The energy processes involved in muscle contraction

Objectives:

A - Understand the role of ATP in the muscle cell

B - Describe the structures directly involved in muscle contraction : Contraction of the skeletal striated muscle cell

A/The role of ATP in the muscle cell

Contractile activity constantly involves ATP molecules. These are supplied by metabolism just as quickly as they are broken down by the contractile process. The ATP available in the muscle fibre (approximately 4 millimoles) allows for a full contraction lasting 1–2 seconds; after the ATP is hydrolysed into ADP, the ADP is rephosphorylated to rapidly replenish the ATP, in a fraction of a second

Q1/ Explain the source of energy in the skeletal striated muscle cell.

Q2/ After examining the two figures (1, 2), list in order the roles of the following elements in the sarcomere: tropomyosin, troponin C, troponin I.

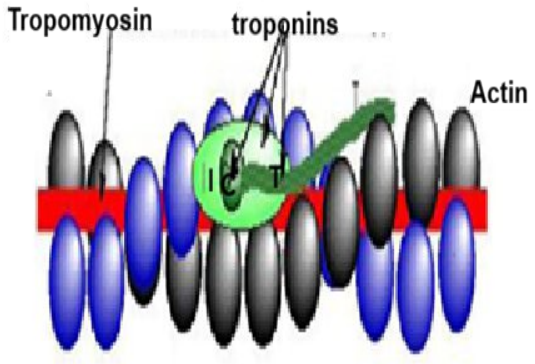

Fig1 : *Actin filaments at rest; all three troponins are visible.*

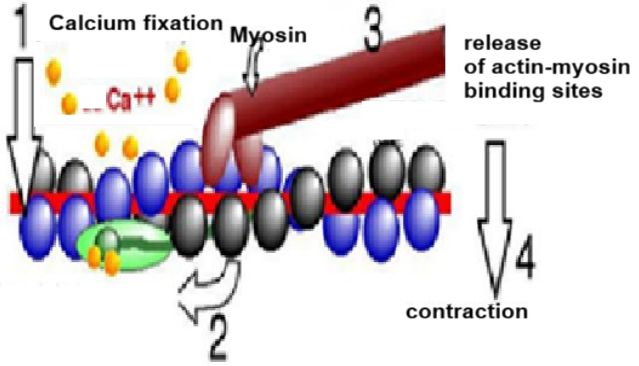

Fig2 *: Actin-myosin binding, following calcium binding to troponin c . (1,2,3)*

Q3/ Explain, using a diagram, how ATP is used by the contractile filaments of the sarcomere

Self-assessment

Activity: the role of calcium and ATP in muscle cell contraction.

Q1/Interpret the figures (3, 4, 5) obtained after measuring myofibril voltages under the following experimental conditions:

a- Isolated myofibrils + ATP + Ca++

b- Isolated myofibrils + ATP + Ca++ + Salyrgan (a toxin that blocks ATP hydrolysis)

c- Isolated myofibrils + ATP + Ca++ + calcium chelator.

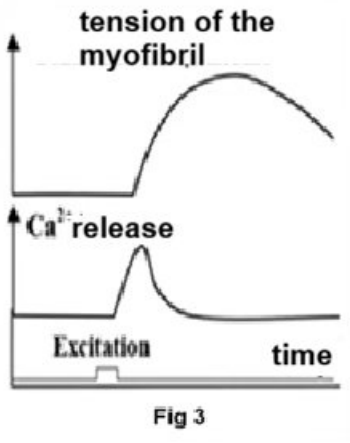

Fig 3

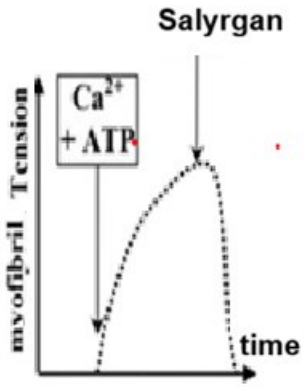

Fig 4

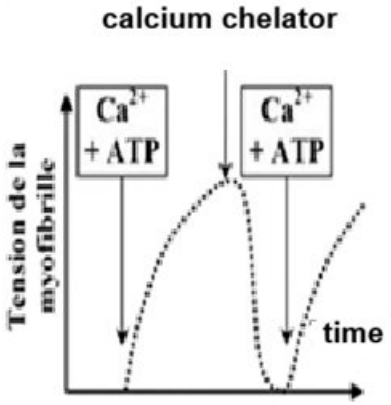

Fig 5

Q2/Using table N1 and the results (Figs. 3, 4, 5), summarise in one paragraph the conditions necessary for muscle contraction demonstrated in this experiment.

***Table N1**: Volume and quality of the blood, in the muscle (rest and contraction).*

	Arterial blood (100ml)	Venous blood (100ml)
<u>muscle at rest</u> blood flow through the muscle (12l/Kg)	Oxygen 20 ml Carbon dioxid 50 ml Glucose 90 mg	Oxygen 15 ml Carbon dioxid 54 ml Glucose 87 mg
<u>active muscle</u> blood flow through the muscle (56l/Kg)	Oxygen 22 ml Carbon dioxid 42 ml Glucose 90 mg	Oxygen 4 ml Carbon dioxid 62 ml Glucose 80 mg

To recap: Tick the correct answer

1- The initial muscle contractions consume:

- stored ATP
- glycogen
- lactic acid

2- Phosphocreatine regenerates ATP in the muscle:

- before lactic acid fermentation

- after lactic acid fermentation

- after respiration

3- During lactic fermentation, the glycogen in the muscle comes from:

- the muscle itself

- the liver

- the blood

4- The hydrolysis of ATP in myosin 2 is directly linked to:

- myosin

- tropomyosin

- the actin-myosin bond

5- Each time a new ATP molecule binds to the head of myosin 2, this head:

- binds to actin

- detaches from actin

- pivots, causing the sarcomere to contract

6- the rapid pathways for muscle ATP regeneration are:

- hydrolysis of creatine phosphate and lactic fermentation

- hydrolysis of creatine phosphate and glycogenolysis

- hydrolysis of creatine phosphate and ADP phosphorylation

7- The longitudinal striations of a muscle fibre are:

the sarcomeres (transverse striations)

the myofibrils (which allow for longitudinal striation)

the RS (reticulum)

8- ATP regeneration via:

-aerobic

-lactic aerobic

-alactic anaerobic

8- ‘nerve impulses’ originating from the CNS (central nervous system) lead to the release of sarcoplasmic calcium .

9

- Muscles can contract anaerobically.

10-In skeletal striated muscle, some fibres are adapted to the aerobic energy pathway and others to the anaerobic energy pathway.