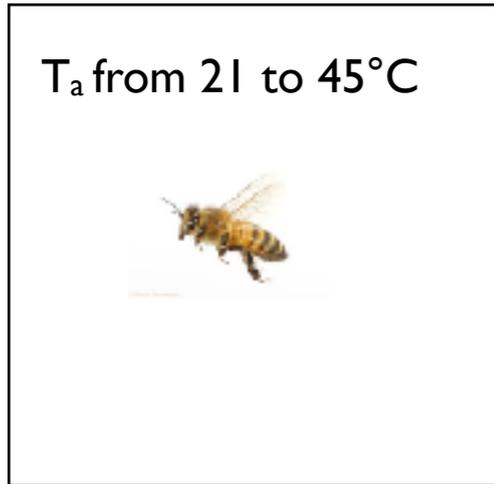


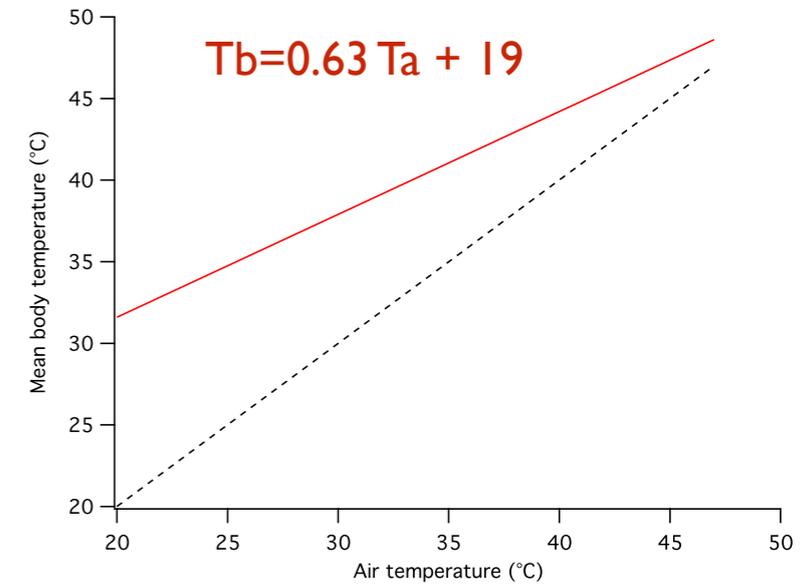
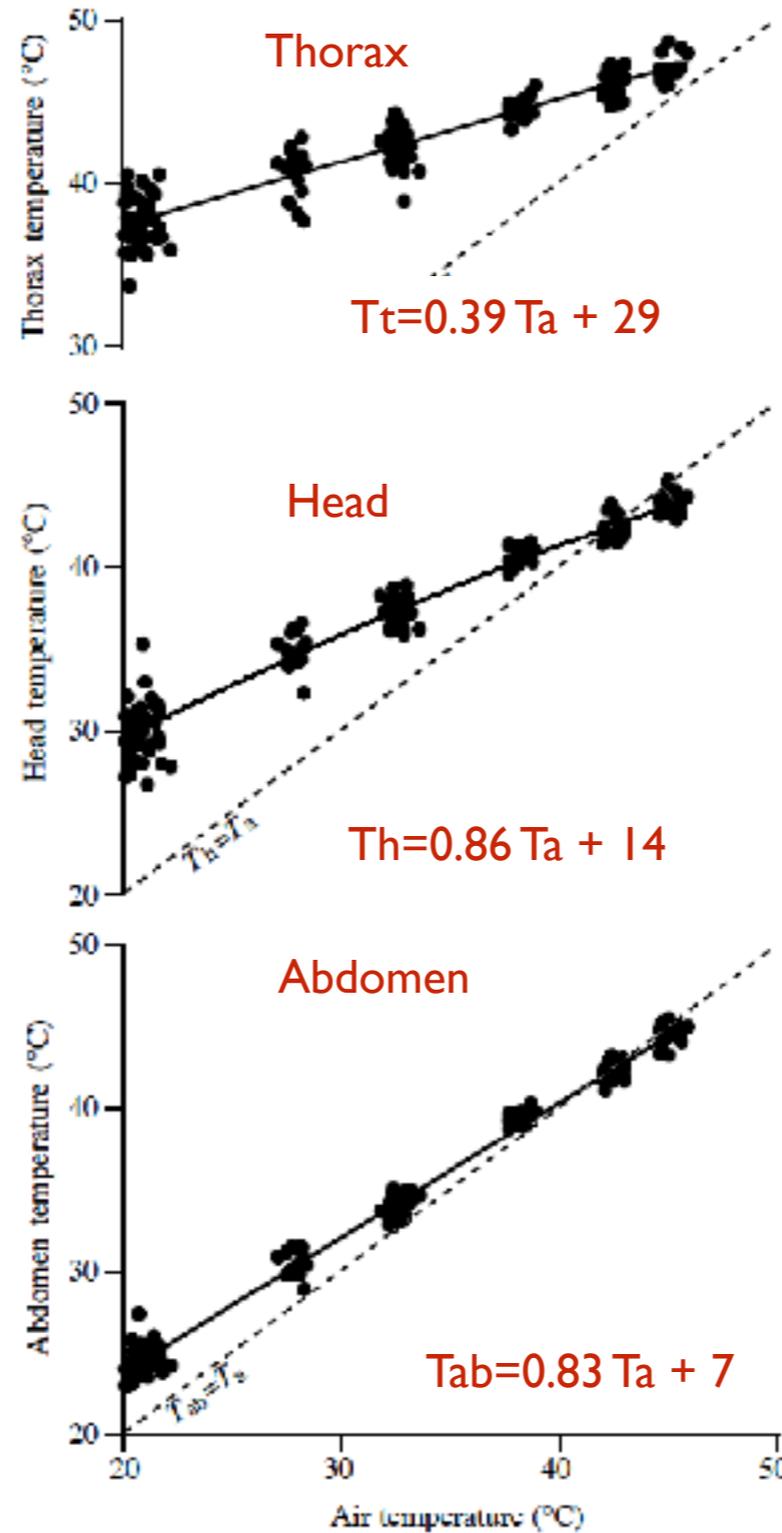
# The honeybee problem



- measurement of  $d[CO_2]/dt$  and  $d[H_2O]/dt$
- measurement of body temperature at different times

Mean body mass 75 mg  
 Mean surface areas  
 head 27 mm<sup>2</sup>  
 thorax 80 mm<sup>2</sup>  
 abdomen 63 mm<sup>2</sup>  
 total 170 mm<sup>2</sup>

Metabolic power 640 mW/g  
 Flight mechanical power 27 mW/g



Surface weighted average body temperature

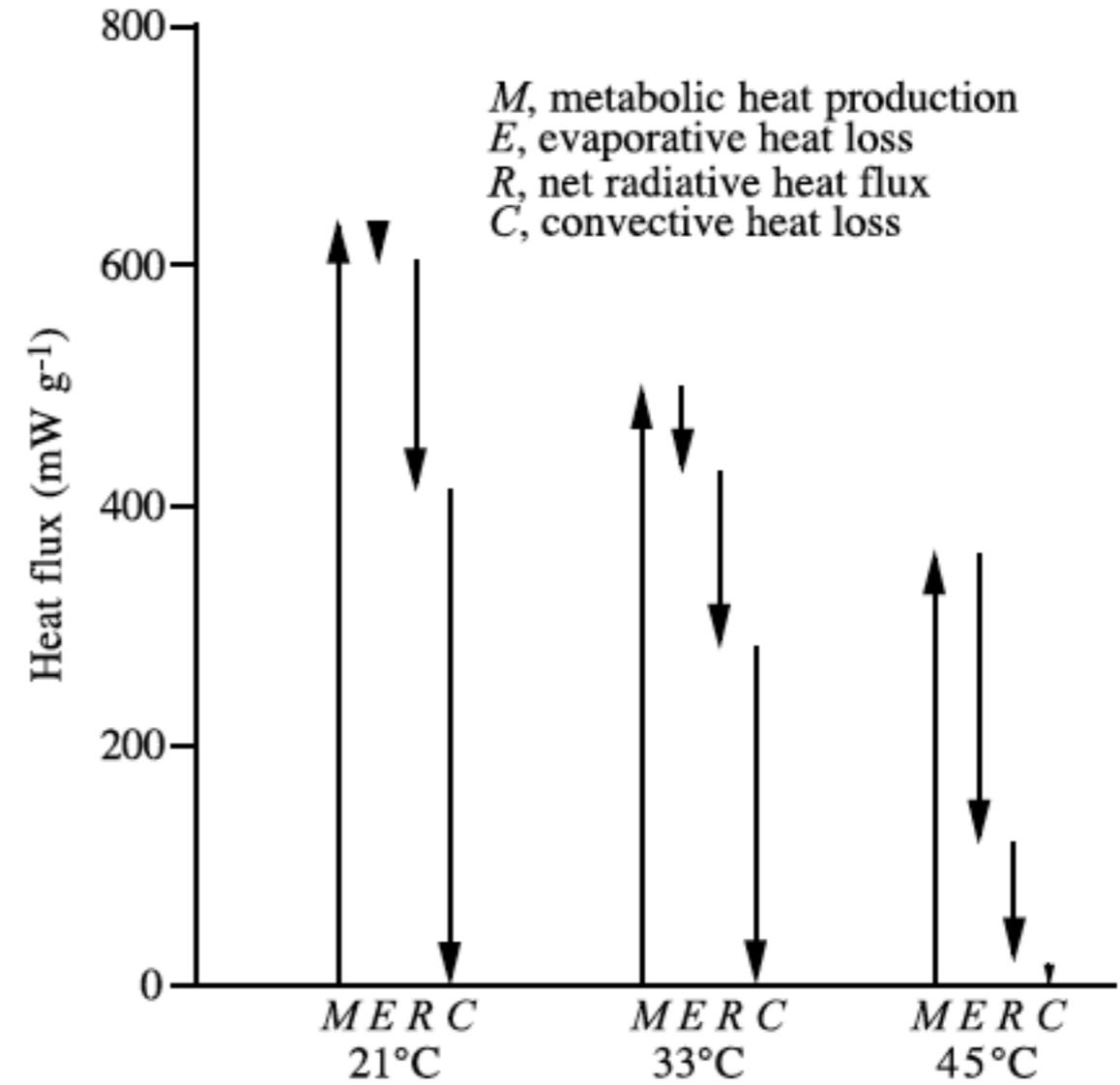
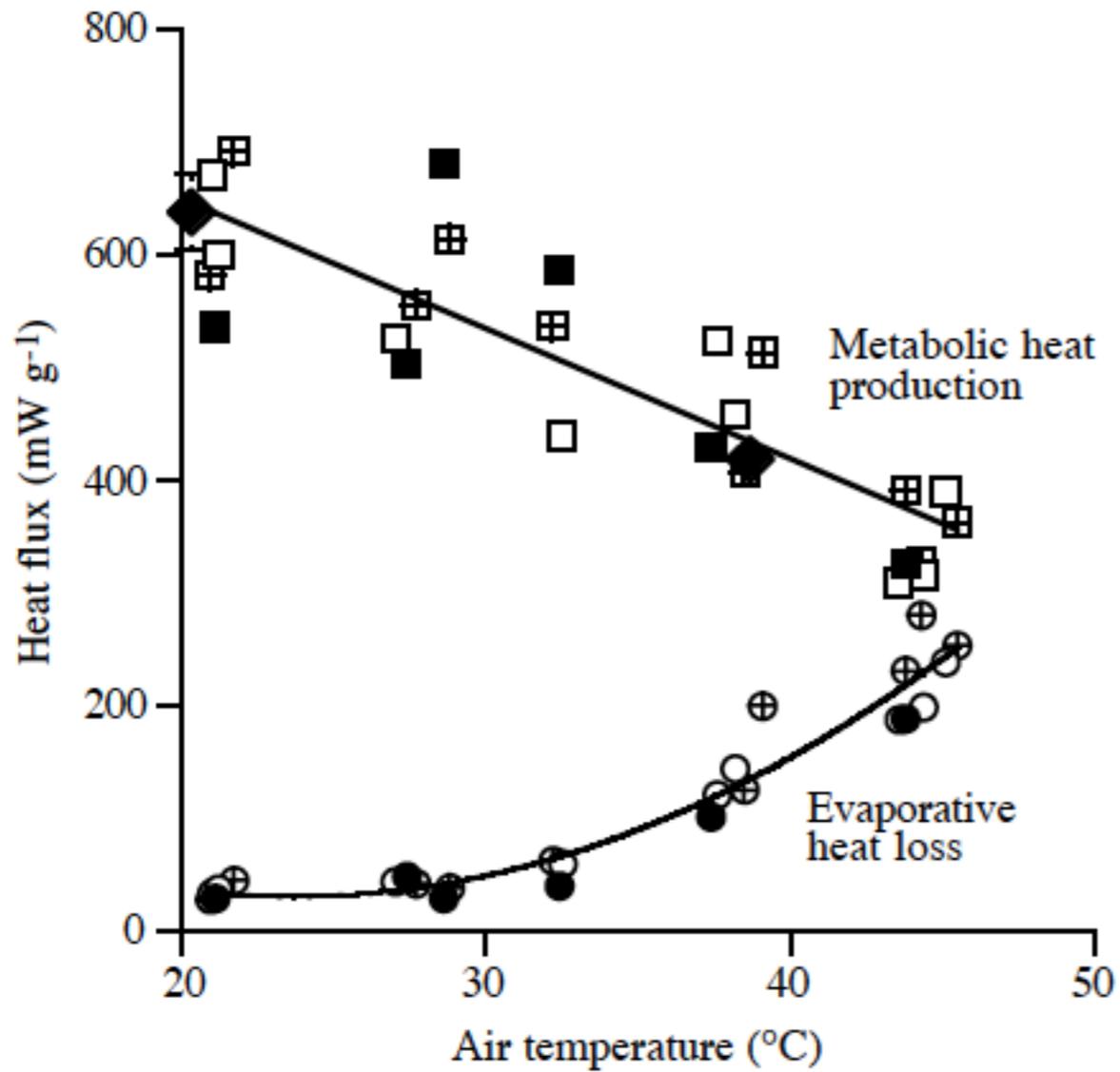
Body temperatures are independent of time

# The honeybee problem



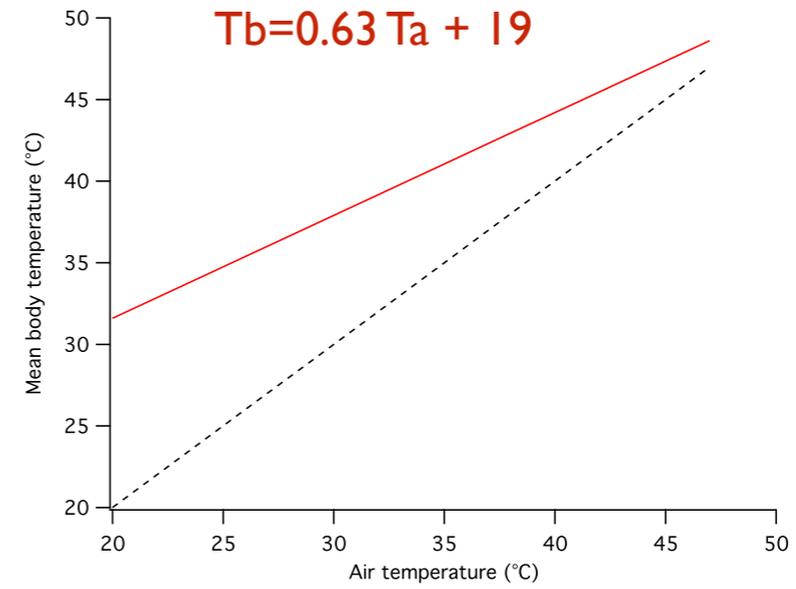
What are the different mechanisms involved in heat exchange ?  
Write the overall heat balance

# The honeybee problem



*C* is not measured but deduced from the overall heat balance

# The honeybee problem II

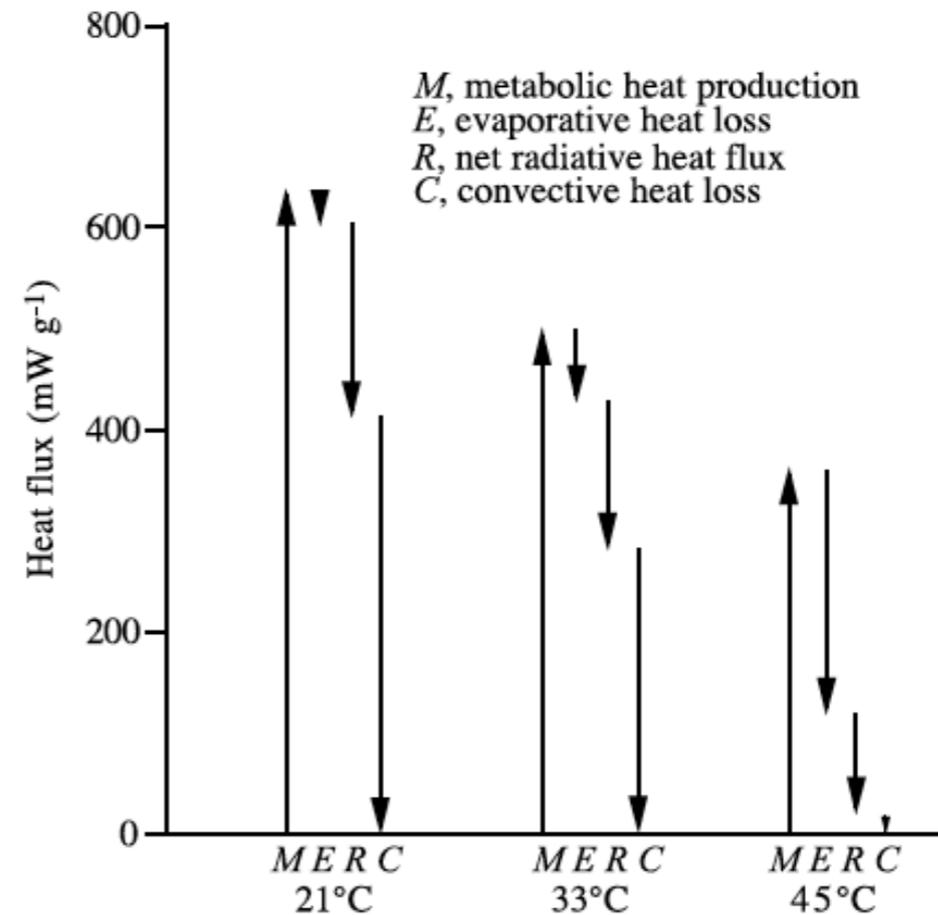


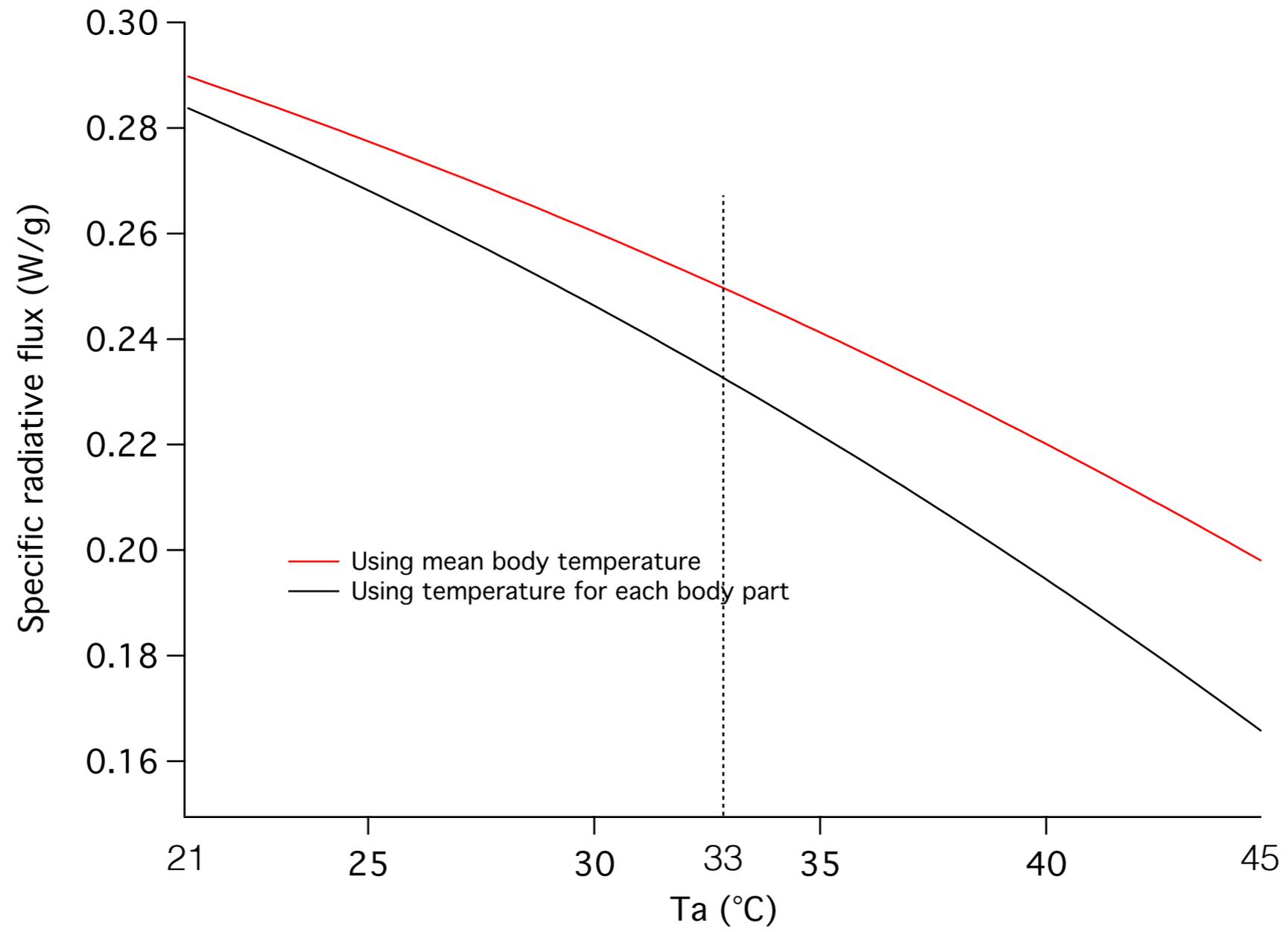
Estimate the heat flux due to radiation

body surface emissivity  $\epsilon_b$  0.98

emissivity of the glass container  $\epsilon_g$  0.90

Surface weighted average body temperature





# The honeybee problem



How can we estimate independently the heat transfer from the bee to the air ?

Is it dominated by diffusion or convection ?

If we evaluate an order of magnitude of this heat flux, is it consistent with the other measurements ?

Physical properties of air :

density  $\rho$  1 kg/m<sup>3</sup>

specific heat  $C_p$  1000 J/kg.K

thermal conductivity  $\lambda$  0.025 W/m.K