DP Biology – B3.3 (HL only)

# Muscle and movement

- How do muscles contract and produce movement?
- What do animals gain from having muscle tissue?

HL statements B3.3.1–10. Textbook pp. 326–340.



Image: a humpback whale breaching. Giles Laurent, CC BY-SA 4.0.

# Objectives for each class

| Class | Statements | By the end of the class, you can... |
|---|---|---|
| **1** | B3.3.1, B3.3.9 | Compare motile and sessile organisms, and give reasons why animals move from place to place |
| **2** | B3.3.2 | Explain how actin and myosin slide to shorten a muscle |
| **3** | B3.3.3, B3.3.8 | Explain how titin and antagonistic muscles return a muscle to its length, using the intercostal muscles |
| **4** | B3.3.4 | Describe a motor unit and how it controls a muscle |
| **5** | B3.3.5 | Explain how skeletons anchor muscles and act as levers |
| **6** | B3.3.6–7 | Explain movement at the hip joint and measure the range of motion of joints |
| **7** | B3.3.10 | Explain how marine mammals are adapted for swimming |

# Everything moves

B3.3.1



Barnacles: sessile adults. Chris Light, CC BY-SA 4.0.

| | Motile | Sessile |
|---|---|---|
| **Meaning** | Moves from place to place | Fixed in one place |
| **Example** | Humpback whale | Barnacle, coral |
| **Movement** | Whole body: swimming, walking, flying | Parts only: feeding cirri, tentacles |

## Key idea

Movement is a feature of all living things. Sessile animals still move parts of their bodies to feed, and often have a motile larval stage that finds a new place to settle. Plants move too, by growing towards light or, in the Venus flytrap, by closing a trap.

# Why animals move

B3.3.9

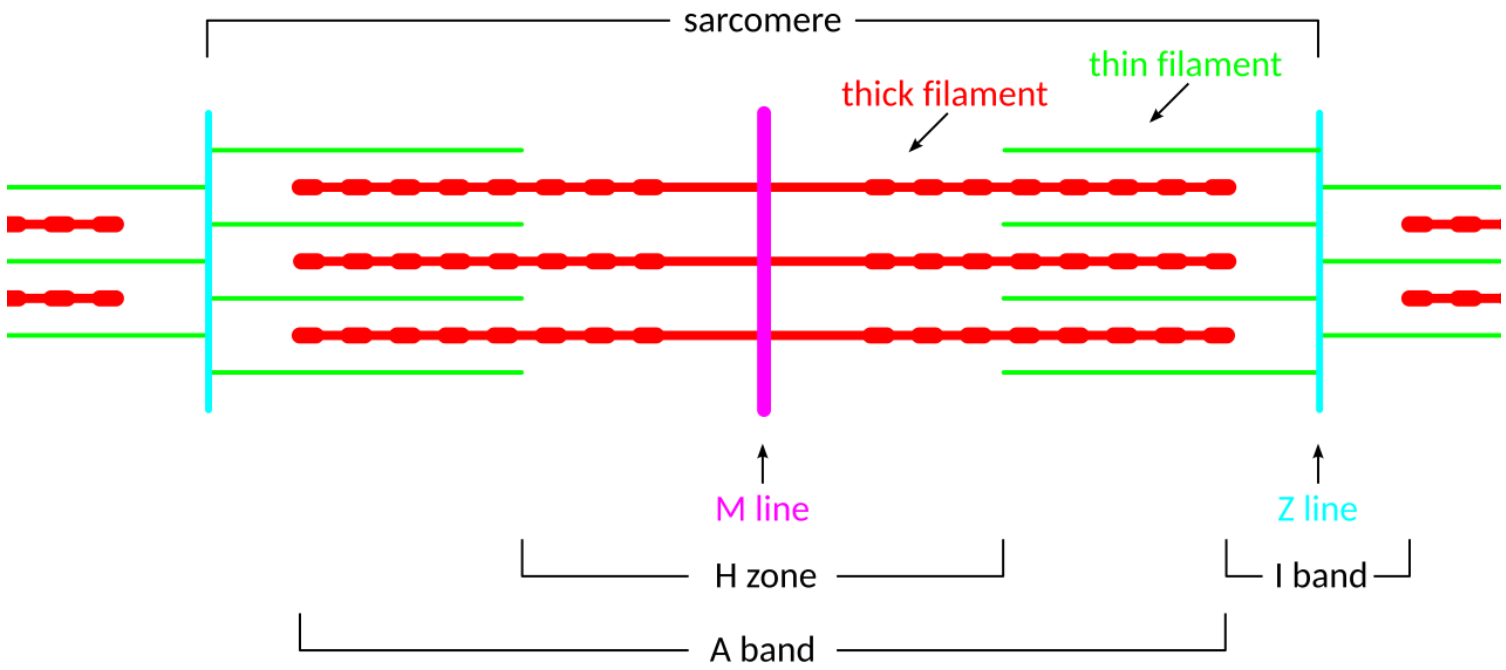
| Reason | Example |
|---|---|
| **Foraging for food** | Honey bees fly kilometres to collect nectar and pollen |
| **Escaping danger** | Impala leap away from a lion; squid jet away using their mantle |
| **Searching for a mate** | Male moths fly towards the scent of a female |
| **Migration** | Humpback whales swim between cold feeding waters and warm breeding waters each year |

**Research**

Find one more example of each reason, from a different animal group.

# The sarcomere

B3.3.2




A sarcomere: thick (myosin) and thin (actin) filaments. CC BY-SA 3.0.

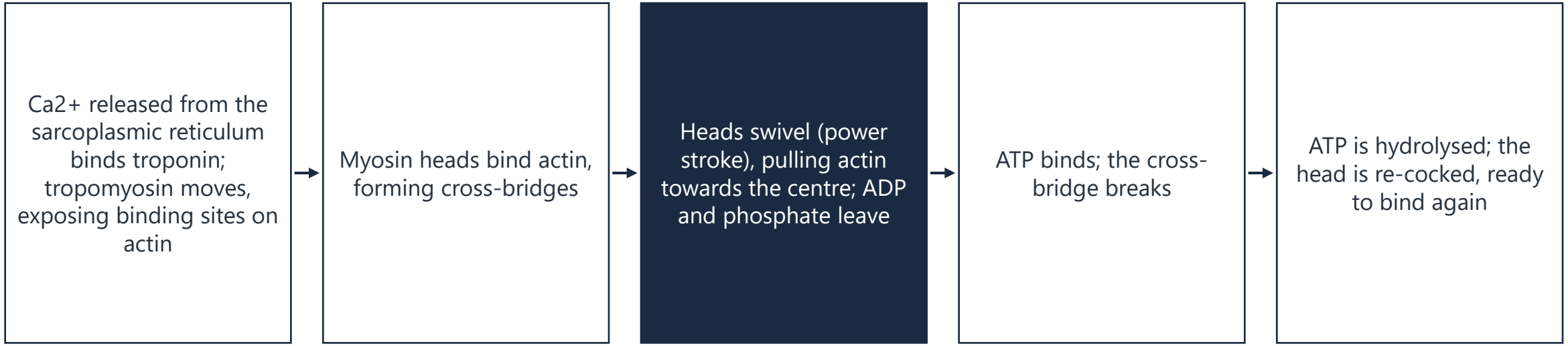
- A muscle fibre contains many myofibrils
- Each myofibril is a chain of **sarcomeres**, from one Z line to the next
- Thick filaments are **myosin**; thin filaments are **actin**
- The overlap makes the light and dark bands (striations)

## In contraction

Actin filaments slide over myosin towards the centre of the sarcomere. The Z lines move closer and the light band and H zone get shorter, but the filaments themselves do not change length.

# How the filaments slide

B3.3.2

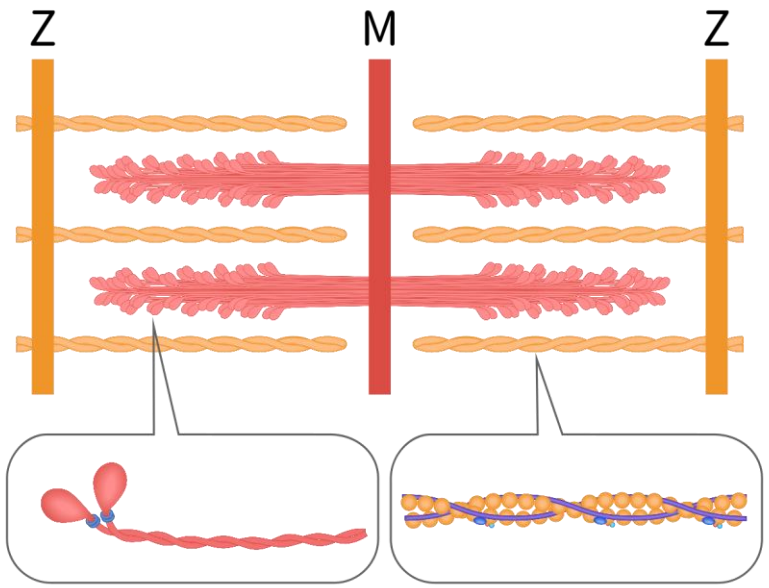



## Think about it

After death, ATP runs out and muscles lock stiff (rigor mortis). Use the cycle to explain why. Then explain why contraction stops when calcium ions are pumped back into the sarcoplasmic reticulum.

# Titin and antagonistic muscles

B3.3.3




- Muscles can only pull: they exert force only when they contract
- So muscles work in **antagonistic pairs**: when one contracts, it stretches the other
- **Titin**, the largest known protein, runs from the Z line to the middle of the sarcomere
- When stretched, titin stores energy like a spring and helps the sarcomere recoil
- It also stops the sarcomere being overstretched

Sarcomere detail. DBCLS, CC BY 4.0.

### Example

Biceps and triceps: the biceps bends (flexes) the elbow, the triceps straightens (extends) it.

# Intercostal muscles: an antagonistic pair

B3.3.8

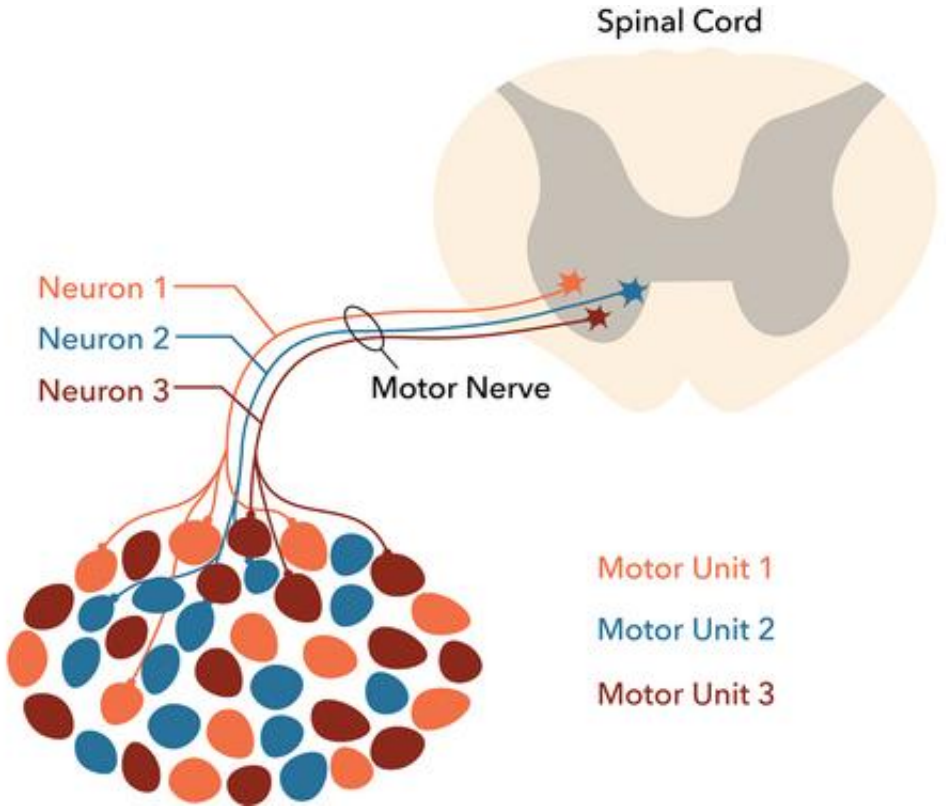
| | External intercostals | Internal intercostals |
|---|---|---|
| **Fibre direction** | Run one way between ribs | Run at right angles to the external layer |
| **When they contract** | Ribs move up and out: inhalation | Ribs move down and in: forced exhalation |
| **Effect on the other layer** | Stretch the internal layer, storing energy in its titin | Stretch the external layer, storing energy in its titin |

### Key idea

Because the fibres in the two layers run in different directions, the same contraction moves the ribs in opposite directions. Each layer resets the other.

# Motor units

B3.3.4




Three motor units in one muscle. D. Walsh and A. Sved, CC BY-SA 4.0.

- A **motor unit** is one motor neuron and all the muscle fibres it controls
- The neuron branches; each branch ends at a **neuromuscular junction** on one fibre
- Acetylcholine released there triggers contraction of the fibre
- All fibres in a unit contract together

### Fine and strong control

Eye muscles have small units (a few fibres each) for precise control. Leg muscles have large units. More force comes from using more units at once.

# Skeletons: anchors and levers

B3.3.5

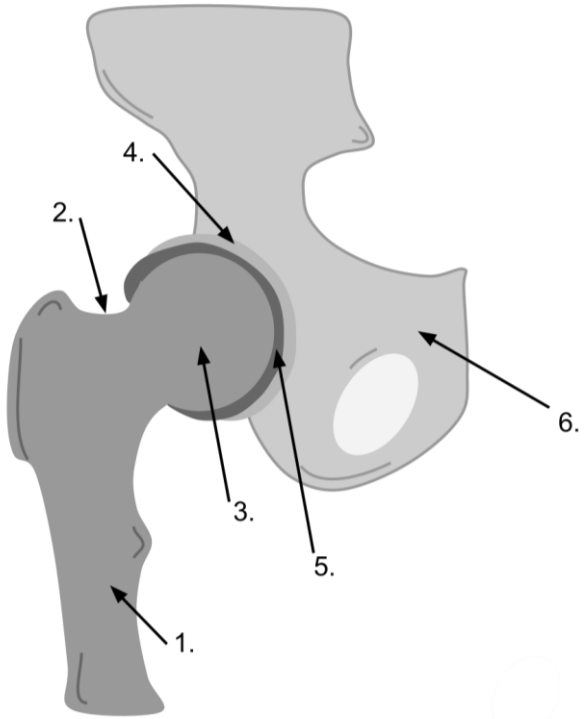
| | Exoskeleton | Endoskeleton |
|---|---|---|
| **Where** | Outside the body | Inside the body |
| **Example** | Arthropods such as insects and crabs | Vertebrates |
| **Muscles attach** | To the inside of the skeleton | To the outside of bones, by tendons |

### Levers

A bone is a lever and the joint is the pivot (fulcrum). A muscle applies the effort where its tendon attaches, and the load is the weight being moved. Levers can change the size, speed and direction of the movement. Muscles attached close to a joint give fast, wide movements.

# The hip: a synovial joint

B3.3.6




| Part | Role |
|---|---|
| **Femur and pelvis** | The bones that move; ball (femur head) fits the socket |
| **Cartilage** | Smooth layer that reduces friction and absorbs shock |
| **Synovial fluid** | Lubricates the joint |
| **Ligaments** | Join bone to bone; stop unwanted movement |
| **Muscles and tendons** | Muscles pull; tendons join them to bones |

Hip joint: femur head in the pelvis. Kcotton15, CC BY-SA 4.0.

# Range of motion



| Joint | Type | Movement |
| --- | --- | --- |
| **Hip, shoulder** | Ball and socket | In three planes, and rotation |
| **Elbow, knee** | Hinge | Mainly in one plane: flexion and extension |

### Practical

Use a goniometer (a protractor with two arms) or an app on a phone to measure the angle through which a joint moves. Compare hip and knee, or compare people. Keep the starting position and the method the same each time.

### Variables

Range of motion depends on joint type, and can be affected by age, training, injury and warming up.

# Built for swimming: marine mammals

B3.3.10



Humpback whale. Giles Laurent, CC BY-SA 4.0.

| Adaptation | How it helps |
|---|---|
| **Streamlined body** | Less drag in water |
| **Flippers** | Forelimbs for steering and balance |
| **Fluke** | Tail moved up and down for thrust (fish tails move side to side) |
| **Blowhole** | Breathe at the surface without lifting the head; airway is separate from the gut |

**Link**

Whales and dolphins descend from land mammals. Their flippers still contain the same bones as a human arm, and the up-and-down tail movement comes from the way land mammals bend their backs when running.

# Check that you can explain

1. Motile and sessile organisms, and four reasons for locomotion
2. The structure of a sarcomere and the cross-bridge cycle
3. Why muscles need antagonists, and the role of titin
4. How the intercostal muscles move the ribcage
5. What a motor unit is
6. Exoskeletons, endoskeletons and levers
7. The parts of the hip joint and the range of motion of joints
8. Adaptations of marine mammals for swimming

# Exit activity: 5 minutes

**On your own and without notes. Hand this in as you leave.**

1. State the role of calcium ions in muscle contraction.
2. Explain why muscles work in antagonistic pairs.
3. State two adaptations of whales for swimming.

# Image credits

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Barnacles 2165.jpg – Chris Light – CC BY-SA 4.0

Sarcomere diagram.svg – SlothMcCarty – CC BY-SA 3.0

202107 Structure of skeletal muscle.svg – DataBase Center for Life Science (DBCLS) – CC BY 4.0

Motor unit.png – Daniel Walsh and Alan Sved – CC BY-SA 4.0

Ball and Socket Joint (Hip joint).svg – Kcotton15 – CC BY-SA 4.0

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