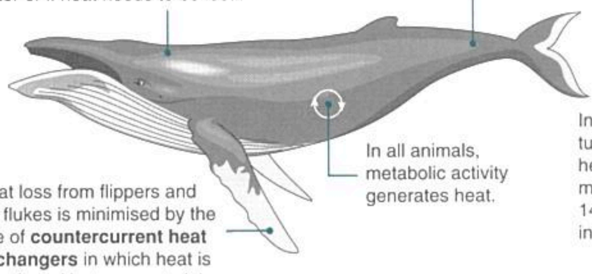
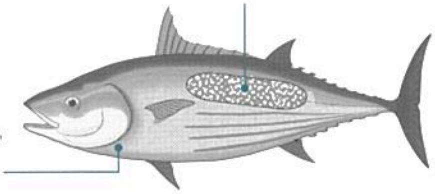
206 Control of Body Temperature

Key Idea: Animals control body temperature by exchanging heat with their environment.

For a body to maintain a constant temperature heat losses must equal heat gains. Heat exchanges with the environment occur via three mechanisms: **conduction** (direct heat transfer), **radiation** (indirect heat transfer), and **evaporation**. The importance of each of these mechanisms depends on environment, i.e. air or water.

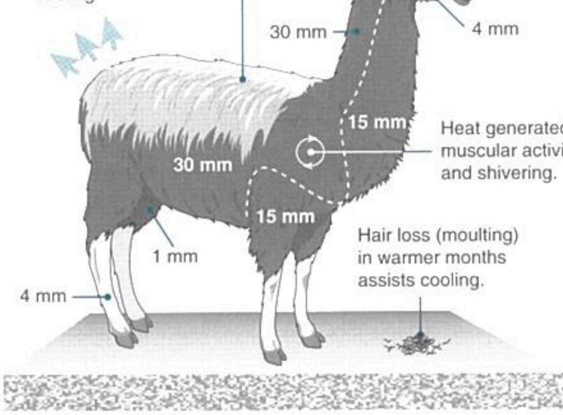


Water has a great capacity to transfer heat away from organisms; its cooling power can be more than 50 times greater than that of air. For most aquatic animals (with the exception of aquatic birds and mammals and a few fish) heat retention is impossible. Instead, they carry out their metabolic activities at the ambient temperature. For most marine organisms this does not fluctuate much.

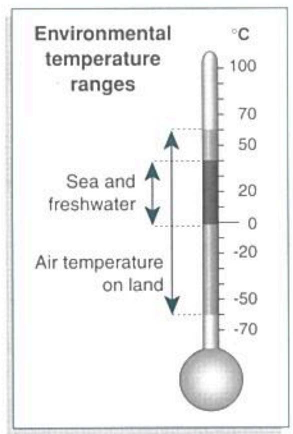


Temperature regulation mechanisms in water

- Low metabolic activity
- Heat generation from metabolic activity
- Insulation layer of blubber
- Changes in circulation patterns when swimming
- Large body size
- Heat exchange systems in limbs or high activity muscle



For most mammals, the thickness of the fur or hair varies around the body (as indicated above). Thermoregulation is assisted by adopting body positions that expose or cover areas of thin fur (the figures above are for the llama-like guanaco).



Temperature regulation mechanisms in air

- Behaviour or habitat choice
- Heat generation from metabolic activity
- Insulation (fat, fur, feathers)
- Changes in blood flow
- Large body size
- Sweating and panting
- Tolerance of fluctuation in body temperature

Animals adapted to temperature extremes (hot or cold) can often tolerate large fluctuations in their body temperature before they become stressed. In camels, the body temperature may fluctuate up to 7°C (34°C to 41°C) over a 24 hour period.

Panting to lose accumulated heat is important in dogs, which have sweat glands only on the pads of their feet.

Circulation changes slow heat loss in water and speed heat gain when basking on land in marine iguanas.

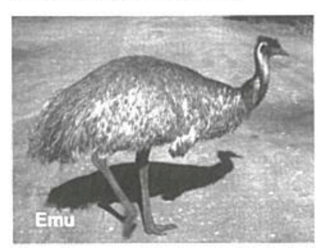
Thick blubber and large body size in seals and other marine mammals provide an effective insulation.

Mammals and birds in cold climates, like the musk oxen above, cluster together to retain body heat.

Behaviours to reduce heat uptake via conduction, e.g. standing on two legs, are important in desert lizards.

Bumblebees can heat up their flight muscles by shivering. Their thick fuzz conserves the heat they produce.

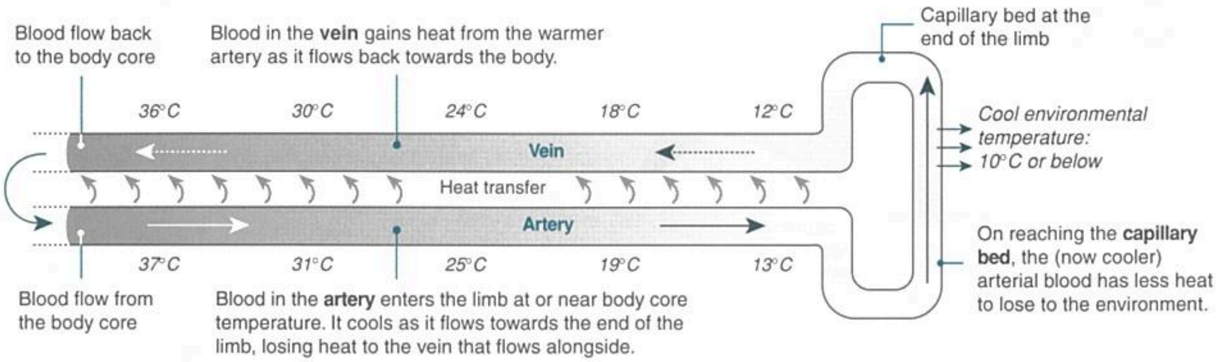
Thick hair, fur or wool traps air next to the skin. This insulating air layer reduces heat loss and slows heat gain.



The plumage of birds acts similarly to fur or hair in mammals. The feathers trap air which slows heat gain and loss.

Countercurrent Heat Exchange Systems

Countercurrent heat exchange systems occur in both aquatic and terrestrial animals as an adaptation to maintaining a stable core temperature. The diagram illustrates the general principle of countercurrent heat exchangers: heat is exchanged between incoming and outgoing blood. In the flippers and fins of whales and dolphins, and the legs of aquatic birds, they minimise heat loss. In some terrestrial animals adapted to hot climates, the countercurrent exchange mechanism works in the opposite way to prevent the head from overheating: venous blood cools the arterial blood before it supplies the brain.



1. (a) How does water differ from air in the way in which it transmits heat away from the body of an organism?

   (b) Identify two ways in which a "warm bodied" animal can maintain its internal temperature in water:

   (c) How does a large body size assist in maintaining body temperature in both aquatic and terrestrial species?

   (d) How do small terrestrial animals compensate for more rapid heat loss from a high surface area?

2. (a) How does thick hair or fur assist in thermoregulation in mammals?

   (b) Why is fur/hair thickness variable over different regions of a mammal's body?

   (c) How would you expect fur thickness to vary between related mammal species at high and low altitude?

   (d) How do marine mammals compensate for lack of thick hair or fur?

3. (a) Why do fast swimming fish use countercurrent exchange mechanisms in their swimming muscles?

   (b) In some large sharks (e.g. white pointer and mako), countercurrent exchangers are used to maintain a higher temperature around the gut. What is the advantage of this adaptation?

4. (a) What is the role of group behaviour in temperature regulation in some animals?

   (b) Name an animal, other than musk oxen, that uses this behaviour: