BIOCHEMISTRY OF MUSCLE CONTRACTION

Q. What is a muscle? Muscle tissue?

Q. What are the general properties of muscle tissue(s)?

A. 3 types of muscle tissue;

a) Skeletal muscle - attached to skeletal system (bones)

b) Cardiac muscle - found in heart

c) Smooth muscle - found in walls of internal organs e.g. stomach, intestines, blood vessels.

A. All muscle tissues share these general properties;

a) Contractility - shorten

b) Excitability - respond to stimulation

c) Extensibility - lengthen

d) Elasticity - revert to original shape, size.

Q. What are the functions of the skeletal muscle system?

A. - Body movement
- Protection of deeper tissues
- Guards entrances and exits.
- Generates body heat

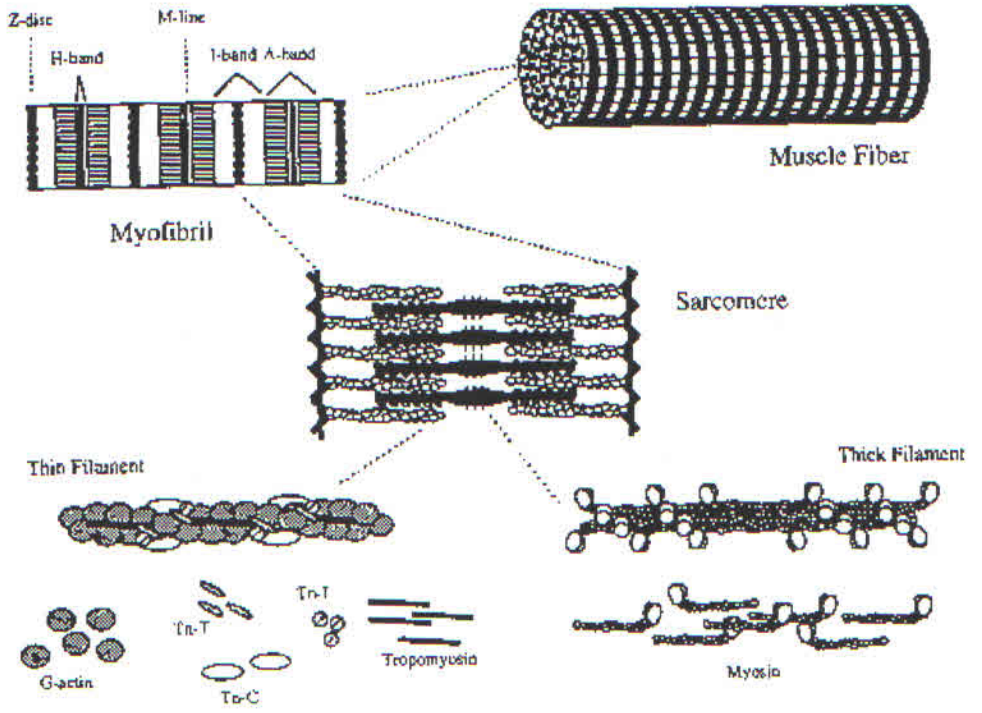
Muscle vocabularies;

1. Muscle fibre = muscle cell.
2. Sarcoplasm = cytoplasm of muscle cell.
3. Sarcolemma = plasma membrane of the muscle cell.
4. Sarcoplasmic reticulum (SR) = The ER in muscle cells - stores Ca^{2+} ions.

Muscle proteins
- Contractile
  - Myosin
  - Actin
- Regulatory
  - Tropomyosin
  - Troponin
    - TnC
    - TnT
    - TnI

SKELETAL MUSCLE

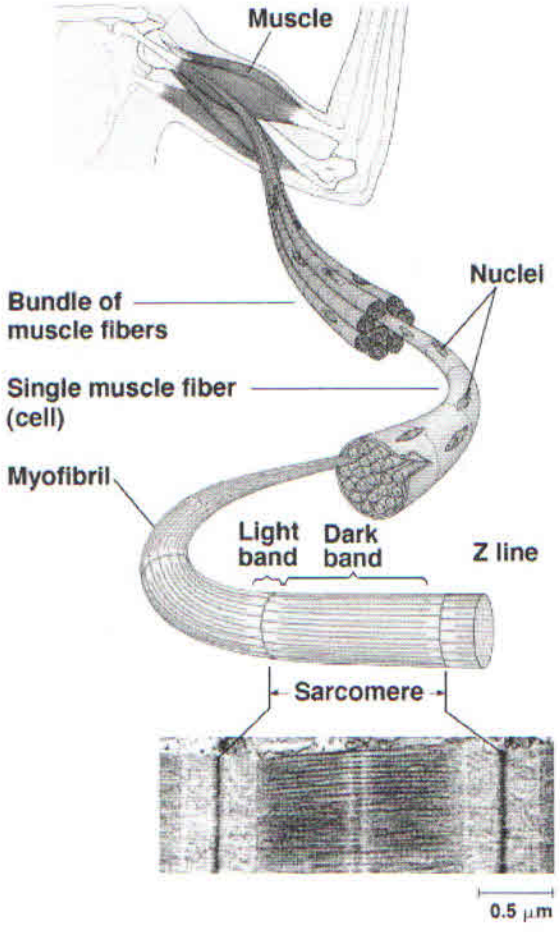
Disintegration of the Muscle

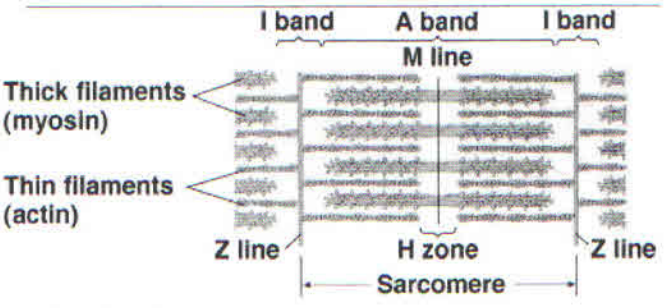


Muscle fibers consist of many individual myofibrils. The alternating dark (A) and light (I) bands in the myofibrils are observed by light microscopy. The sarcomere is the fundamental morphological unit of the contractile protein matrix and it is defined as the region between two Z-lines (disks). The sarcomeres are functionally coupled in series. Two major structures form the striated muscle sarcomere: the thin filaments (about 1 micron long) which project from either side of the Z-lines to the center of the sarcomere. The thin filaments are composed of 3 different proteins, actin, tropomyosin, and troponin (consisting of three subunits, Tn-T, Tn-I, and Tn-C). The other major structure in the sarcomere are the thick filaments, about 1.6 micron in length and are located in the center of the sarcomere.

In the above figure, a schematic organization from the level of the entire muscle fiber to the individual contractile and regulatory proteins is depicted.

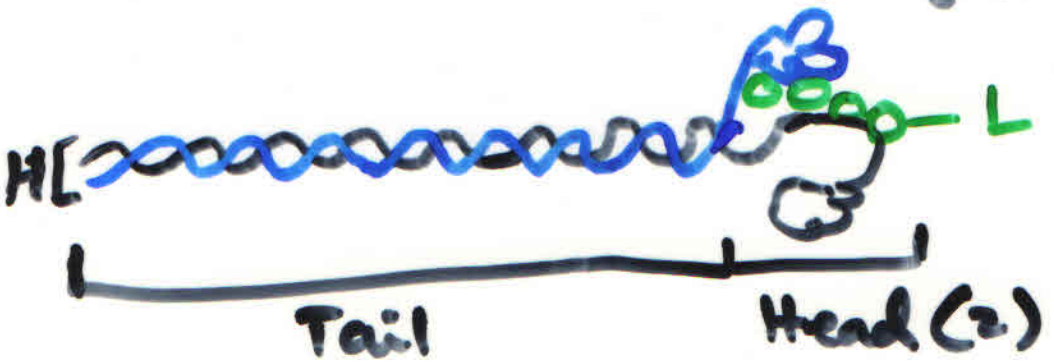
Organization of the Sarcomere

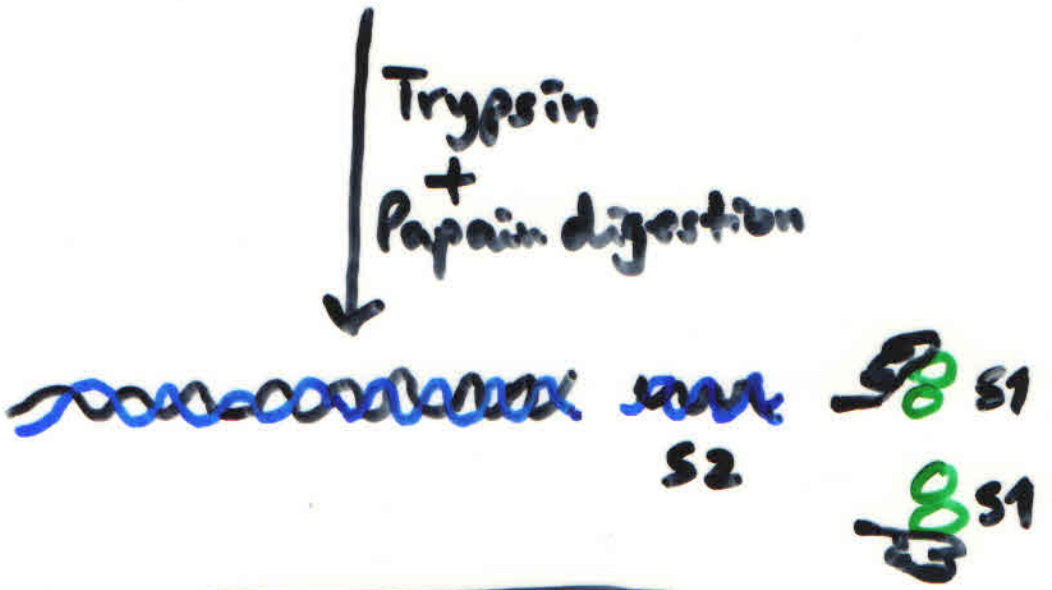


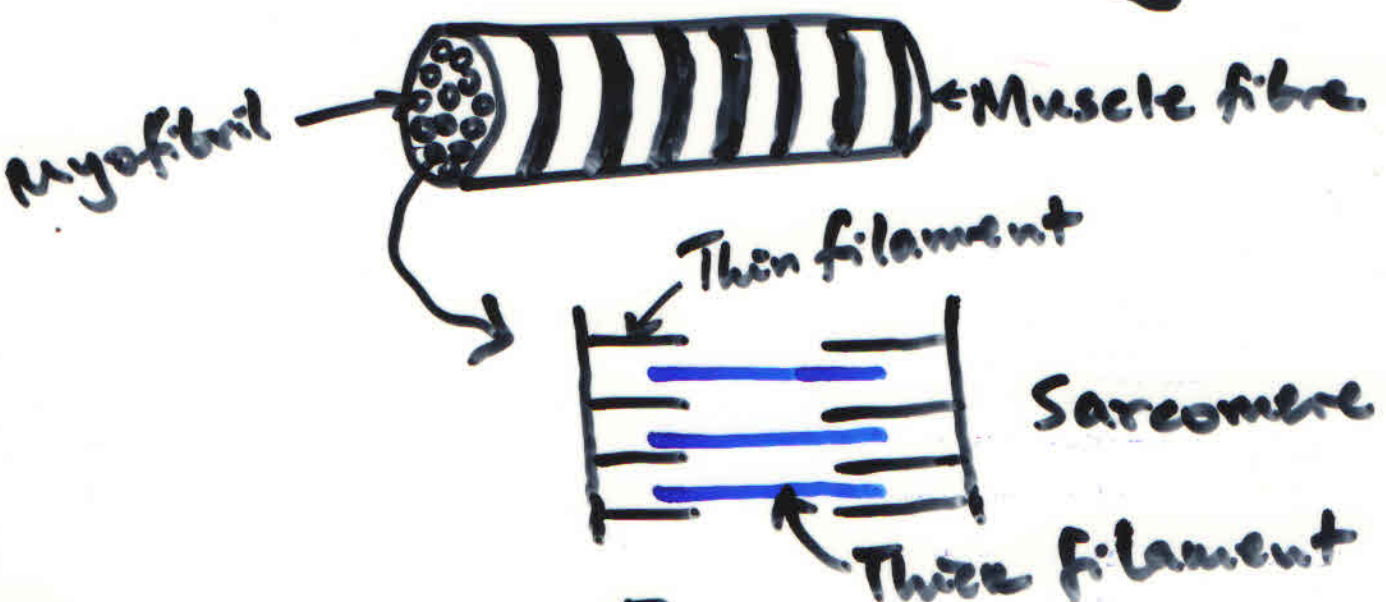


MYOSIN AND ACTIN

A. MYOSIN – 6 subunits < 2 Heavy, 4 Light







Thin filament = $\overset{F}{\text{A}}$ctin + Tropomyosin + troponin.

Thick filament = Myosin rod like structures.

B. ACTIN

- Acts as a physiological activator of myosin ATPase whose substrate is $MgATP^{2-}$.
- 2 Forms
  - Monomeric or globular actin - GA
  - Filamentous actin (fibrous) - FA = Polymeric

GA ⇒ Contains bound ATP (GA-ATP)
FA ⇒ Contains bound ADP (FA-ADP)

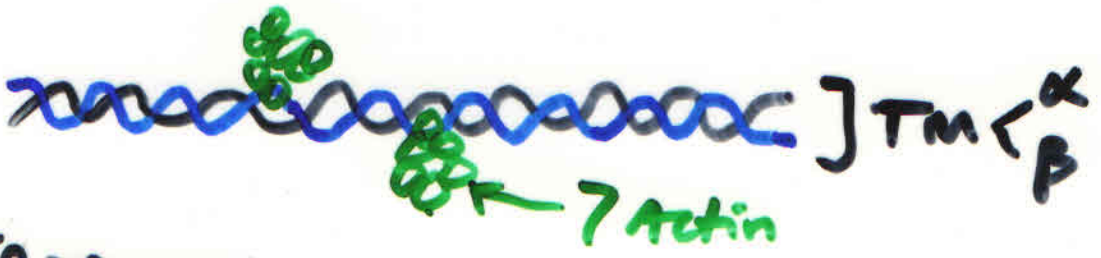
TROPOMYSIN AND TROPONIN

A. TROPOMYSIN (Tm)

- Its properties are similar to those of myosin.
- 2 α-helical chains (α and β);
  α - fast on SDS-PAGE = smaller.
  β - slow = bigger.

Red muscle = more β e.g. human
White muscle = more α e.g. Avian, rabbit

- Has a high affinity to actin.



B. TROPONIN

- 3 subunits - each with a function;
  TnC = binds Ca^{2+}.
  TnT = binds to tropomyosin.
  TnI = inhibits actomyosin ATPase.

SARCOMERE

- It is the functional unit of muscle.
- A functional unit is the smallest part of the "whole" that does the job of the entire structure. It contracts and generates force when electrically stimulated.
- It is arranged such that the thick and thin filaments "slide" past each other during contraction
  "The Sliding Filament Theory"

* Both contractile proteins do not shorten or lengthen - they just "slide".

A sarcomere is made of;

The H band = contains myosin (thick filament) only.

The I band = contains Actin (thin filament) only = light band.

The A band = contains all of the myosin, regardless of how much actin is overlapping = Dark band.

* During contraction "some" bands change in width = the width of some bands change.

∴ H & I ⇒ shorten and lengthen

A ⇒ DO NOT CHANGE

Q. What are the biochemical events of muscle contraction?

Q. Demonstrate the chronology of events leading to muscle contraction.

Mechanism of ATP hydrolysis;

WEAK = SLOW

$M + ATP \rightleftharpoons M \cdot ATP \rightarrow M \cdot ADP \cdot P_i \longrightarrow M + ADP + P_i$

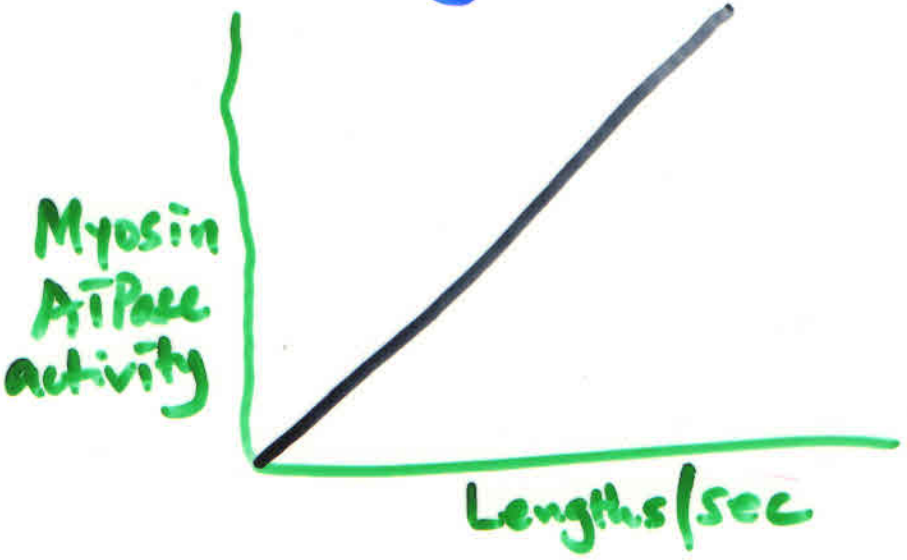
STRONG = FAST

ROLE OF ACTIN AS ACTIVATOR

$AM + ATP \rightleftharpoons AM \cdot ATP \rightarrow AM \cdot ADP \cdot P_i \longrightarrow AM + ADP + P_i$

OF ATPase

↑ ATPase activity = ↑ shortening speed



Stimulation → Ca^{2+} release → Ca^{2+}–TN

Relaxed (Inside negative)

Contraction (Inside positive)

1. Contraction
   - Concentric (Shorten) e.g. Bicep curl.
   - Eccentric (Lengthen) e.g. Push-ups.

2. Contraction
   - Isometric = No movement.
   - Isotonic = movement.

3. Contraction
   - Voluntary = Conscious e.g. skeletal muscle.
   - Involuntary = unconscious e.g. Cardiac muscle, Smooth muscle.

Read on;

① Excitation - Contraction Coupling.

② The action potential - role of Ca^{2+}

③ Sliding Filament Theory.

④ The Cross Bridge cycle;

4 steps

1. Cross bridge formation - Ca^{2+}
2. The power stroke.
3. Cross bridge detachment.
4. Reactivation of myosin head.

⑤ http://www.youtube.com/watch?v=AwWyFAPN

⑥ http://www.slideshare.net/guest0f3dd9/muscle-contraction-2914609