatty Acid

How many carbon atoms are in the above acid, what are the number of carbon atoms that have the double bonds

Answer 18 carbons, the carbon atoms that share double bond are 9 and 12.

Notice we don't say 9,10,12 and 13. we just mention the smaller number of each pair of carbon atoms

$18:2\Delta^{9,12}$ or $18:(9,12)$

It is Linoleic Acid

so it is $\omega 6$

So we can write its structure in the following format

Fatty acids contain 1 double bond are known as monounsaturated fatty acids

Fatty acids contain 2 or more double bonds are known as polyunsaturated fatty acids

Some Carboxylic acids of physiological importance

You should know the structure of the acids indicated by the arrows

From the acids indicated by the arrows:

-Name three saturated fatty acids

-Name two monounsaturated fatty acids

-Name three polyunsaturated fatty acids

Pay attention to the difference in the names of those two acids

COMMON NAME	STRUCTURE
Formic acid	1
Acetic acid	2:0
Propionic acid	3:0
Butyric acid	4:0
Capric acid	10:0
Palmitic acid	16:0
Palmitoleic acid	16:1(9)
Stearic acid	18:0
Oleic acid	18:1(9)
Linoleic acid	18:2(9,12)
Linolenic acid	18:3(9,12,15)
Arachidonic acid	20:4(5, 8,11,14)
Lignoceric acid	24:0
Nervonic acid	24:1(15)

The common name for Triacylglycerol (TAG) is FAT or Oil (in Plants)

- Fat is the major energy reserve in the body
It is stored in adipose tissue
- Adipocyte is the cell of the adipose tissue
85-90% of the adipocyte volume is Fat (TAG)
- It is more efficient to store energy in the form of TAG

Why FAT not Carbohydrates?

* First: it is **more reduced** (contains less oxygen):

Complete oxidation: one gram of fat → 9 kcal

compare with energy produced by oxidation of carbohydrates

complete oxidation: 1 gram of carbohydrates → 4 kcal

* Second: it is **Hydrophobic**:

-(can be stored without H₂O)

carbohydrates are **hydrophilic**

(1 gram carbohydrates binds 2 grams H₂O)

Why FAT not Carbohydrates? (Continued)

Average adult has 10 Kg of Fat

How many calories?

90,000 kcal ($10 \times 1000 \times 9$)

Answer! Use your calculator if you want,

What is the mass of **carbohydrates** that produces 90,000 kcal ?

$90,000 / 4 = 22,500$ grams

22.5 Kg of carbohydrates will produce the same energy produced by 10 kg of fat

How much water with it?

$22.5 \times 2 = 45$ Kg H₂O

FATTY ACID as FUELS

- Fatty Acids are the major fuel used by tissues

Fuel type

FA

Glucose

Amount used
/12 hours gram

60 gram = (540 Kcal)

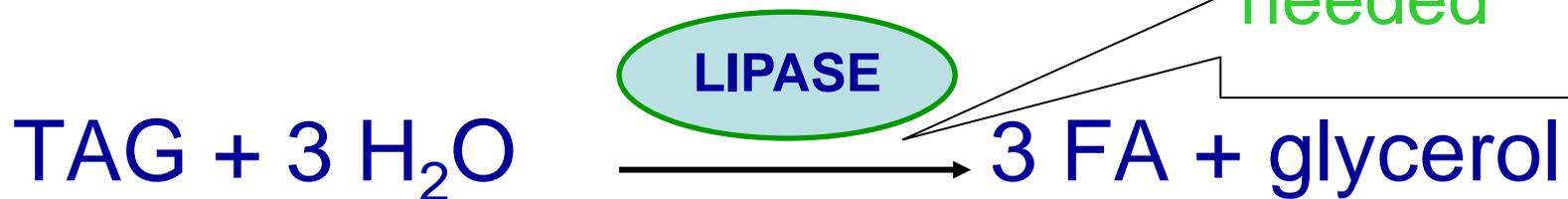
70 gram = (280 Kcal)

But glucose is the major Fuel in extracellular fluids. So fat is continuously used and replaced (turnover)

Mobilization of stored fats

The need for hormonal signal

- Fat is stored in Adipose tissue,
to be used as source of energy by other tissues
- When needed a hormonal signal must reach the adipocytes.
- → Hydrolysis of TAG



Enzyme is needed

LIPASE

:Hormone Sensitive Lipase

Hormones that activate the Hormone Sensitive Lipase

- Glucagon
- Epinephrine
- Norepinephrine
- ACTH

What is the significance of activation by glucagon?

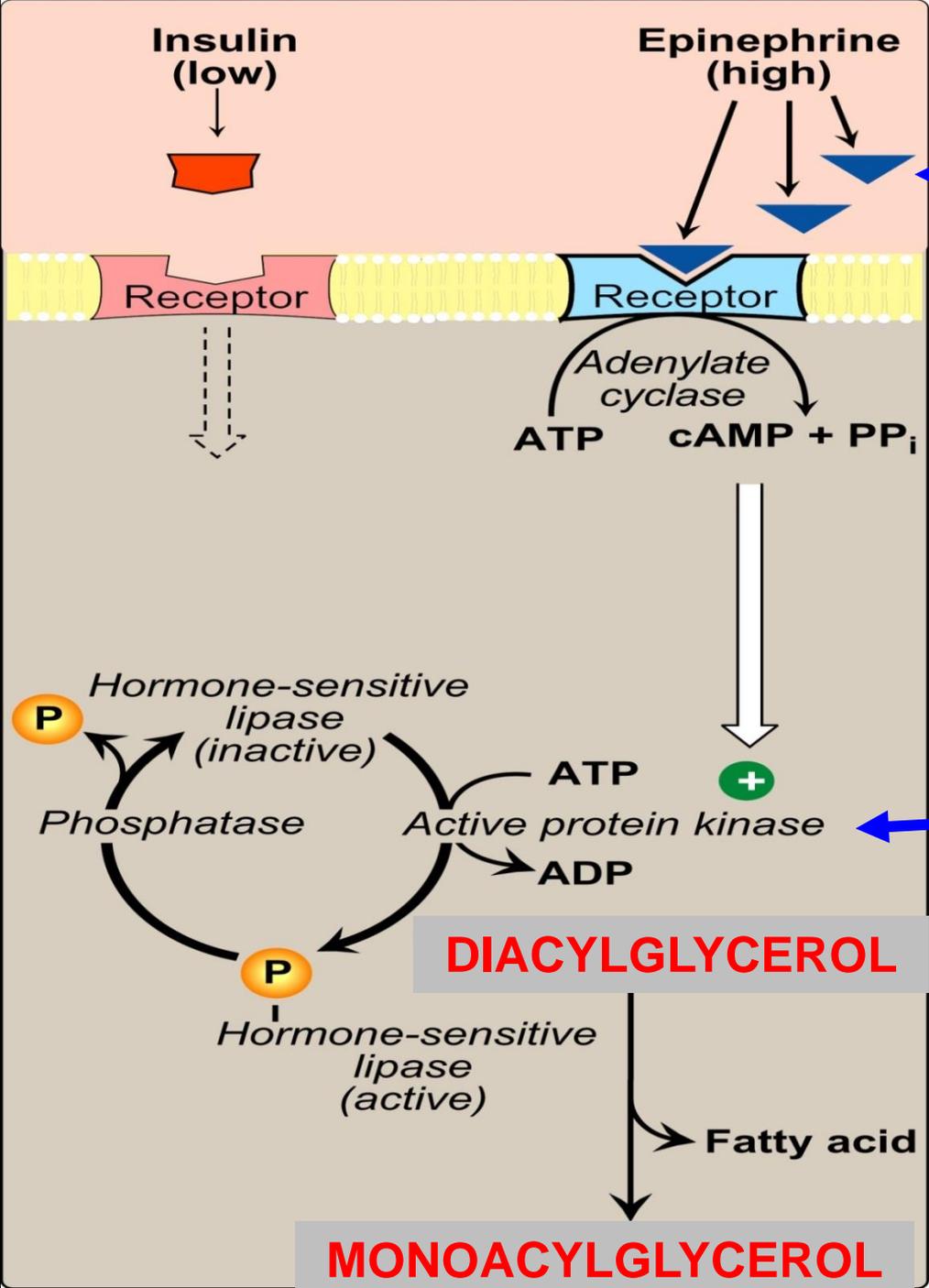
Answer: Glucagon is secreted when glucose is decreased, which means fat is needed

These hormones are secreted in stress states,, which means high energy demand, ie. fat is needed

What is the significance of activation by Epinephrine and Norepinephrine?

What is ACTH?

Answer: It is a hormone that stimulates the adrenal cortex gland.



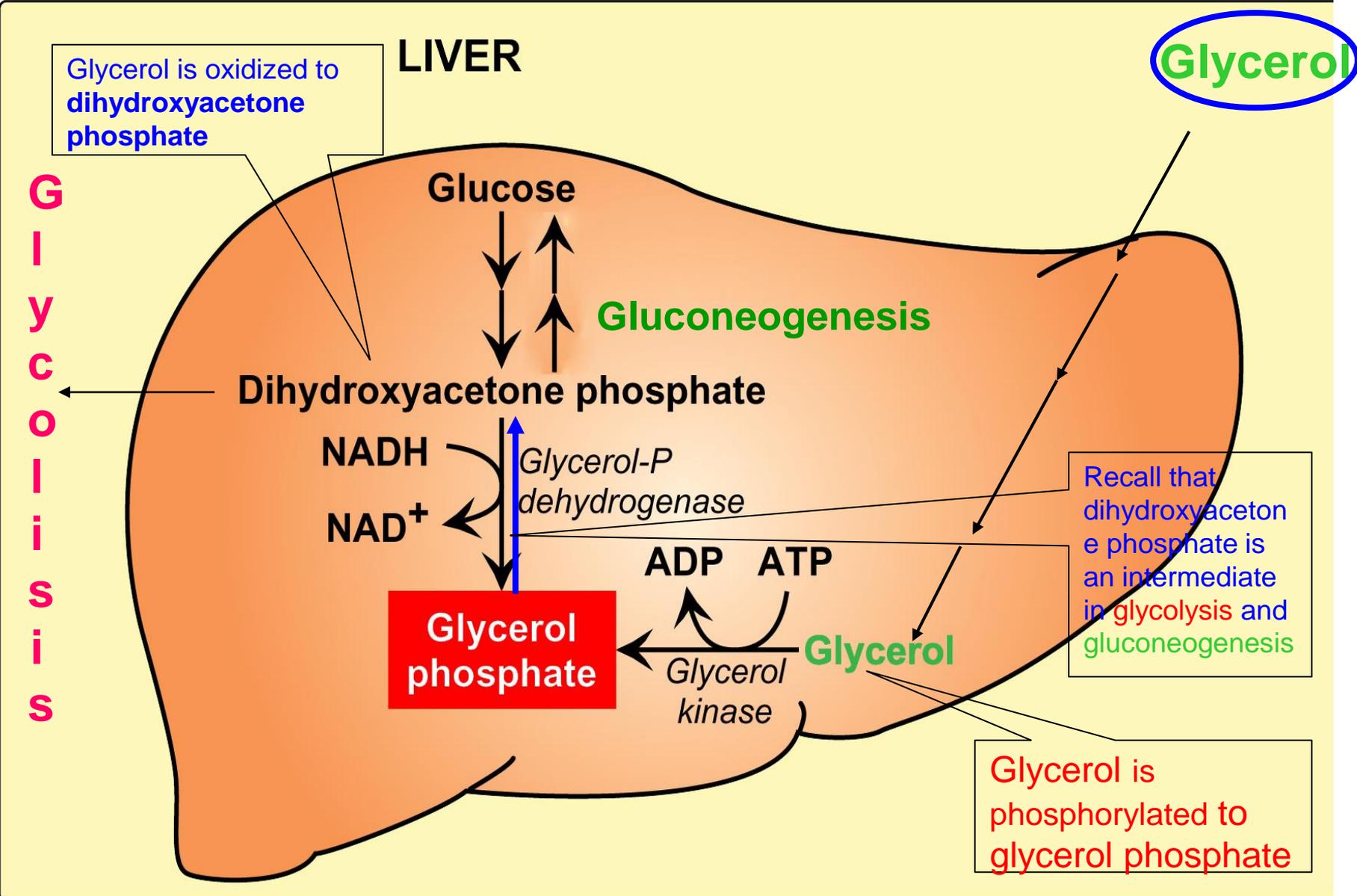
Mechanism of activation of hormone sensitive lipase by epinephrine or glucagon

When the hormone is increased in the blood, it binds to specific receptor on plasma membrane.

Hormone binding to its specific receptor → activation of adenylate cyclase → ↑↑ cAMP

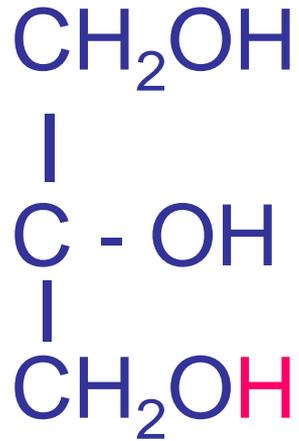
cAMP activates protein kinase A that adds phosphate group to hormone-sensitive lipase → Activation

Glycerol is produced from hydrolysis of TAG is released into the plasma then reaches the liver.

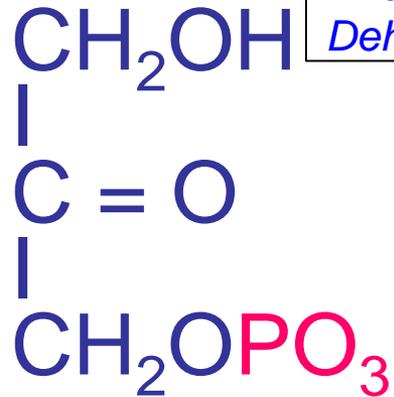


- Dihydroxyacetone phosphate is used in the liver in gluconeogenesis rather than in glycolysis!
- Why?

Conversion of Glycerol to Dihydroxyacetone Phosphate



Glycerol



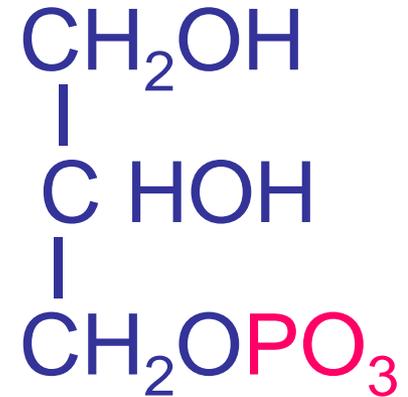
Dihydroxyacetone Phosphate

ATP is the donor of phosphate group
What is the name of the enzyme?
Answer: Glycerol kinase

What is the name of the enzyme?
Answer: Glycerol Phosphat Dehydrogenase

NADH

NAD⁺



Glycerol 3 Phosphate