

Muscles and Movement (AHL)

Stephen Taylor

Bandung International School

Movement: the human machine



joints
'moment' or
pivot for
movement

bones
act as levers
and structural
support

nerves
coordinate & stimulate
muscle contractions

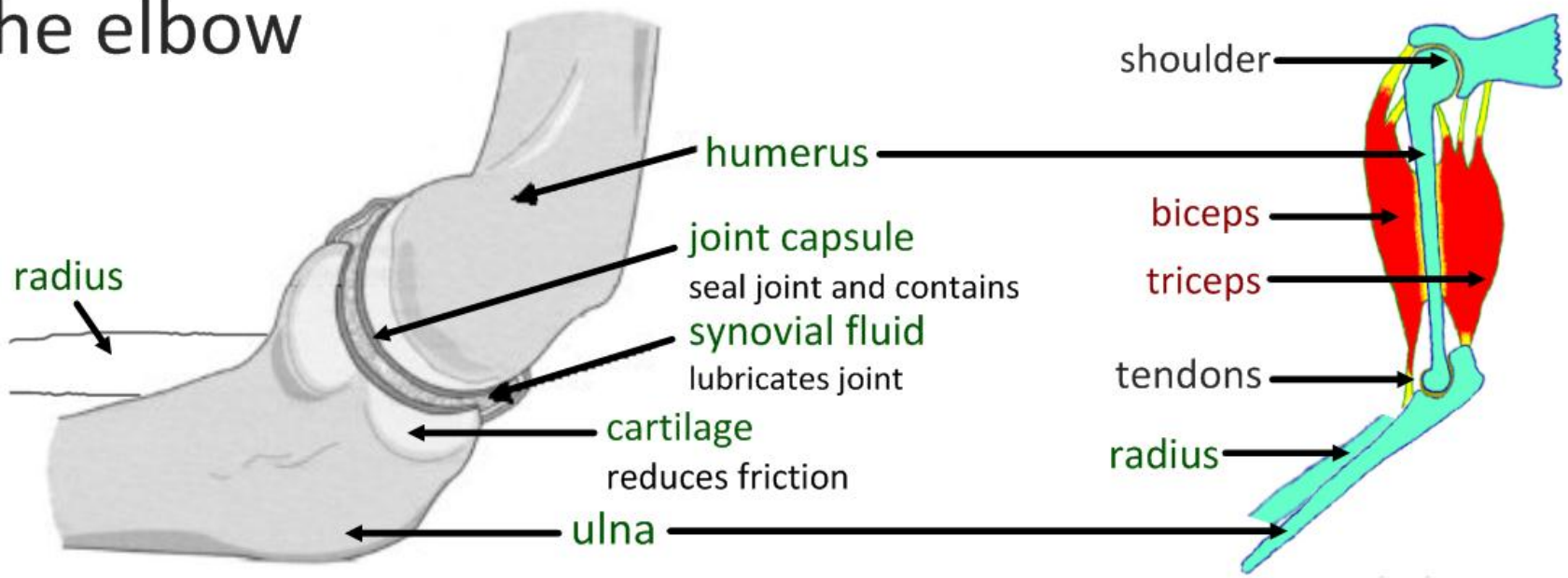
muscles
apply effort or force

tendons
muscle-to-bone

ligaments
bone-to-bone



The elbow



From IB Question Bank

[Source: R. Allen and T. Greenwood, (2001) *Advanced Biology 2, Student Resource and Activity Manual*, 3rd edition, Biozone International Limited, page 98]

Joint structure reflects function:



http://content.answers.com/main/content/img/oxford/Oxford_Body/019852403x.elbow.1.jpg

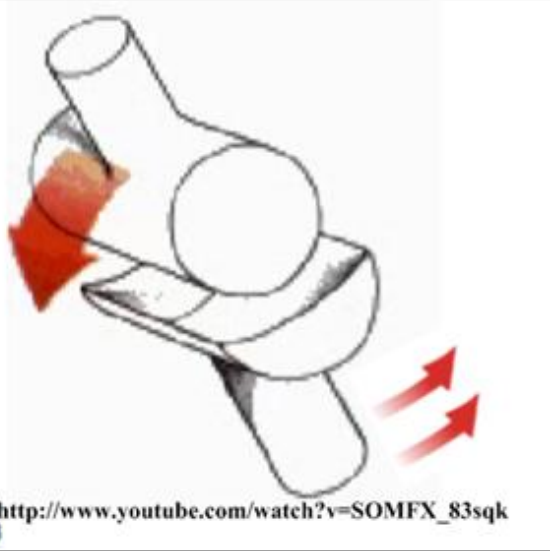


http://www.youtube.com/watch?v=SOMFX_83sqk

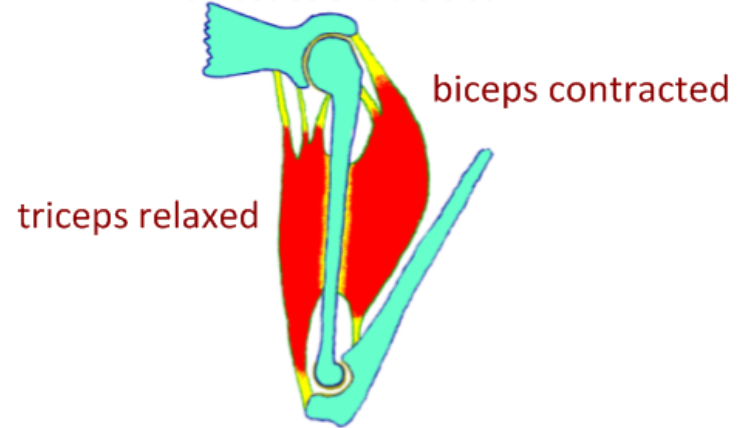
The elbow is a hinge joint

it has a limited range of movement

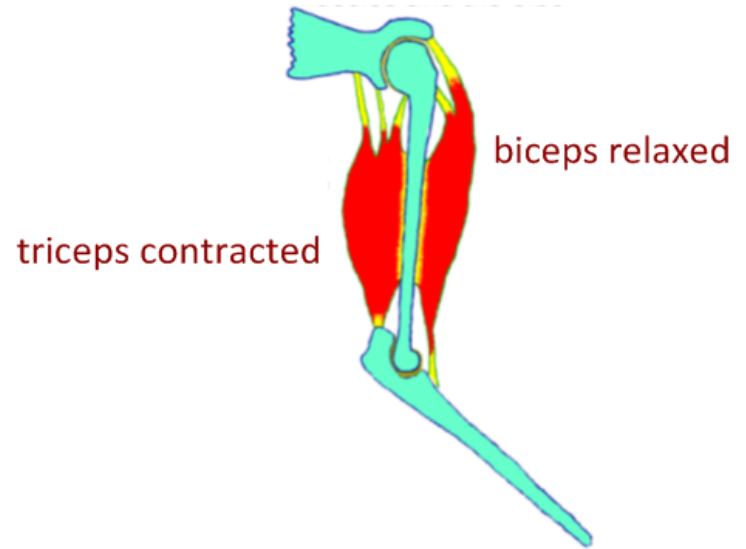
The **biceps** and **triceps** are **antagonistic muscles**:



"bend"

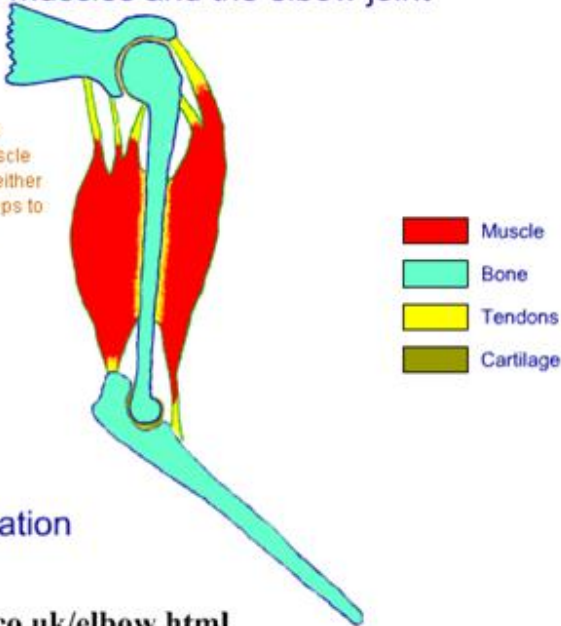


"extend"



Antagonistic muscles and the elbow joint

You can find out what happens when a muscle contracts by clicking either the biceps or the triceps to see what happens.



More information

<http://sambal.co.uk/elbow.html>

The knee is a pivotal hinge joint:

http://www.youtube.com/watch?v=SOMEX_83sqk



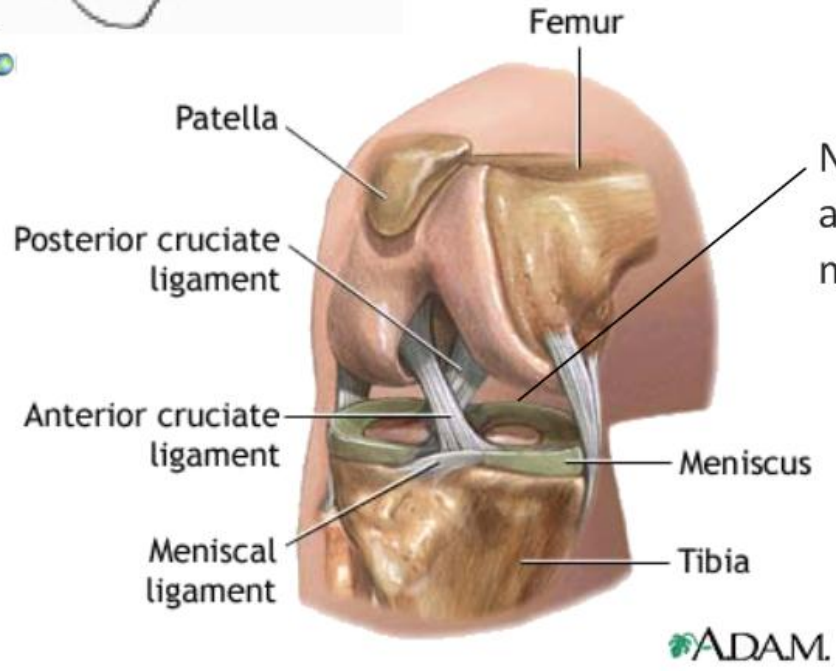
It's main range of movement is like a hinge joint, yet it allows some pivotal movement as well.

It is one of the most complex joints in the human body.

Animated X-ray:



http://en.wikipedia.org/wiki/File:Knie_ct.gif



Notice in the diagram and the animated radiograph above that the femur and the tibia do not actually make contact with each other in movement.

Cartilage and synovial fluid protect and lubricate the knee joint, reducing impact harm. Strong ligaments hold the knee in place.

<http://medicalimages.allrefer.com/large/knee-arthroscopy-series.jpg>

The hip is an example of a ball-and-socket joint

rotation and hinge



http://www.youtube.com/watch?v=SOMFX_83sqk

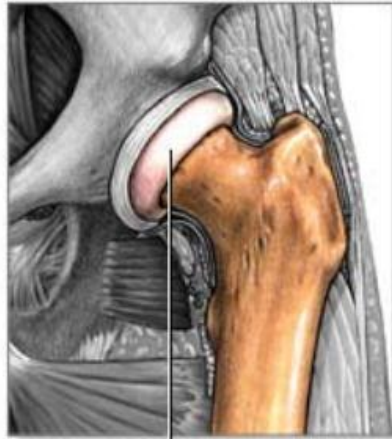
It allows movement in all axes and planes. Ball-and-socket joints allow the greatest range of movement.

The shoulder is also a ball-and-socket joint.

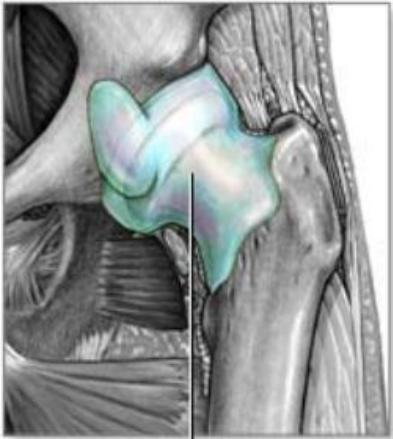
Hip X-ray:



<http://upload.wikimedia.org/wikipedia/commons/2d/Hueftgelenk-gesund.jpg>



Cartilage



Synovial membrane

http://assets.aarp.org/external_sites/adam/graphics/images/en/18027.jpg



More about joints in the body:

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Inside the hip joint

Front view
Right hip

Overview	Pelvis
Femur	Acetabulum
Femoral head	Acetabular labrum
Femoral neck	Femoral head ligament
Femoral ligaments	

<http://www.midsouthorthopedics.com/hipanatomy.htm>

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Patient Education

Anatomy of the Shoulder

The muscles and joints of the shoulder make it the most mobile joint in the human body.

Humerus

View/Modify

NEAT STEP

hip
knee
shoulder
hand
foot & ankle

<http://www.midsouthorthopedics.com/education.htm>

Introduction | A Healthy Knee | Osteoarthritis of the Knee

An Inside Look at Your Knee

The pain and stiffness associated with osteoarthritis (OA) of the knee are caused by specific physical changes in your knee. Take a look at what actually happens in a knee with OA by clicking on the links above. You'll also get other important information about OA and how it can affect you.

The more you know about OA of the knee, the easier it will be to discuss your pain with your doctor.

http://choroknamu.com/tt/site/db/board/om_gungol/upload/1_10000/1692/is_en_pt_knee.swf

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Inside the knee joint

Front view
Right knee

BONES	SOFT TISSUE
Femur	Tibia
Condyle	Meniscus
Patella	Fibula

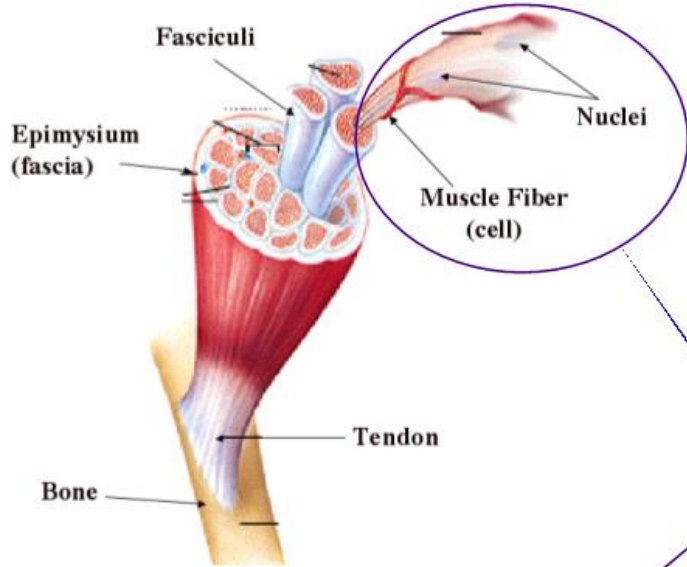
SEE BACK

<http://www.midsouthorthopedics.com/knee anatomy.htm>

The Striated Muscle Cell

Skeletal muscle tissue is striated - has dark and light bands - and contracts longitudinally.

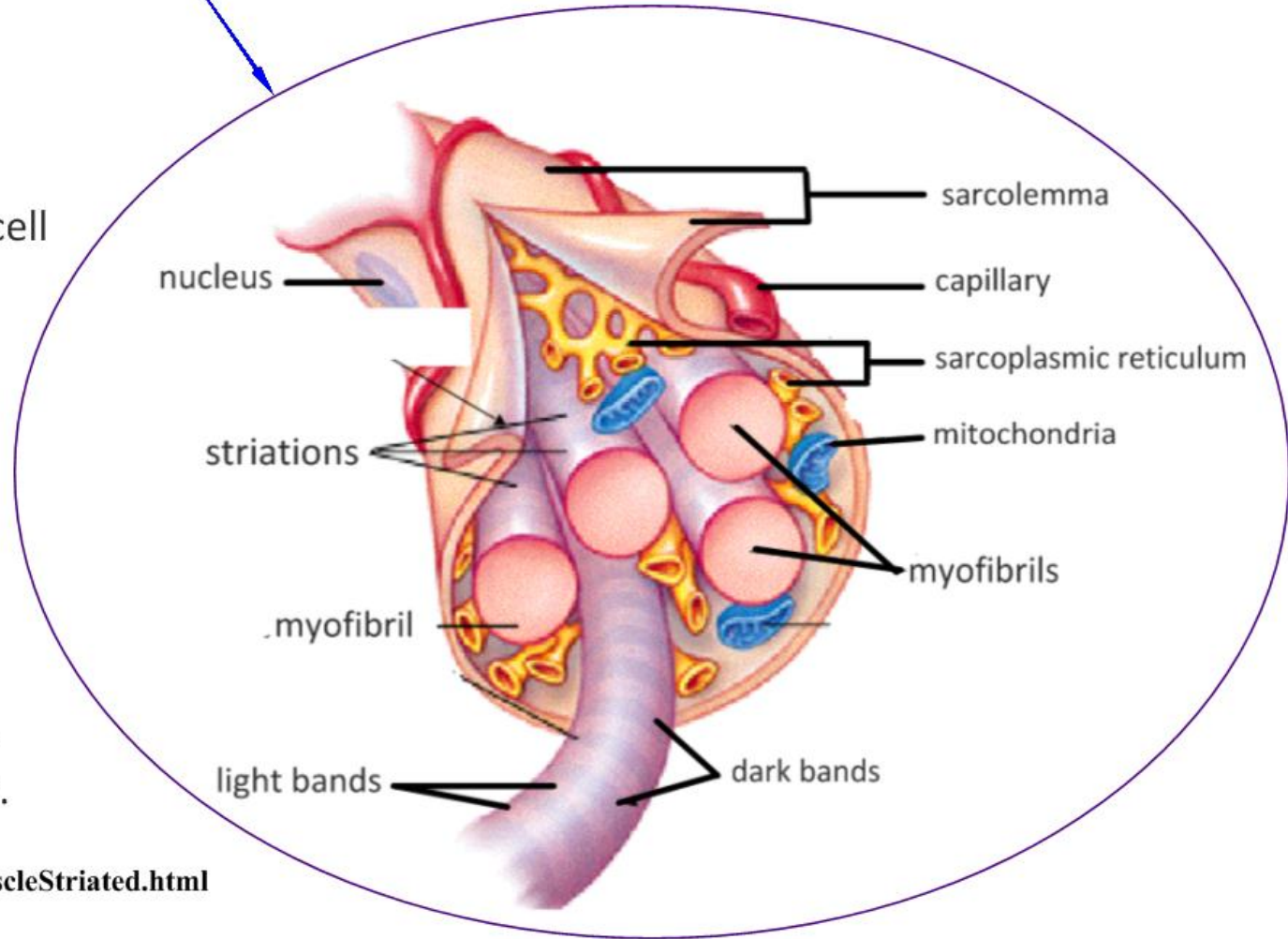
Muscle cells are bundled together in fasciculi, held in place by the **sarcolemma** (membrane).



A single skeletal muscle cell is **multinucleated**, with the nuclei arrange along the edges.

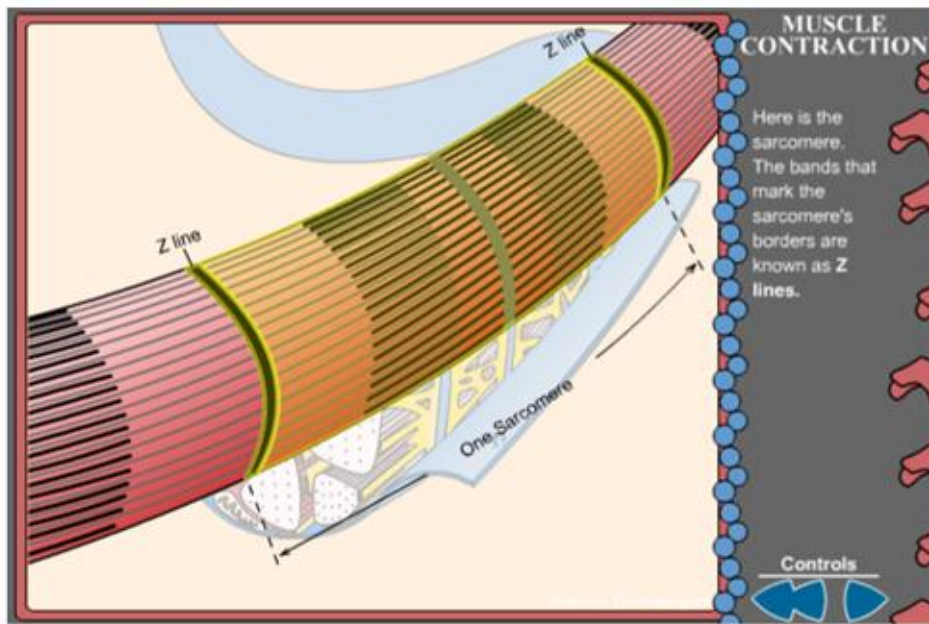
Myofibrils are single fibres within the cell.

Many **mitochondria** are also present as there is a high demand for ATP.

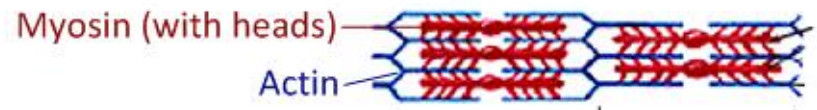
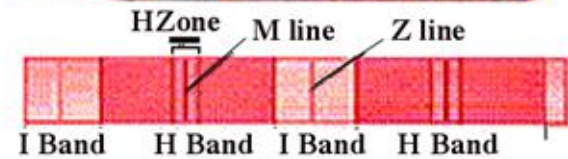
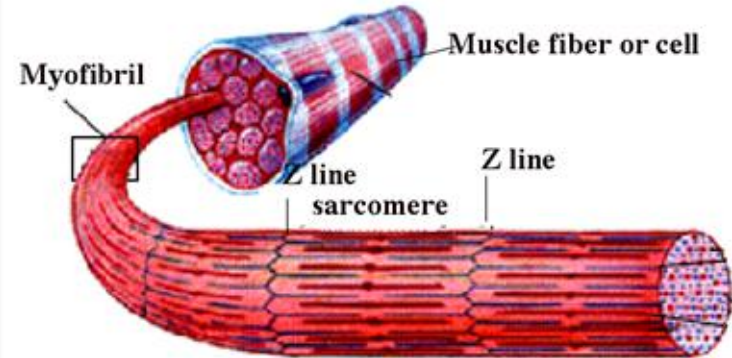


A sarcomere is a repeating unit of a striated muscle cell.

In between two Z-lines, we find overlapping actin and myosin fibres.

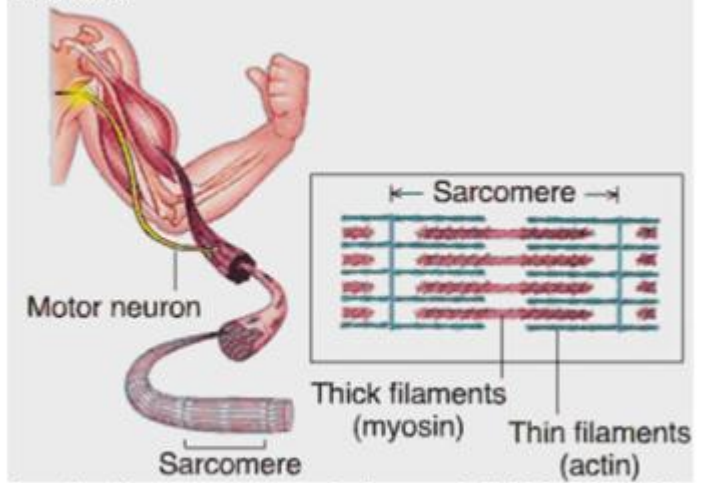


http://www.brookscole.com/chemistry_d/templates/student_resources/shared_resources/animations/muscles/muscles.html



<http://www.ucl.ac.uk/~sjjgsc/muscleSlidingFilament.html>

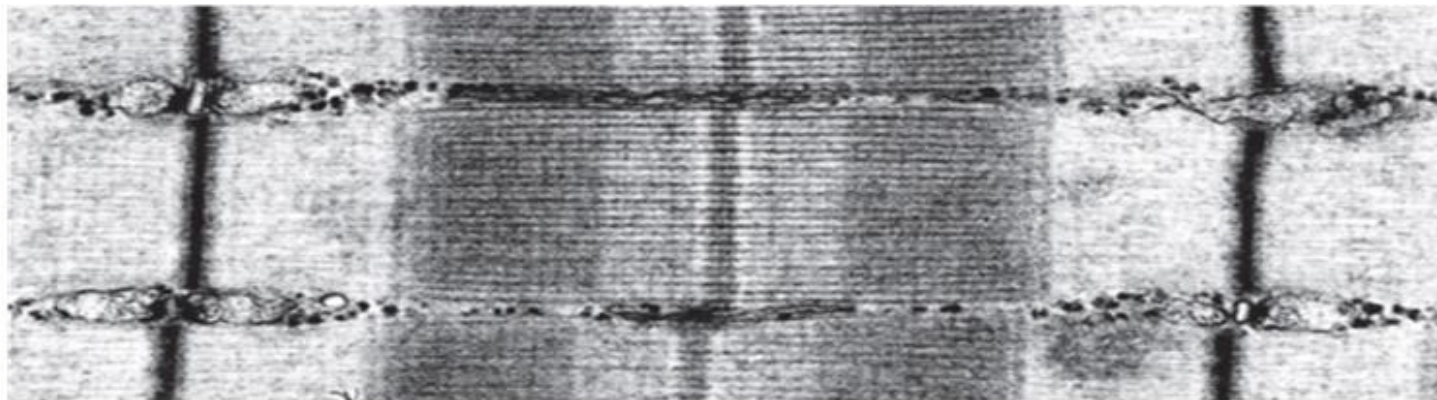
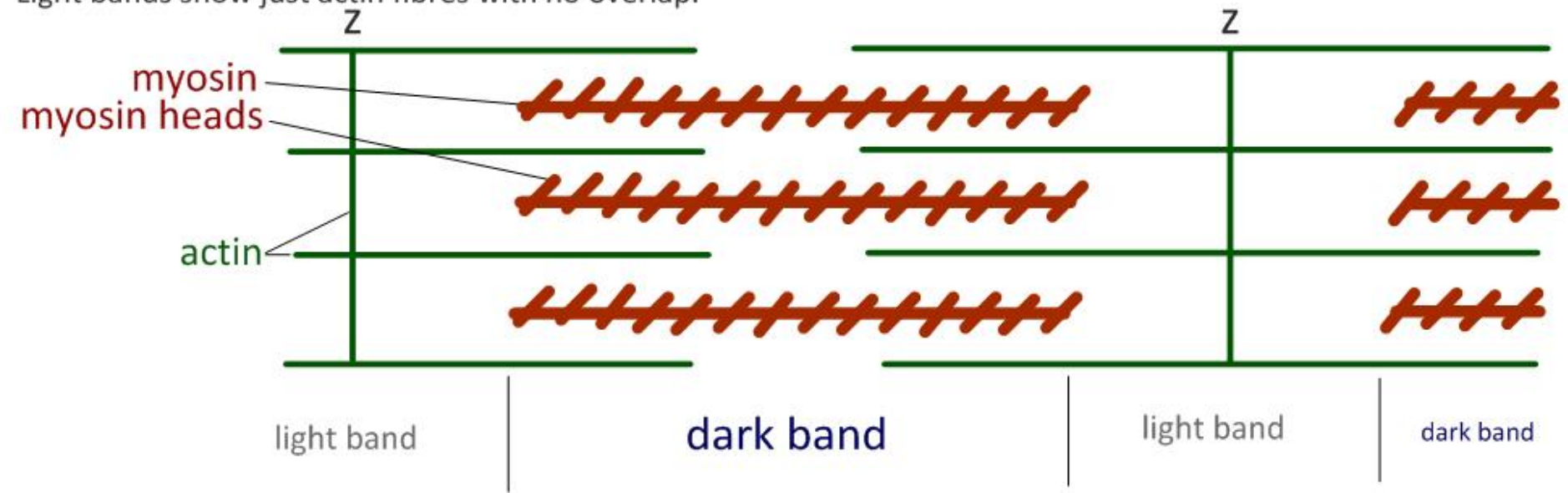
Watch:



http://media.pearsoncmg.com/bc/bc_campbell_biology_6/cipl/ins/49/HTML/source/71.html

The sarcomere

Where we see dark bands, the actin and myosin are overlapping.
Light bands show just actin fibres with no overlap.

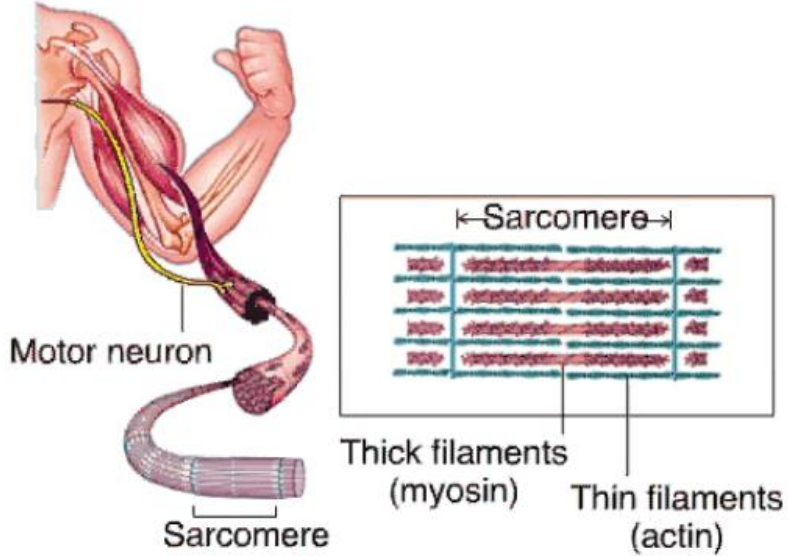
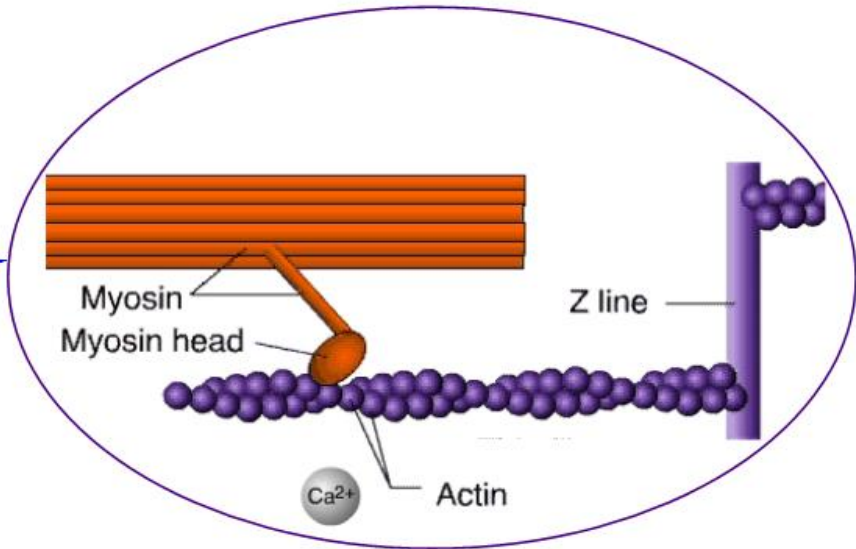
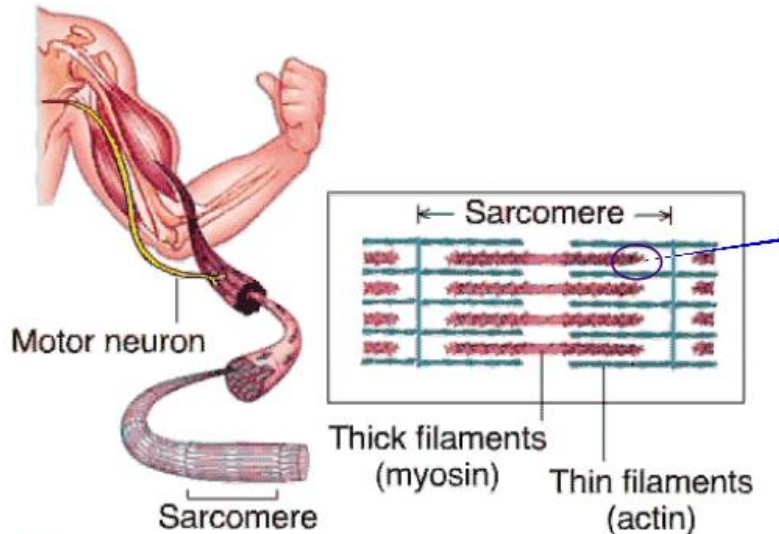


<http://www.ks.uiuc.edu/Research/telethonin/MuscleL1.jpg>

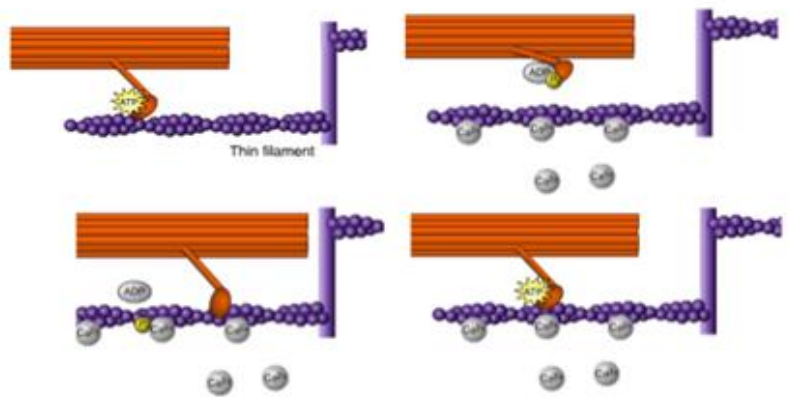
Electron microscope image



When muscles contract, actin slides over the myosin and causes the sarcomere to shorten:



How does it work?
Watch this:



http://media.pearsoncmg.com/bc/bc_campbell_biology_6/cipl/ins/49/HTML/source/71.html

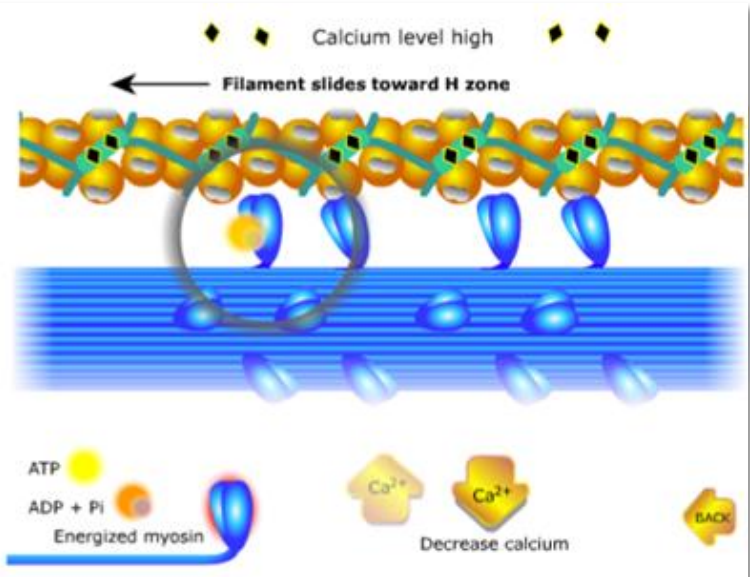
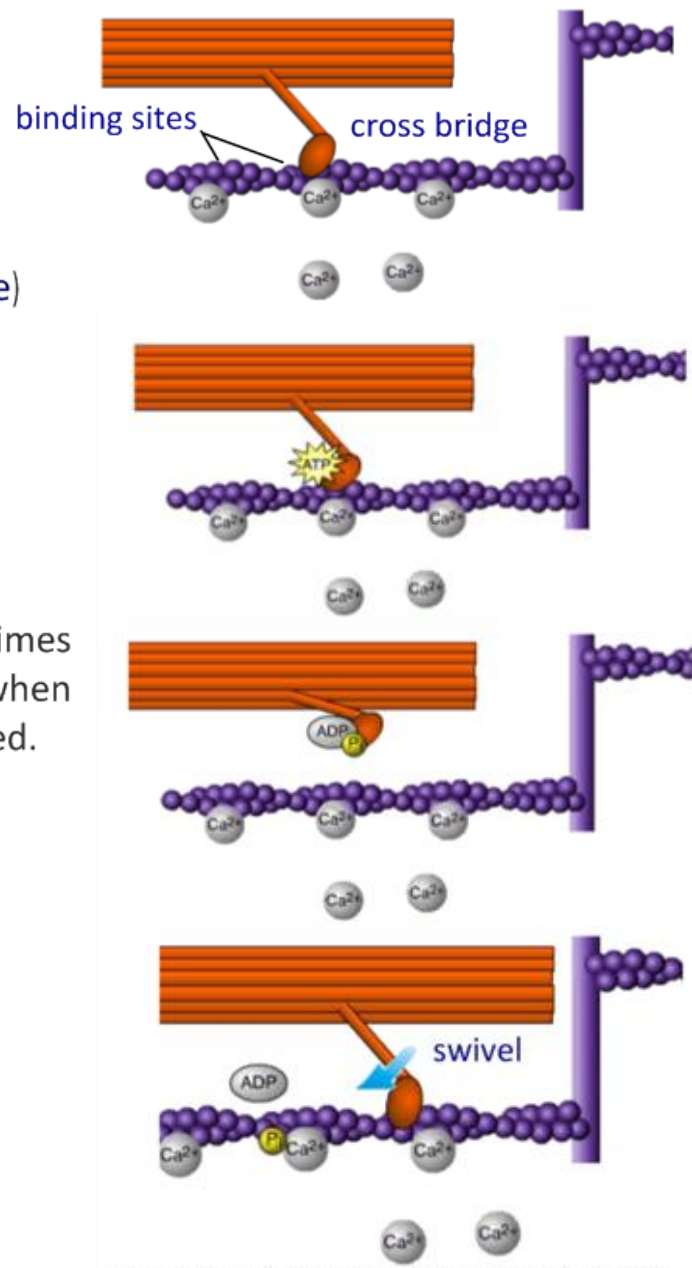
http://media.pearsoncmg.com/bc/bc_campbell_biology_6/cipl/ins/49/HTML/source/71.html 49-31-MuscleContraction.mov

Skeletal muscle contractions:

When an **action potential (AP)** reaches a striated muscle cell, the **sarcoplasmic reticulum releases calcium ions Ca^{2+}** into the myofibrils. Ca^{2+} opens up **binding sites** on actin.

Myosin heads are bound to **actin binding sites** (making a **cross bridge**) and are stimulated to move. This causes the **actin to slide over myosin**, towards the centre of the **sarcomere**.

ATP releases the myosin head and re-sets it. It forms a new cross bridge with a different actin binding site and continues contraction.



This happens up to 5 times per second and ends when no more Ca^{2+} is released.

<http://www.blackwellpublishing.com/matthews/myosin.html>

http://media.pearsoncmg.com/bc/bc_campbell_biology_6/cipl/ins/49/HTML/source/71.html

Explain how skeletal muscle contracts.

(8 marks)

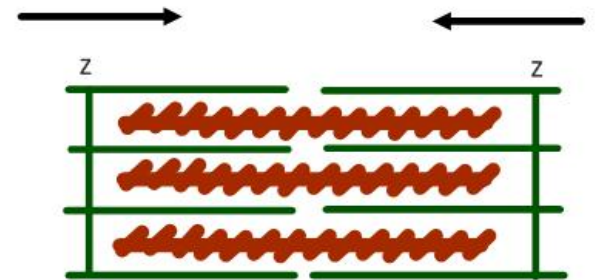
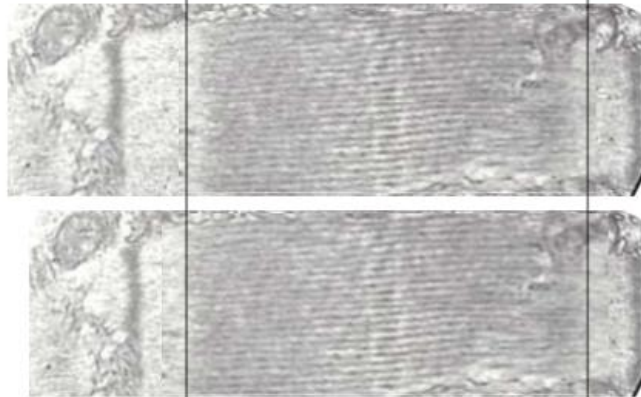
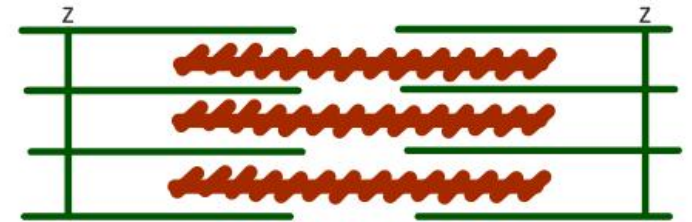
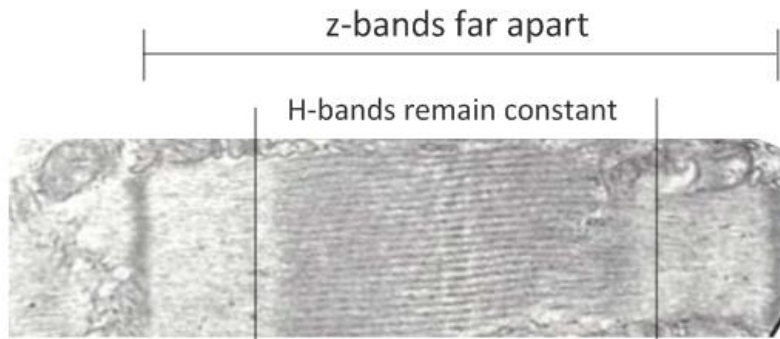
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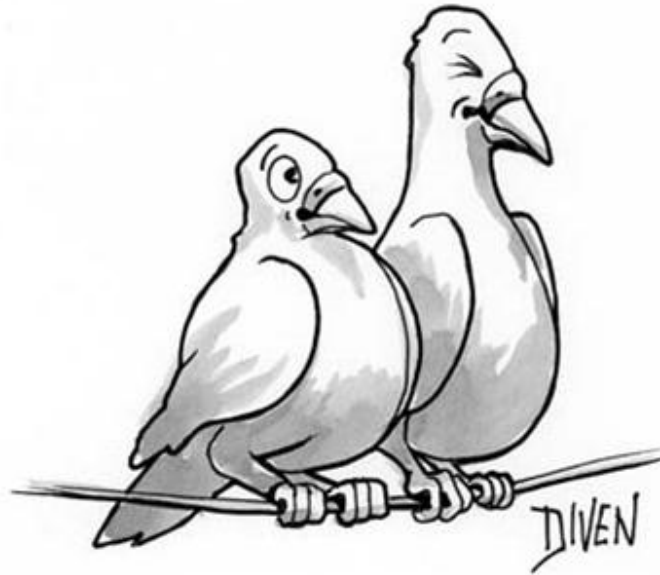
(8 marks)

muscles/fibres/myofibrils contain (repeating) units called sarcomeres;
muscle/sarcomeres contain actin filaments and myosin filaments;
actin fibres are thin and myosin fibres are thick;
arriving action potential causes release of Ca^{2+} ;
from sarcoplasmic/endoplasmic reticulum;
 Ca^{2+} binds to troponin;
causing troponin and tropomyosin to move (on actin);
exposing binding sites on actin / for myosin;
ATP binds to myosin heads releasing them / breaking cross bridges;
ATP hydrolysed / split into ADP + P_i ;
ATP/energy causes myosin heads to change shape / swivel / become cocked;
myosin heads bind / form cross-bridges to (exposed) actin binding sites;
myosin heads swivel / move actin (releasing ADP + P_i);
myosin filaments move actin filaments towards centre of sarcomere;
sliding of filaments / actin and myosin shortens the sarcomere;

(From the QuestionBank CDRom)

Electron micrographs showing contraction of one sarcomere:





Foot cramp?

For more IB Biology resources:

<http://sciencevideos.wordpress.com>