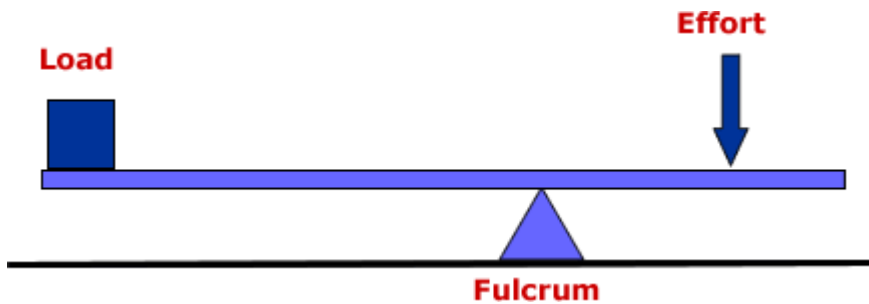


Understanding:

1. Explain the role of bones and exoskeletons.

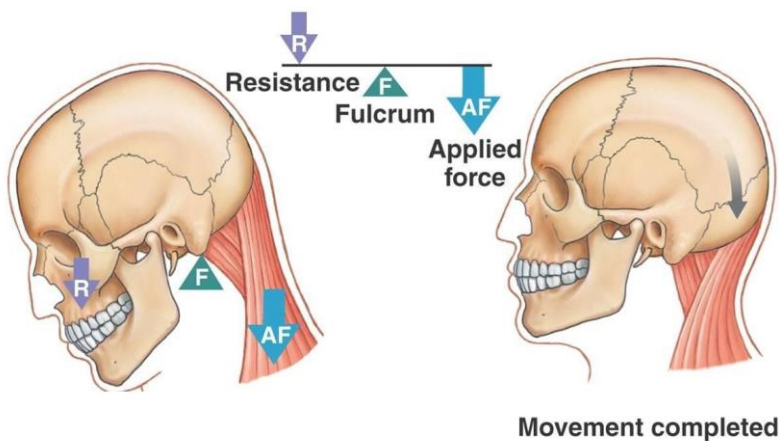
- Bones (endoskeletons) and exoskeletons are both hard collagen containing calcium structure. We have endoskeletons while animals like crustaceans and arthropods have exoskeletons.

They have a common, very crucial role. It is to act as a lever.



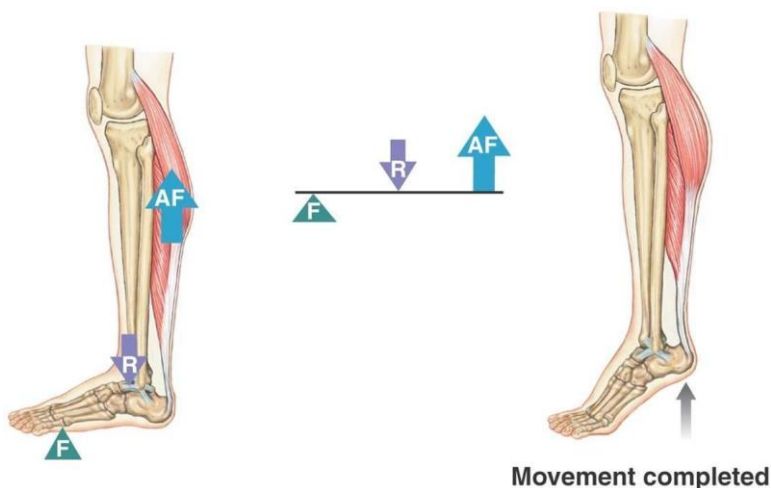
This is a lever, and one needs some basic physics to understand how this applies to our skeletons. In a lever, there is always a fulcrum where the lever balances, the load/resistance and the effort that works against the load. Note that the effort is always the muscle!

The first type is class 1 lever. Although class 1 is rare in human bodies, we still have some.



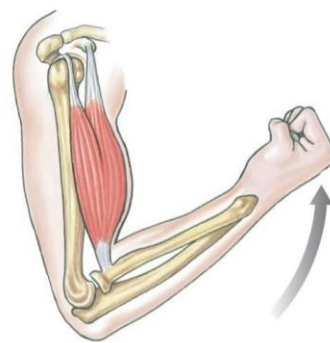
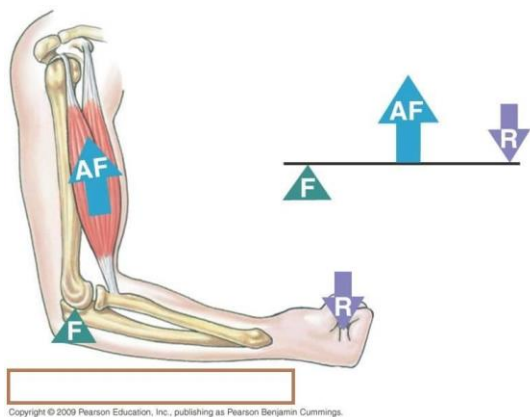
Our head is an example. The load/resistance is our cranium, fulcrum the connection of spine and cranium, and the effort is neck muscle.

The second type is a class 2 lever.



Our legs are an example. The toes are our fulcrum/pivot/axis of rotation. The resistance/load is the bone at the centre of mass, and our effect is the muscle again.

The third type is a class 3 lever. This is most common in our body.



Movement completed

Our arms are an example. The fulcrum is our joint, effort is our muscle and the load is our hand.

Basically, in order to identify the type of lever in our body, one has to first identify the axis of rotation, and the muscle in use. Then the load/resistance will come automatically. It can be found by relaxing the muscle and see where it goes.

2. Explain synovial joints.

- Synovial joint is the most common joint in our body. Basically, these are thin layers of cartilage that reduces friction between bones and allows movement.

We have around 300 joints in fact, so one can understand why there are so many cases of arthritis.

But hey, we have so many ways to move our bones! Some may rotate, some may only flick up and down, some may twist etc. So we have different structures of synovial joints.

Joint	Movement
Knee	Flexion and extension or basically bending and straightening.
Hip	Flexion and extension Lateral movement or abduction and adduction. Rotation
Shoulder	Flexion and extension Lateral movement or abduction and adduction. Rotation

Extra notes

- Ligament is connective tissue that connects the bone with bone. Tendon is connective tissue that connects bone with muscle.

3. State that movement of the body requires muscles to work in antagonistic pairs.

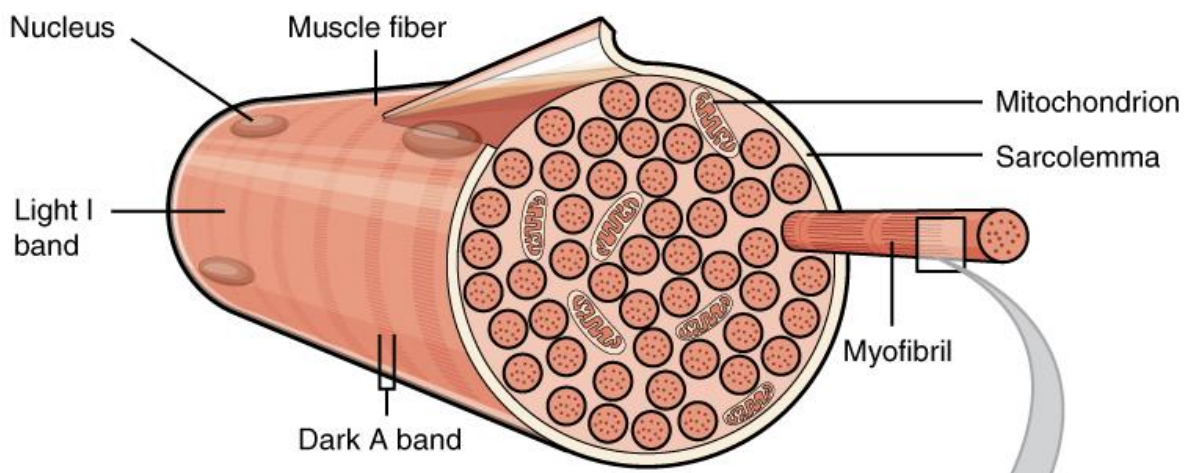
- We know what these are from 6.4. Biceps and triceps are also antagonistic.

4. State that skeletal muscle fibres are multinucleate and contain specialized endoplasmic reticulum.

- We should first distinguish between smooth and skeletal muscle. It is very simple. Smooth muscle is not attached to a bone, while skeletal muscle is. Thus skeletal muscle moves the skeleton! Oh, we also have the cardiac muscle, and that is as it sounds the heart muscle.

Muscle cells have many nuclei, which is quite amazing. Erythrocytes have none which is even more amazing. Nevertheless, there is a practical reason why the embryos fuse to make long strands of muscle cells. Since muscle must contract, it is good if they have a large contraction. Contractions that are one cell long are not going to be neither synchronized nor very effective.

This is what the striated/striped muscle is composed of.



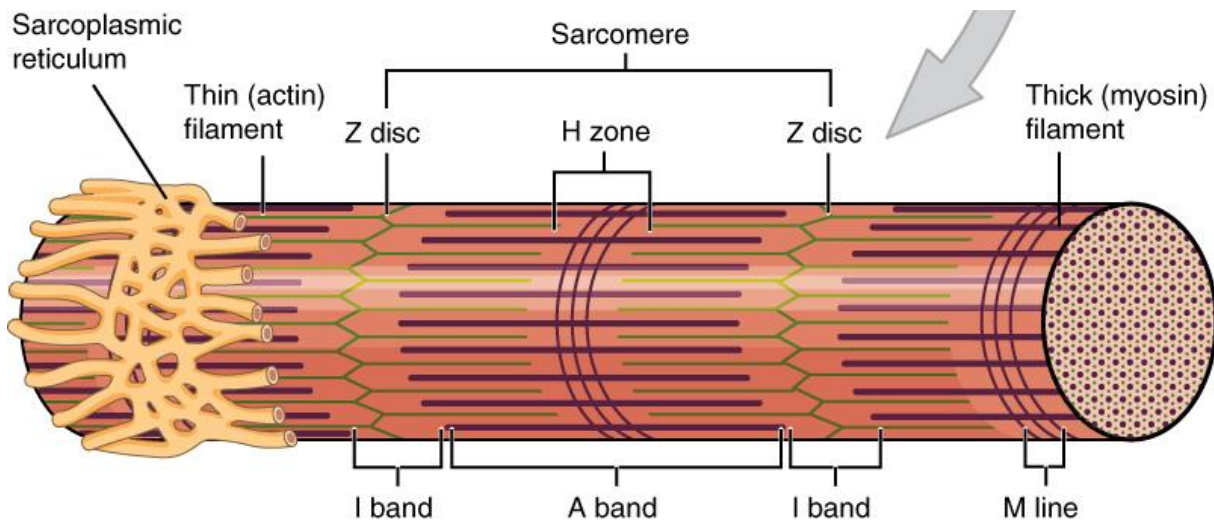
I must say that the muscle fibre looks very peculiar. One muscle fibre has one plasma membrane called sarcolemma and lots of nuclei and mitochondrion inside. They also have a special endoplasmic reticulum called sarcoplasmic reticulum. These act as a signal to contract at once.

So just to make things clear, striated muscle > muscle fibre > myofibril.

5. State that muscle fibres contain many myofibrils.

- Yeah, there are lots of tubes inside a tube.

6. Explain the structure of myofibril.



This is how the myofibril looks like. Discs are what make the myofibril contract.

The sarcomere is the contracting part and is the distance between two Z discs. The "I band" is also known as the light band because they have light colour in microscope. The "A band" is also known as the dark band because they have dark colour in microscope.

The purple lines are the myosin filaments and green ones the actin filaments. The mechanism of how they contract will be covered soon.

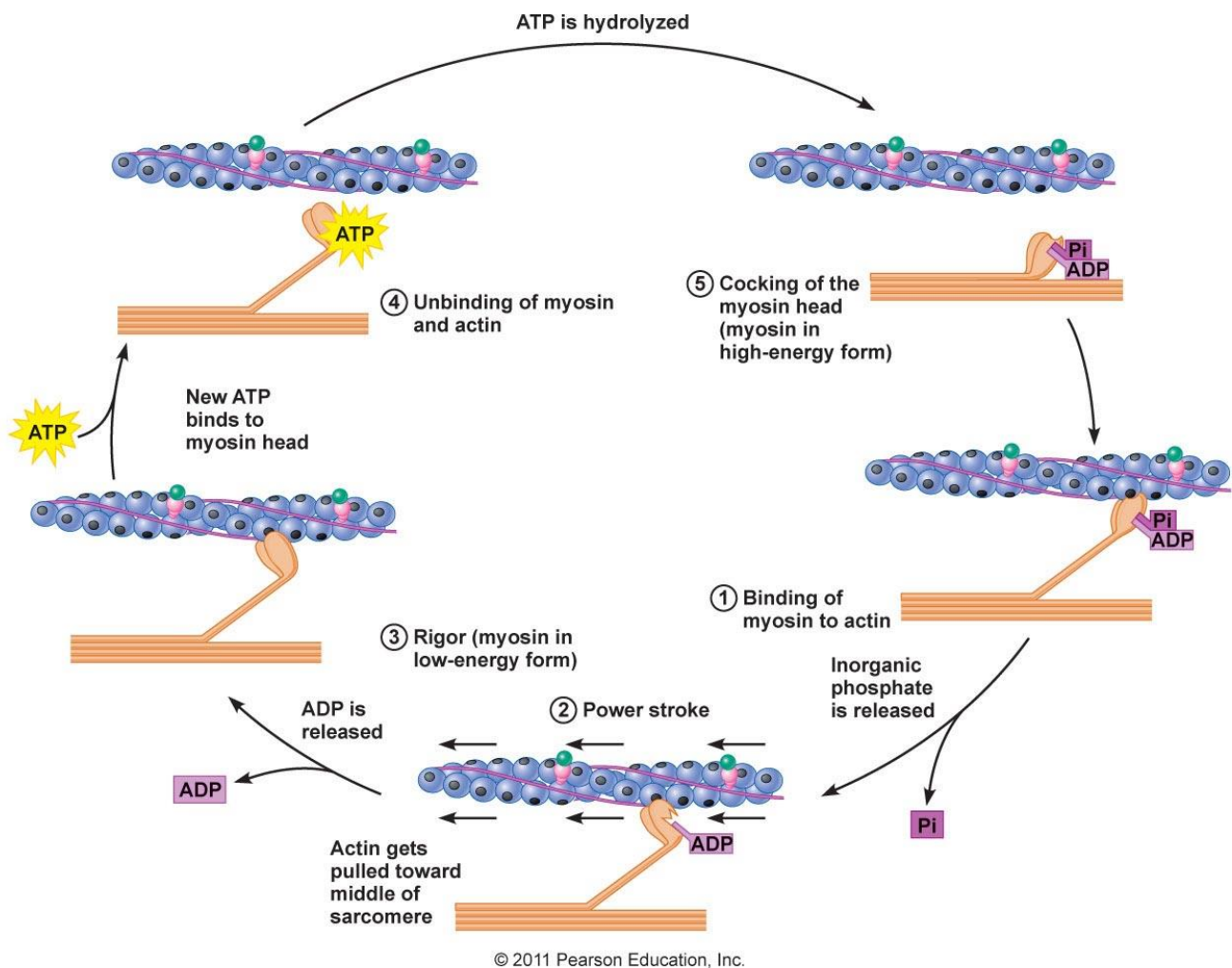
7. Explain the mechanism for muscle contraction.

- The basic mechanism is that the myosin "climbs" up the actin filament using ATP. There are only specific places myosin can bond, and those bonds are called cross-bridges.

8. Explain the role of ATP in muscle contraction.

- This is the really important part. You MUST understand this.

Note that this would be the right section of the sarcomere since myosin is climbing to the right.



3. I want to start with point 3 because it is easier and more natural so to say. So here, the muscle is at rest. The myosin is happy binding to the actin.

4. Now we want some action. ATP binds to myosin and breaks the bond.

5. The energy needed to break the bond results in ATP breaking as well into $ADP + P_i$. This will make the myosin head more "cocked" (lol) and move further out.

1. As P_i is released, the myosin changes its shape back to its "un-cocked" (double lol) state.

2. This makes the myosin climb to the right, and here ADP is released.

9. Explain the molecules that control muscle contractions.

- Now you may have realized that something does not make sense. It cannot be that the resting state can be myosin and actin bounded because then, well, the contraction cycle would not make sense! It would never return to its original position!

So, we have proteins called tropomyosin. These block the binding sites on actin. When we want to move, signals from motor neurons make sarcoplasmic reticulum release calcium ions. These calcium ions remove the tropomyosin and now myosin can bind.

Thus the larger picture of sequence is release of calcium ions → cross bridge formation after removing tropomyosin → actin filament and myosin are “reset” and ready climb → ATP is used.

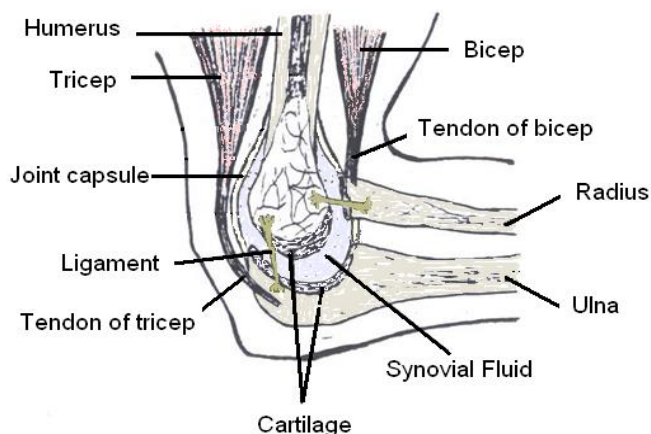
Applications and skills:

1. Explain that how an insect leg uses antagonistic pairs of muscles.

- Basically, it is the same as humans. Grasshoppers contract to jump.

2. Be able to annotate a diagram of the human elbow.

- We don't have to draw, but we must be able to annotate the different parts.



Humerus – the bone where triceps and biceps are attached.

Triceps and biceps – the antagonistic pairs. It is obvious which one of them can flex and extend.

Joint capsule – “capsules in” the joint so dislocation does not happen.

Synovial fluid – lubricates the joint.

Cartilage – it wraps the bones and also reduces friction.

Ulna – bone attached to triceps. Remember ulna as in under.

Radius – bone attached to biceps.

3. Be able to draw labelled diagrams of the structure of a sarcomere.

- This time we have to draw. The drawing is very simple once you have understood the mechanisms.

Be sure to include myosin and actin (hello Mr. Obvious), z-line, sarcomere, light band and dark band. EASY!

4. Be able to use of electron micrographs to find the state of contraction of muscle fibres.

- When muscle is contracted, the distance between z-lines a.k.a. sarcomere is shorter. Note that the length of dark band does not change since length of myosin is same. But the light band is shorter since it is contracted.