

Aerobic And Anaerobic Metabolism

قد يكون السطر الذي حرم
عينك النوم ليلة شفاء لداء
أرق العليل ليالٍ أطول ..
خلقت بلسماً فلا تشتكي

- Color Index:

- **Important.**
- Extra Information.
- **Doctors slides.**

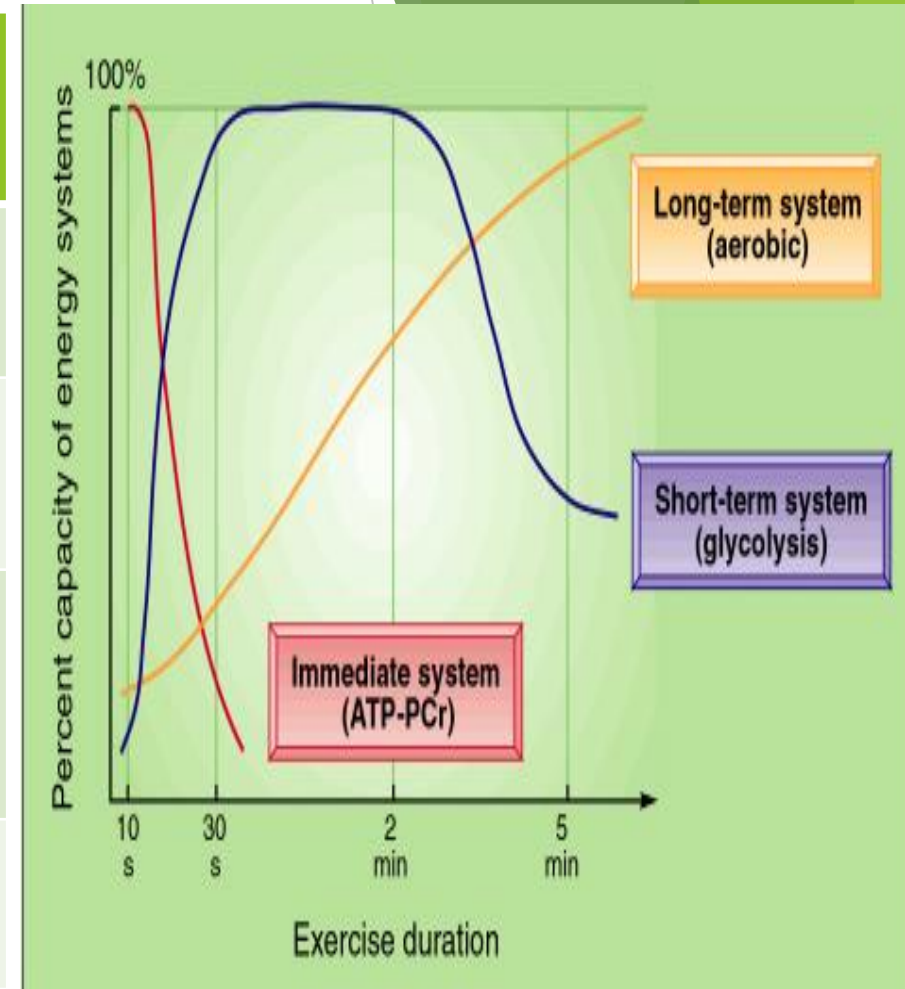


Objectives:

- ▶ **By the end of this lecture, the should be able to:**
- ▶ Recognize the importance of ATP as energy source in skeletal muscle
- ▶ Compare three systems of energy transfer in the body
- ▶ Differentiate between energy metabolism in red and white muscle fibers
- ▶ Understand how skeletal muscles derive ATP from aerobic and anaerobic metabolism
- ▶ Discuss the importance of Cori and glucose-alanine cycles in energy metabolism

Three systems of energy transfer

Type of system:	Immediate system (ATP-PCr)	Short term system (glycolysis)	Long term system (aerobic)
Type of metabolism:	Anaerobic	Anaerobic	Aerobic
Type of energy source:	Phosphocreatine (PCr)	Glucose	Fatty acid
type of exercise:	High intensity exercise	High intensity exercise (it happens when the muscle is contracting)	Continuous exercise (less intensity)
Duration:	3-15 sec	15 sec. to 2 min.	hours

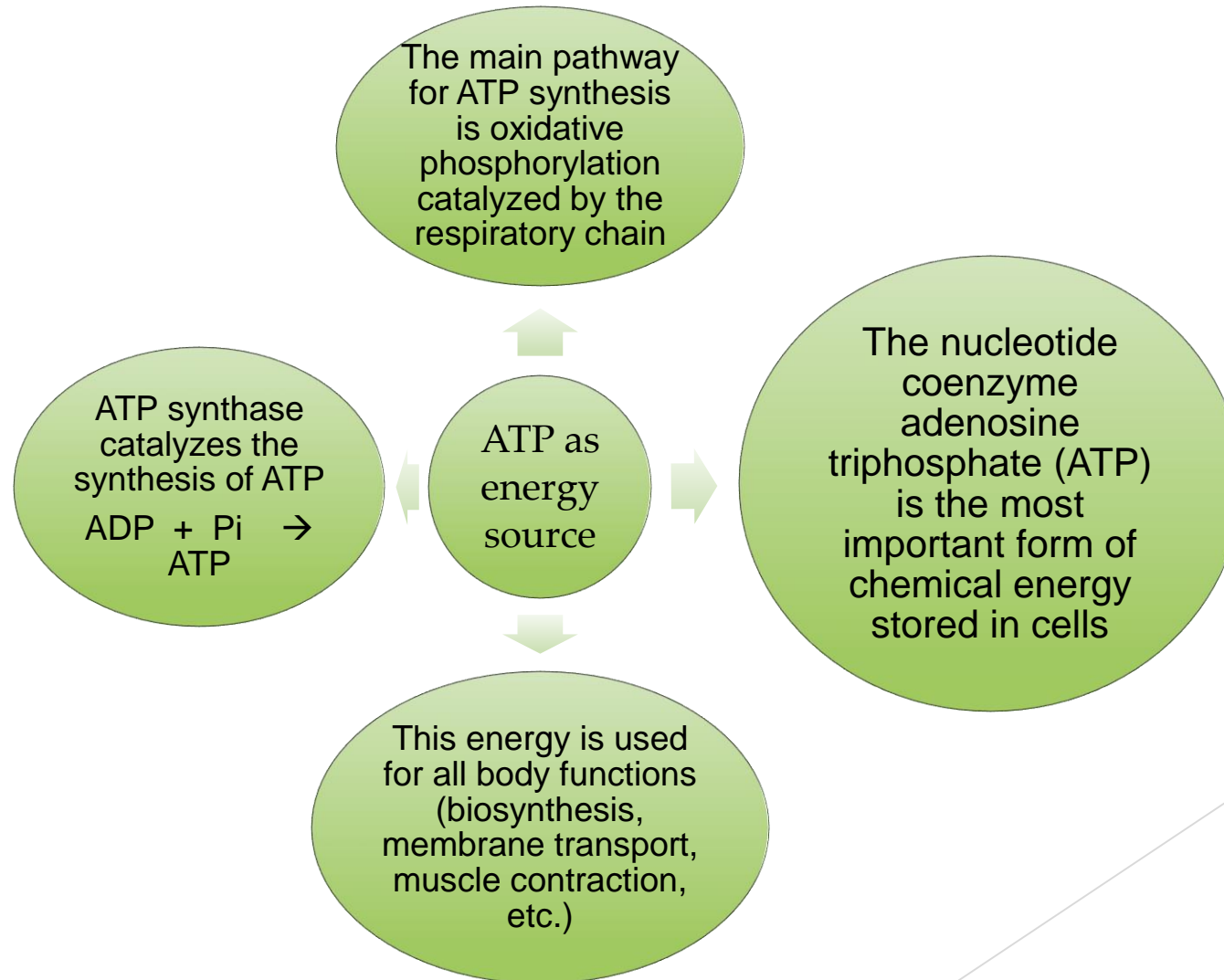


The three systems are overlapping

يعني في الخلية الطاقة دائماً متوفرة من خلال ان هذه الانظمة تنتج الطاقة بشكل مستمر

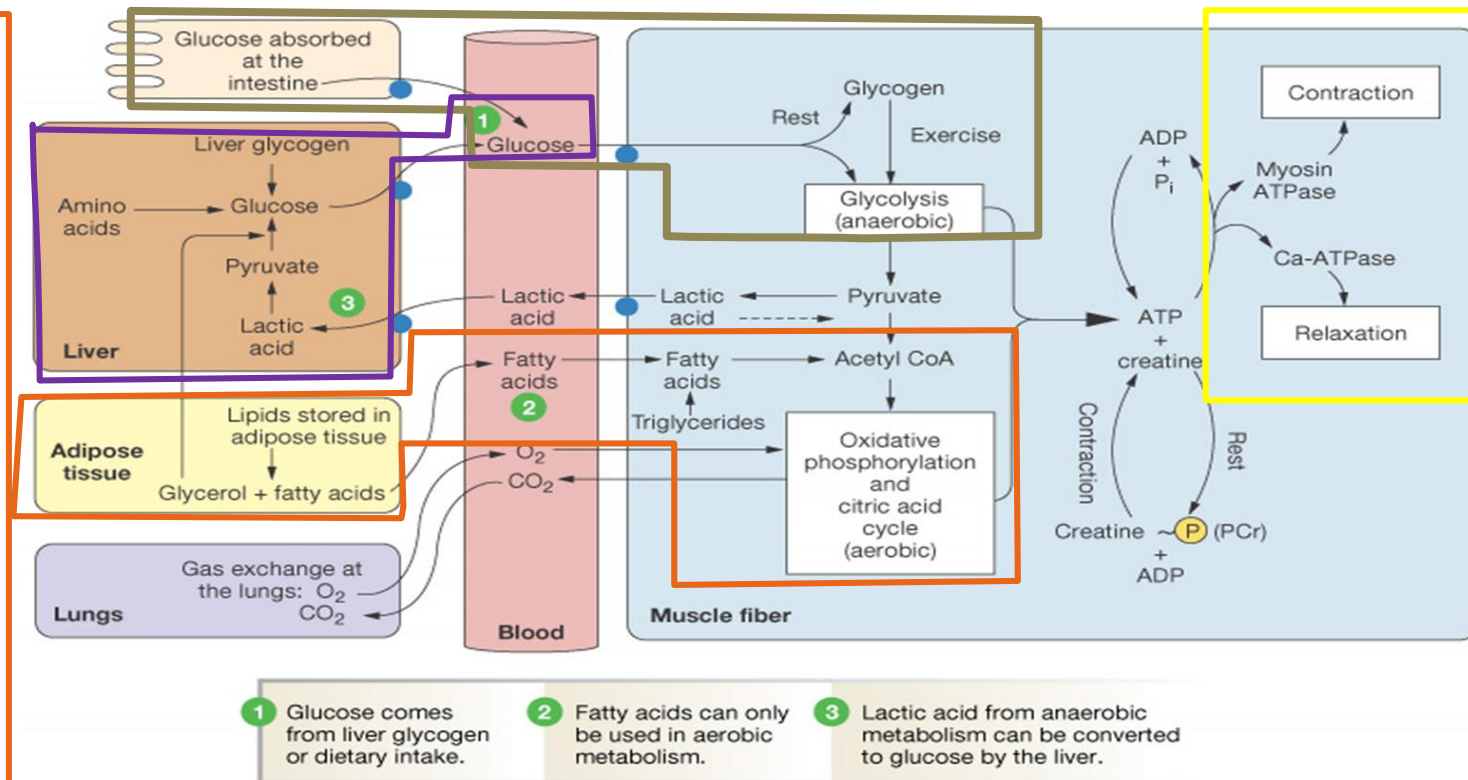
ATP as energy source

Breakdown of ATP into ADP+PO₄ releases energy



Overview of energy metabolism

adipose tissue will give fatty acid > goes to blood stream > goes to muscle fibers > get converted into Acetyl CoA > undergoes oxidative phosphorylation + O₂ produced from the lung (aerobic pathway) to give ATP



The produced ATP will be used for contraction and relaxation.
 -myosin ATPase (for contraction)
 -Ca-ATPase (for relaxation)

When we eat, glucose is absorbed in the intestine > goes to blood stream > goes to muscle.
 *Inside to muscle fibers:
 -During rest its stored as glycogen.
 -During exercising it undergoes glycolysis (anaerobic pathway) to give ATP

Liver will give glucose from its stored glycogen or amino acid or by undergo gluconeogenesis using fatty acid.
 -glucose then will go to blood stream then to the muscle fibers .

- Gas exchange happens at the lungs- when exercising, breathing increases for more O₂ supplying.

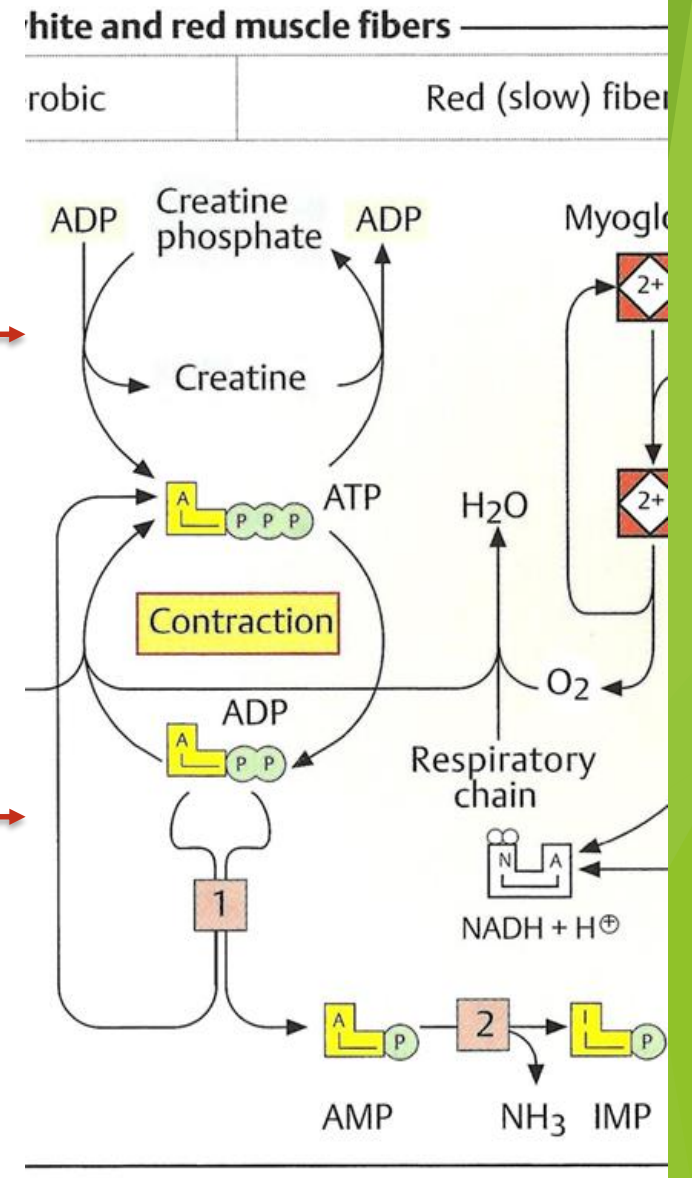
There are 4 ways for muscle fibers to get ATP :

- 1- aerobic by red fibers
- 2- anaerobic by white fibers
- 3- creatine phosphate
- 4- by the enzyme adenylate cyclase;
(will take two ADP and produce 1 ATP & 1AMP)

What do we need the ATP for?
Its used in both contraction and relaxation of the muscle

العضلة في حالة الراحة راح تخزن اي تي بي على صورة كرياتين فوسفيت و جلايكوجين بمجرد ما يصير في حركة تبدأ تستهلك اي تي بي المخزن فيها

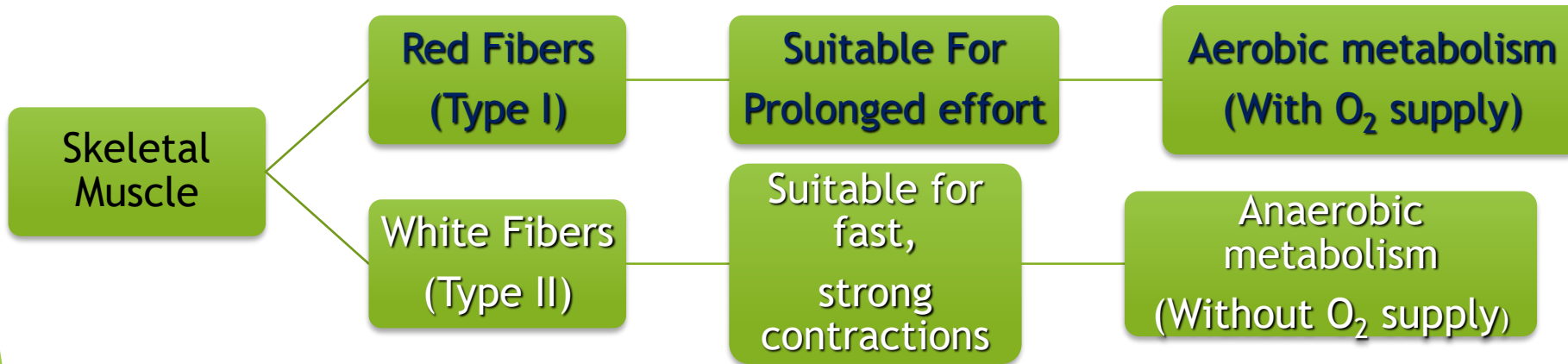
It will be explained in the next slides.



Energy metabolism in muscle

- Muscle contraction requires high level of ATP consumption
- Without constant re synthesis, the amount of ATP is used up in less than 1 sec. of contraction

The muscles can not store energy for more than 1-2 sec. So, they need constant re synthesis.



- Prolonged effort\ running for long time
- Fast, strong contractions\ weight lifting

RED MUSCLE FIBERS (Aerobic metabolism)

- ▶ Red muscle fibers are suitable for prolonged muscle activity

الرياضيون يمتلكون هذا النوع من العضل بسبب الممارسة المستمرة للرياضة

- ▶ Their metabolism is mainly Aerobic and “Depends on adequate supply of O₂”
- ▶ They obtain ATP mainly from **fatty acids**

عشان كذا لما الشخص يبني ينحف يسوي تمارين هوائية لانها تستخدم الدهون:

- ▶ Fatty acids are broken down by beta-oxidation which will produce Acetyl CoA (A process in which the fatty acids are degraded and energy is Produced), Krebs cycle, and the respiratory chain.

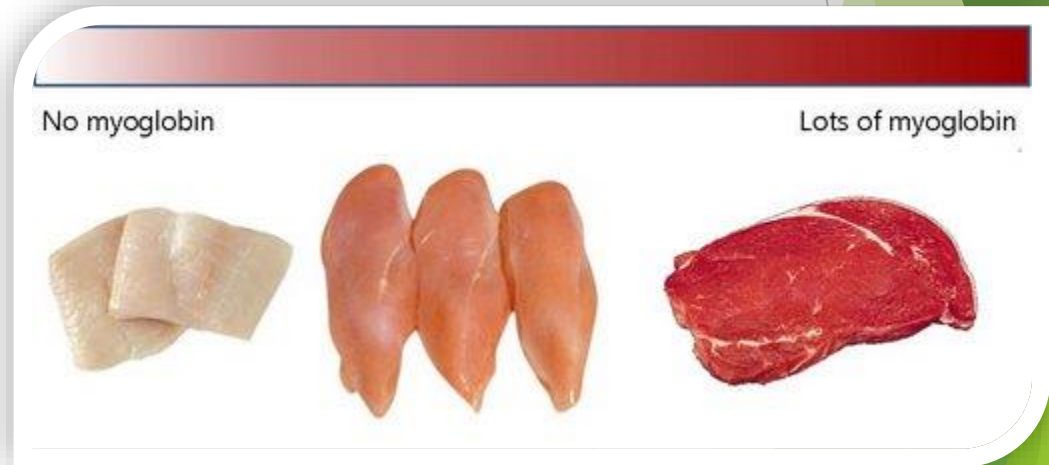
Why its called RED?

Red colour is due to the rich of myoglobin, mitochondria and capillaries

Each one myoglobin binds to ONE molecule of O₂, while hemoglobin bind with 4 O₂

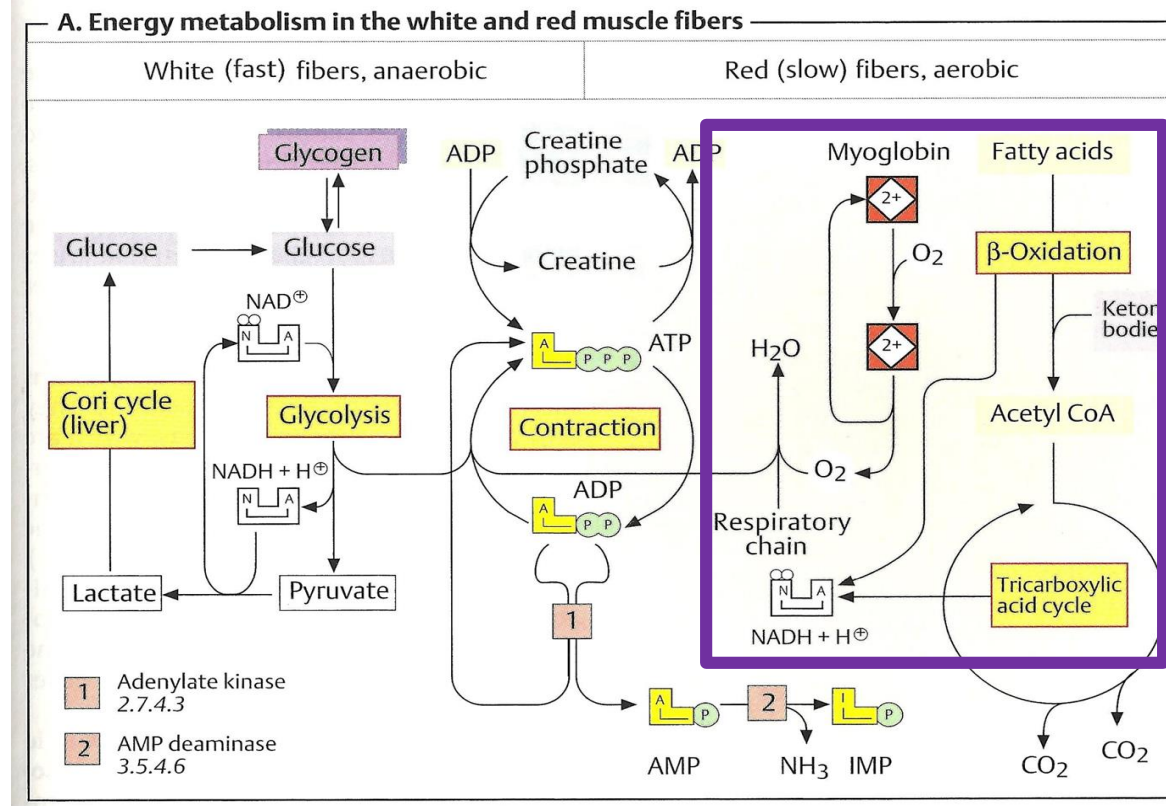
Myoglobin has higher O₂ affinity than haemoglobin

It releases O₂ when its level drops .



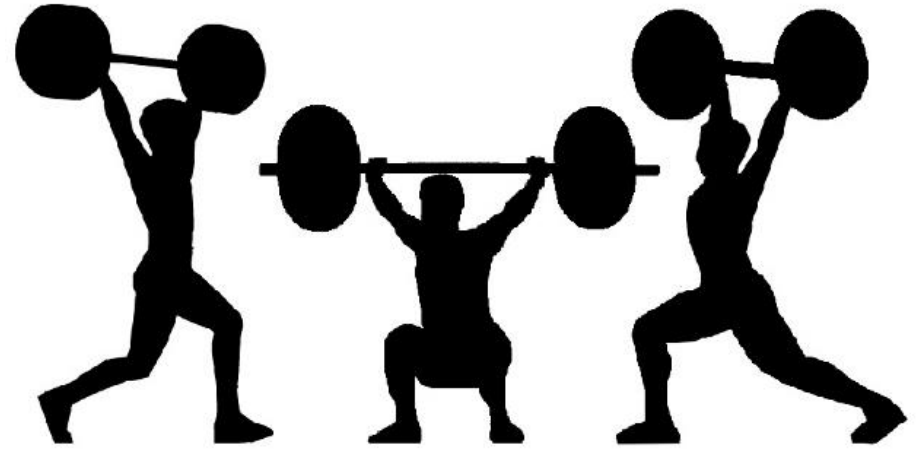
جاء سؤال في الميد تيرم
بنفس الصياغة فركزوا عليها

ATP metabolism in red muscle fibers:



White muscle fibers (anaerobic)

- ▶ White muscle fibers are suitable for fast, strong contractions
- ▶ They mainly obtain ATP from **anaerobic glycolysis**.
- ▶ During intense muscle activity (weightlifting, etc.) O₂ supply from blood quickly drops, then the muscle will use anaerobic glycolysis.
- ▶ They have supplies of glycogen that is catabolized and undergoes glycolysis.



-They are white because they have less mitochondria, capillaries and myoglobin
-They make energy from glycogen breakdown fast

Anaerobic Pathway:

Glycogen > glucose-1-PO₄ > glucose-6-PO₄

anaerobic glycolysis

ATP is produced,
NADH+H⁺ is re-oxidized to maintain glucose
degradation and ATP formation

pyruvate will be converted into lactate

Lactate is resynthesized into glucose in the liver
by Cori cycle

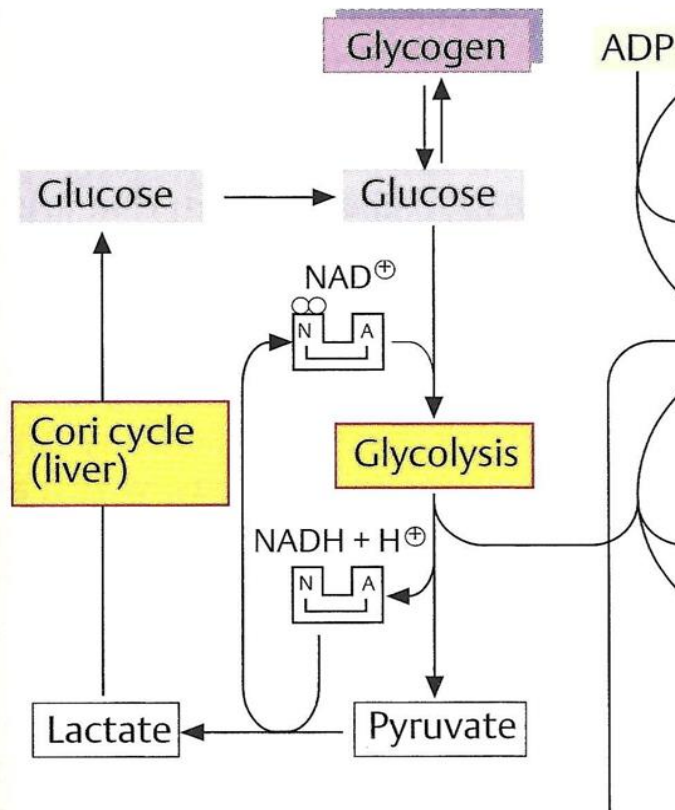
Why skeletal muscles
can't produce new
glucose from lactate?

Because:

- 1- Gluconeogenesis requires much more ATP than is supplied by glycolysis in muscle
 - 2- O₂ deficiencies do not arise in the liver even during intense exercise
- Therefore, liver always has sufficient ATP for gluconeogenesis

A. Energy metabolism in the white a

White (fast) fibers, anaerobic



The Cori Cycle

In anaerobic glycolysis, the glucose is converted to lactate

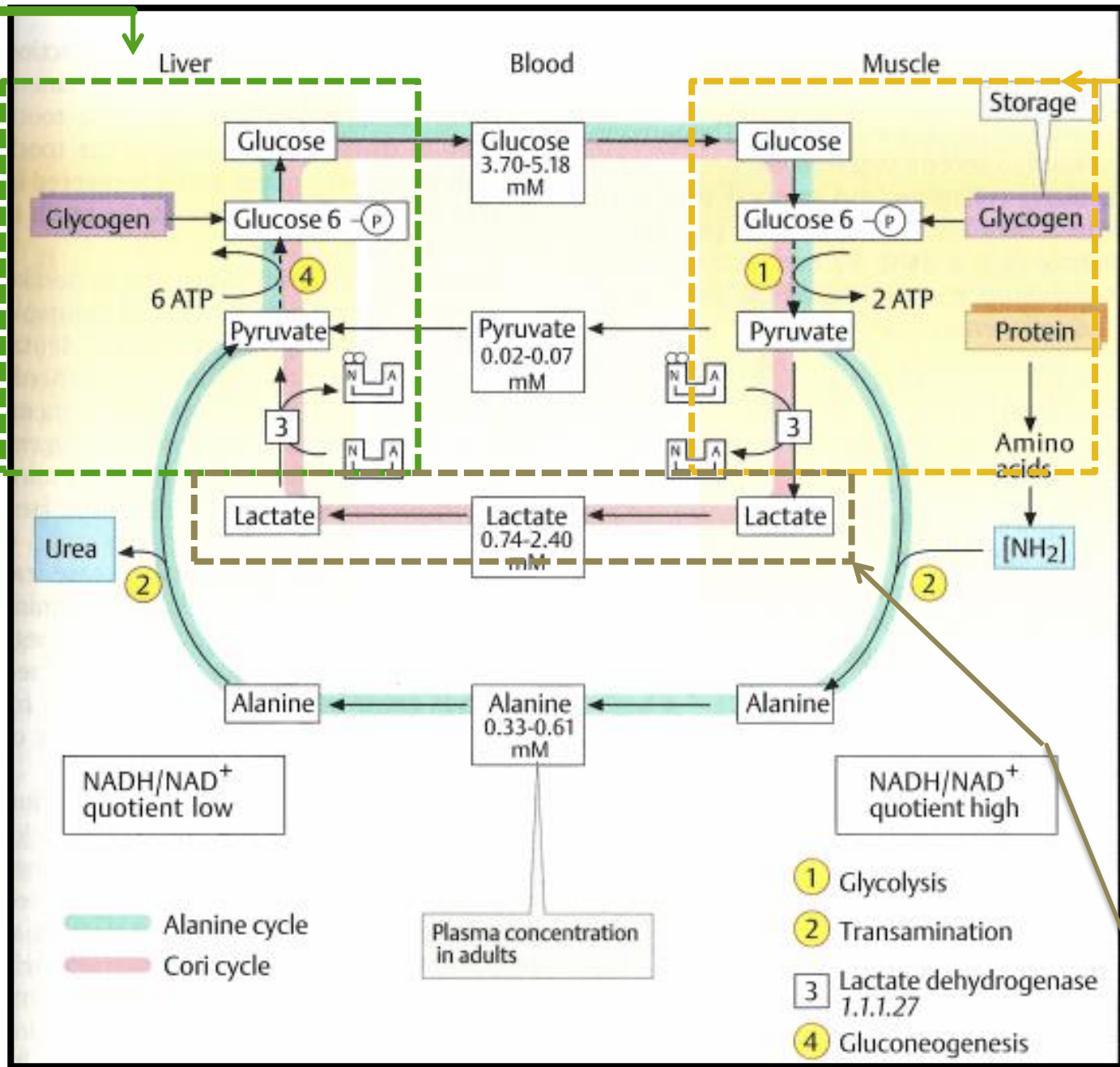
Lactate in muscle is released into bloodstream.

Then ,Transported to the liver

Liver converts lactate into glucose via gluconeogenesis

The newly formed glucose is transported to muscles to be used for energy again .

In the liver:
 5- Liver converts lactate into glucose via gluconeogenesis*.
 6- the newly formed glucose is transported to muscle to be used for energy again “complete cycle”.



In Muscle:
 1- White muscle fibers (Fast & Strong contraction) obtain ATP from Anaerobic glycolysis.
 2- In Anaerobic glycolysis glucose is converted to lactate.

Thanks to 435 team

In the bloodstream:
 3- Lactate in muscle is released into blood.
 4- Transported to the liver.

Summary: Liver converts lactate into glucose via gluconeogenesis, then the newly formed glucose is transported to be used for energy.

The glucose-alanine cycle

شرح مختصر

The alanine cycle in the liver doesn't only provide alanine as a precursor for gluconeogenesis, but also transports to the liver the amino nitrogen arising in muscles during protein degradation. In the liver, it's incorporated (يختلط) into urea for excretion.

ليش تحصل هذي السايكل ؟

عند الفترة الطويلة للصيام وعدم الأكل (مثل رمضان) العضلات الحركية تبدأ تتكسر (تصير العضلات هي مصدر الطاقة) "degraded" والنتاج لتكسر البروتينات اللي في العضلة مادة اسمها (أمينو نيتروجين) ترتبط مع البيروفيت ويصير اسمهم (الالانين) ويدخل هذي السايكل عشان يزودنا بالطاقة.

In Muscles

1

MUSCLES PRODUCE :

Pyruvate from glycolysis during exercise

Amino nitrogen (NH₂) from normal protein degradation

- Pyruvate (with NH₂) is converted to alanine
- Pyruvate + NH₂ = Alanine

In liver

3

- Liver converts alanine back to pyruvate
Alanine - NH₂ = Pyruvate
(NH₂ is Converted to urea which is excreted later.)
- Pyruvate is used in gluconeogenesis (to produce glucose)
- The newly formed glucose is transported to muscle to be used for energy again.

2

ALANINE IS TRANSPORTED FROM THE MUSCLE BY THE BLOOD INTO THE LIVER

NOTE: Alanine is the second important form of transport for amino nitrogen in the blood. And the first transport form is glutamate.

(i) Reactions in skeletal muscle: glycolysis produces pyruvate.

Pyruvate can be transaminated (an α -amino acid donates it's amino group, generating an α -keto acid) to alanine.

(ii) The alanine then enters the blood stream and is transported to the liver.

Alanine is returned to the liver for gluconeogenesis.

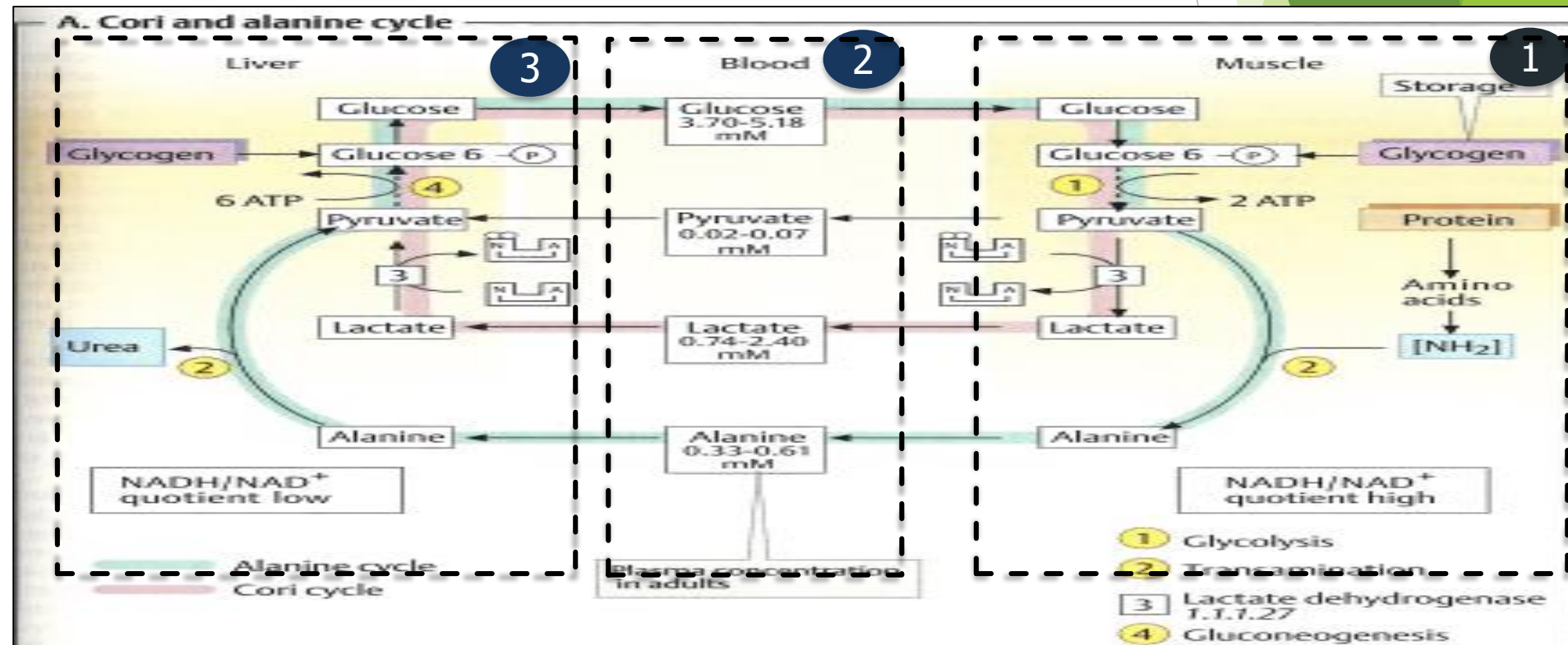
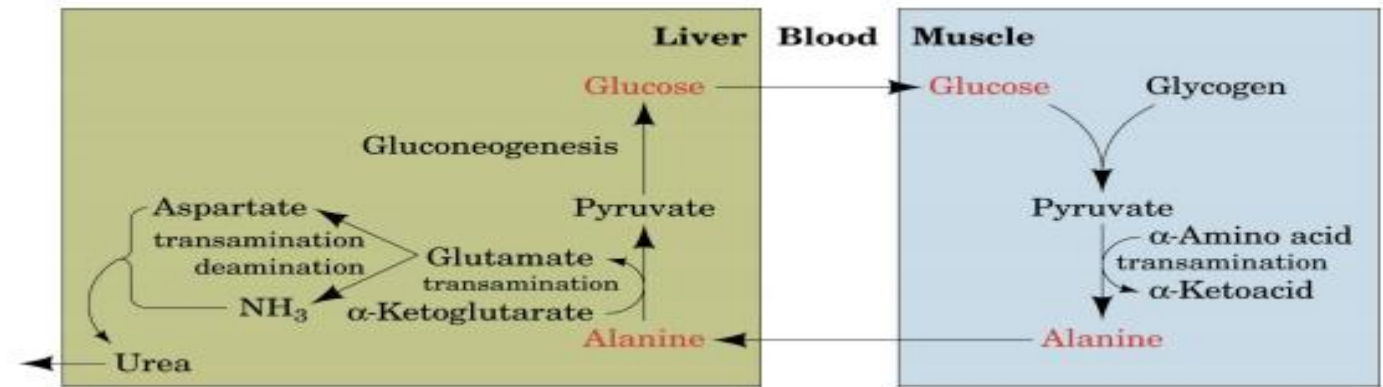
(iii) Reactions in liver:

Within the liver, alanine is converted back to pyruvate by deamination (The removal of amino group).

Pyruvate is available for gluconeogenesis and the glutamate supplies the urea cycle.

Gluconeogenesis converts pyruvate to form glucose.

The newly formed glucose can then enter the blood for delivery back to the muscle.



الارقام اللي بالدوائر
الصفراء اللي بالصورة مو
معانا 😊

Exercise and AMPK

During Exercise

(High-energy demand *require*)

In exercise, the metabolic enzymes are regulated thru phosphorylation by **AMP-activated protein kinase (AMPK)**

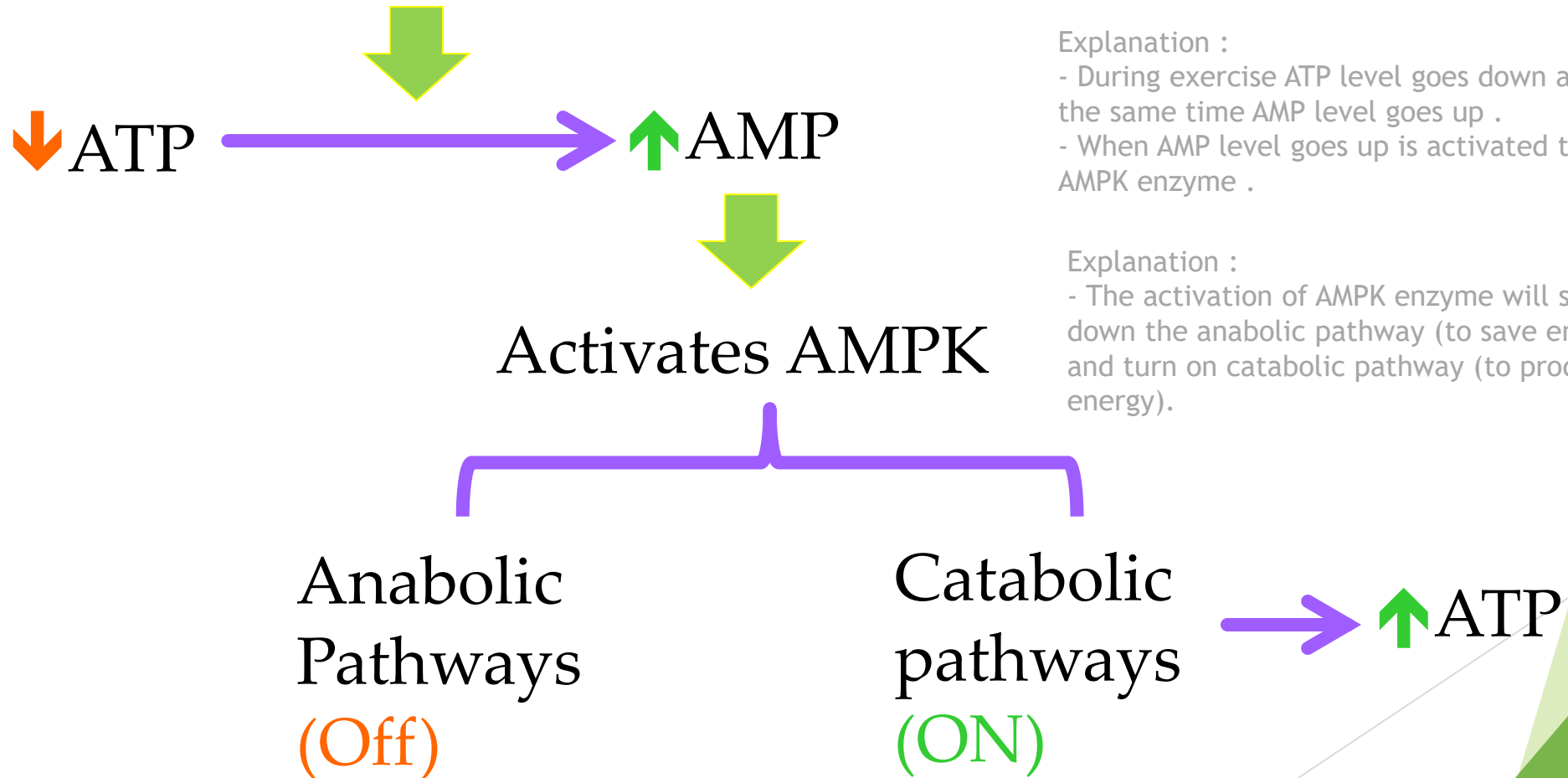
❖ EXTRA : By this process the body try to save energy .

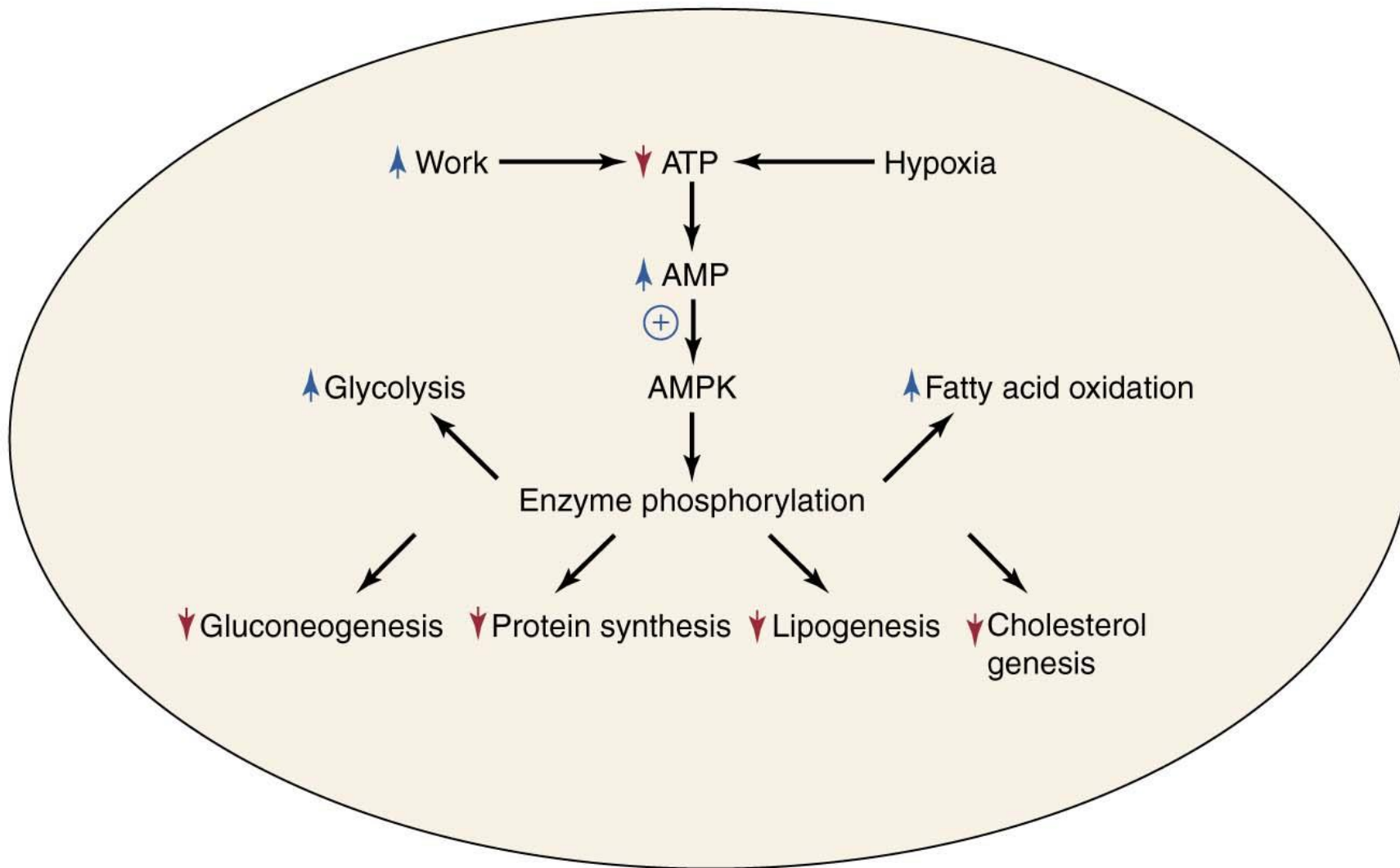
Explanation :

- During exercise ATP level goes down and in the same time AMP level goes up .
- When AMP level goes up is activated the AMPK enzyme .

Explanation :

- The activation of AMPK enzyme will shot down the anabolic pathway (to save energy) and turn on catabolic pathway (to produce energy).





AMPK activation shuts down ATP-requiring processes and stimulates ATP-producing processes

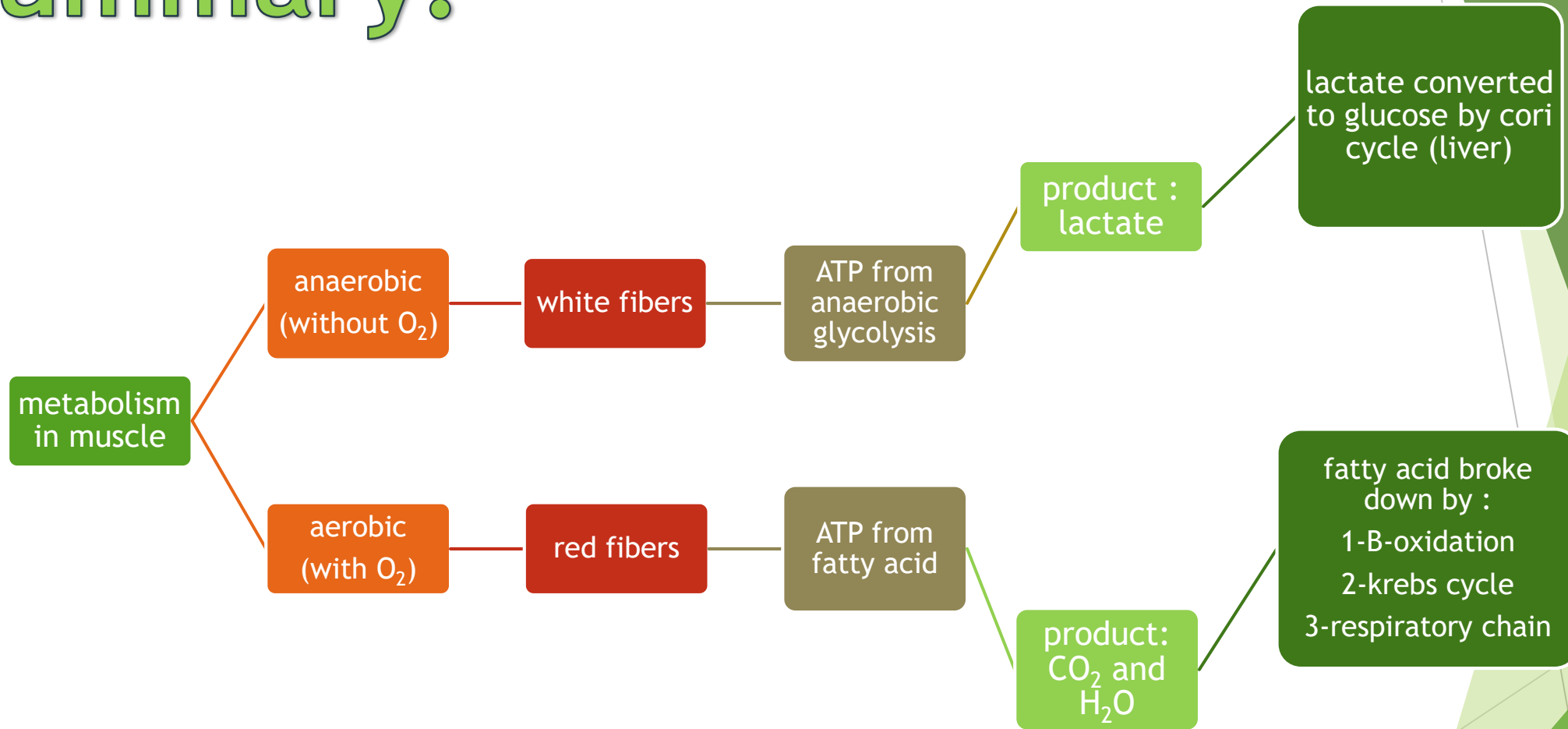
Muscle fatigue and endurance in athletes

- ▶ Muscle fatigue:
Inability of muscles to maintain a particular **strength of contraction over time**.
- ▶ Causes: muscle damage, accumulation of **lactic acid**.
- ▶ Athletes are able to change the proportions of red and white muscle fibers by targeted training. →
- ▶ The expression of muscle proteins can also change during the course of training.
- ▶ This provides them with:
 - High endurance during muscle activity.
 - Efficient energy production and consumption.
 - Delayed fatigue.

Athletes should train to have more red muscle fibers also they can convert white muscle fibers to red. The red muscle fibers are better for them because it is suitable for prolonged effort + it is an aerobic which doesn't cause lactic acid formation which leads to muscle fatigue .



Summary:



Videos

▶ 1-Aerobic system:

<https://www.youtube.com/watch?v=eqWJbELIB68>

<https://www.youtube.com/watch?v=PQMsJSme780>

▶ 2-Anaerobic system:

<https://www.youtube.com/watch?v=TcMqVnVG3Zk>

<https://www.youtube.com/watch?v=uCmNQQWlrc0>

▶ 3-Comparison:

<https://www.youtube.com/watch?v=TcMqVnVG3Zk>

<https://www.youtube.com/watch?v=uB357EX-fdc>

► Girls team members:

- 1- Reem Alserjani
- 2- Lama Alfawzan
- 3- Heba Alnasser
- 4- Rawan Alwadani
- 5- Haifa Alwael
- 6- Ruba Alsalem
- 7- Maha Alghamdi
- 8- Shatha Algeheb
- 9- Ruba Barnawy
- 10- Lama Altamimi

-Contact us on :



► Boys team members:

- 1- Mohammad almutlaq

-Team leaders:

Rania Alessa
Abdullah Almanea