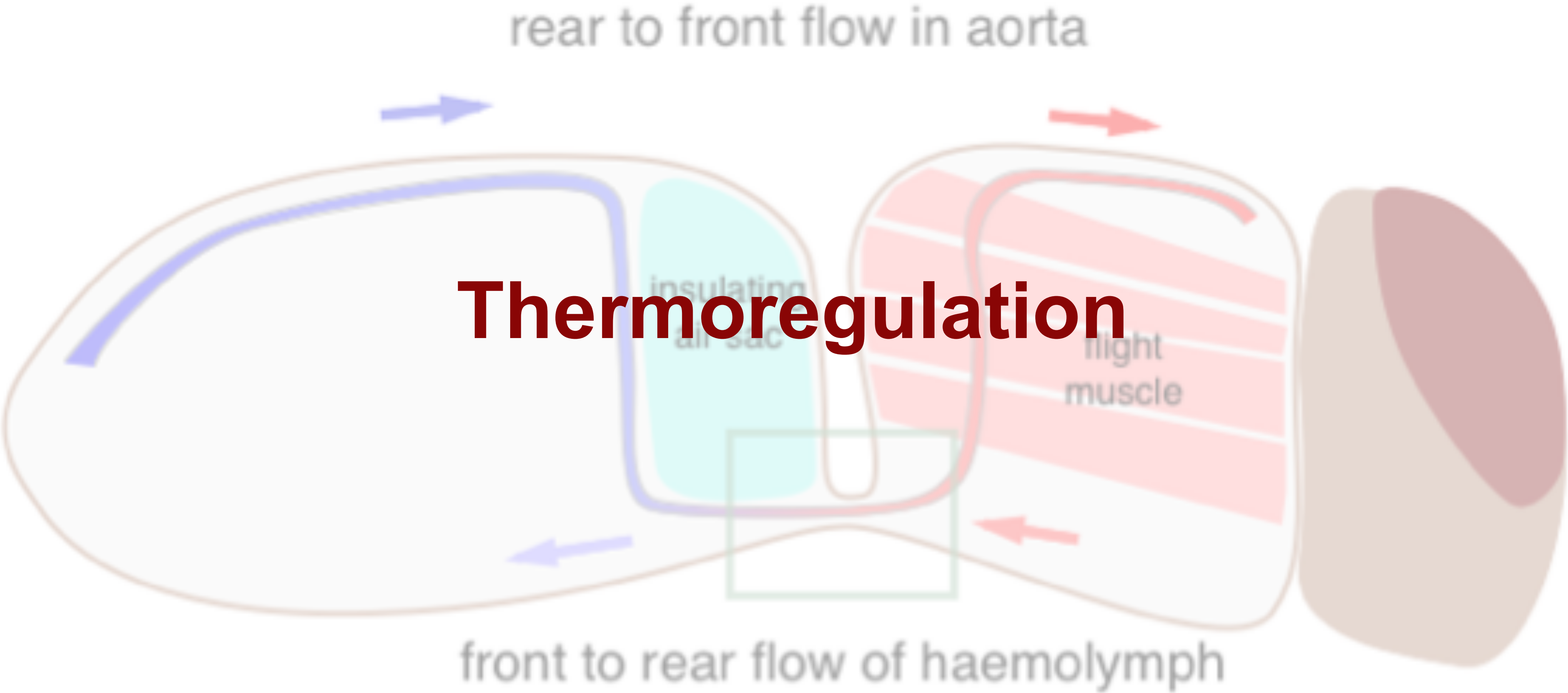
BIOL3238

Thermoregulation



Presented and prepared by D Merritt

Thermoregulation

Thermoregulation is the active control of heat gain or loss to keep body temperature within a specific range.

Temperatures of above 40 degrees or below 0 degrees are generally lethal

Homeothermy. Body temperature is relatively constant and independent of ambient temperature. The term is usually applied to birds and mammals.
Poikilothermy. Body temperature is variable and dependent on ambient temperature.
Endothermy. Heat that determines body temperature is produced by the animal's own energy metabolism. The only continuously endothermic terrestrial animals are birds and mammals.
Ectothermy. Heat that determines body temperature is acquired from the environment by radiation, convection, or conduction.
Heterothermy. Endothermic part of the time and ectothermic part of the time.
Regional Heterothermy. Can switch between endo- and ecto-thermy but do so only in particular parts of the body, i.e. by maintaining temperature “zones” in the body

Thermoregulation

Heat balance can be described by the equation:

$$\frac{dH}{dt} = M - C\,(T_b - T_a)$$

dH/dt: change in heat in the body per unit time

M: amount of heat produced, eg. Metabolic heat

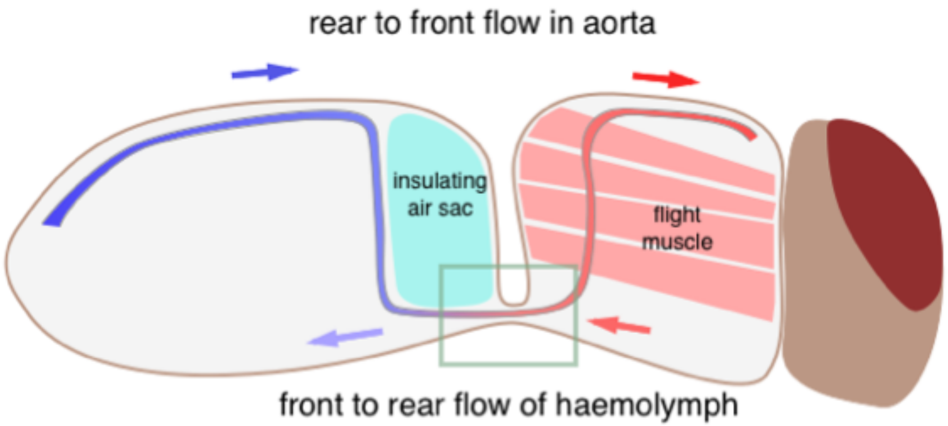
C*:* the body’s conductance or tendency to lose heat

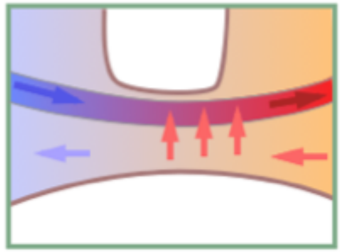
$T_b - T_a$: the difference between the body temperature and the ambient temperature.

Heat can be lost by conduction, convection, radiation, and evaporation.

Insect Flight

- High energy expenditure
- Flight muscles generate metabolic heat
- Heat dissipation in honeybee or moth
- Regional heterothermy
- Heat exchange occurs in abdomen/thorax junction
- Flight muscles adapted to work most efficiently at higher temperatures





heat exchange occurs at petiole

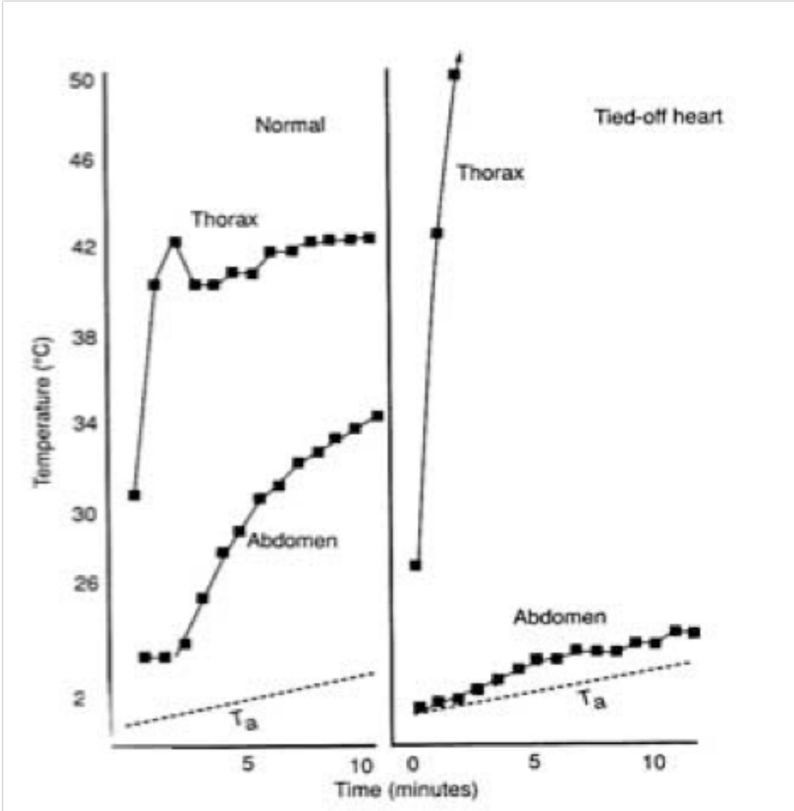
Thoracic haemolymph warmed by flight muscles
Backwards flow of haemolymph through petiole
Opposite flow of haemolymph in aorta
Heat exchanged from haemolymph to aorta at petiole
Heat loss through the abdomen

Insect Flight

Normal: thoracic temperature quickly rises and abdomen follows but not as high

Tied-off heart: abdominal temperature rise reduced

Thoracic temperature rises to lethal level



Warm-up & Cool-down

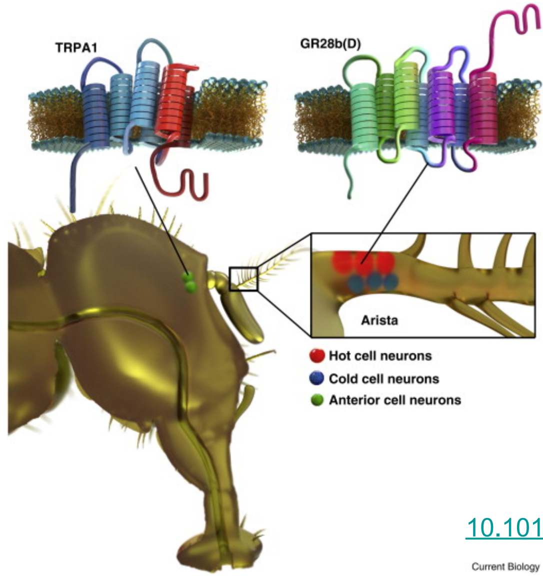
Shivering: muscles work against each other

Honeybees never cool down due to thermoregulation of nest so can forage in winter in temperate climates

Small insects rarely reach very high temperatures because the conductive heat loss is so high that the body temperature is near ambient even during flight

Lots of behavioural mechanisms seeking out appropriate temperature

Drosophila melanogaster selected to prefer high (top) or low (bottom) temperatures. Images are pictures from above of ~1000 flies on a laboratory thermal gradient.
https://www.ocf.berkeley.edu/~dillonm/research.php



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Current Biology

Cool-down Behaviours

Beetles: stilting and undertaking short flights

Honeybee evaporative cooling: regurgitate fluid from crop: under hot conditions “water-collectors” forage, return and distribute water. Fanning leads to cooling

Dragonflies vertical basking

Drinking water

Fog condensation structures

Cold & Heat Tolerance

Supercooling: temperature below 0 without freezing

Freeze tolerance: ice crystal formation does not damage tissue

Heat-shock proteins: expressed after exposure to high temperature

Social Insects

Honeybees

Ants

Termites