Temperature relations

Hot enough for you?

Outline
- Microclimate
- Ecological “laws” for individuals
- Temperature optima of organisms
- Temperature regulation by plants and animals

Microclimates
- What environmental conditions are most important for organisms?

Physiological ecology
- AKA ecophysiology
- How individual organisms respond to the abiotic environment:
  - Temperature
  - Water
  - Light
  - Nutrients

Underlying mechanism
- So, how do individual organisms ultimately respond to their environment?
- “Nothing in biology makes sense except in the light of evolution.”
  - Theodosius Dobzhansky (1900 – 1975)

Ecological “laws” (1)
- Patterns describing how individuals interact with their environment
  - Law of the minimum (von Liebig):
    - Always the same?
    - Co-limitation?
  - Law of limiting factors (Blackman):
Ecological “laws” (2)

- Law of tolerance (Shelford)

Life and temperature

- Life requires a certain temperature (or range of temperatures) for optimal metabolism
  - Cold environments & metabolic rate: prediction?
  - Hot environments & metabolic rate?
  - Why?
  - Overall result?

Trout and an enzyme

- Do trout show an optimum temperature for activity?
  - Acetylcholinesterase activity
  - Why these 2 temperatures?

Plants and temperature optima

- These last examples show natural selection selects for genetically-determined traits that allow the organism to be adapted physiologically to its thermal environment
- But, can an organism show shorter-term adjustments to changes in temperature (within certain evolutionary-set bounds) that allow it to be successful?
  - Acclimation
  - Temperature regulation

Take-home messages:

- Life is a compromise
  - Can you be adapted to all environmental conditions?
  - Once you have maximum fitness under one set of conditions, what does that mean if the environment changes or if you move?
  - Many species can co-exist in the same region by specializing in different conditions
Acclimation by desert shrubs

Temperature regulation
- Organisms must balance gains and losses of heat energy
- Direction of heat transfer?
- Types of heat transfer
  - Short-wave radiation
  - Long-wave radiation
  - Metabolism
  - Evaporation
  - Conduction
  - Convection

Global heat transfers

Desert plants & heat

Physiological groupings

Ectotherms
Endotherms
Heterotherms

Ectotherms (1)
- High thermal conductance
- Metabolic rate increases with increasing temperatures

Fig. 5.9: Eastern fence lizard

Schmidt-Nielsen 1997
Ectotherms (2)

- \( Q_{10} \)
- \( Q_{10} = R_T / R_{T,10} \)
  - Where \( R_T \) is the rate at any given body temperature \( T \)
  - \( R_{T,10} \) rate at body temperature \( T - 10^\circ C \)
- Typically \( Q_{10} \)'s are around 2, which means?

Ectotherms (3)

- How do you regulate your temperature in more extreme conditions that last a long time?
- Diapause
  - Usually genetically determined and timed by various environmental cues (e.g., light and temperature)

Rostgaard & Jacobsen 2005

Endotherms

Heterotherms (1)

- Roach
- Hawkmoth

Heterotherms (2)

- Desert tortoise

Heterotherms (3)

- Dormouse

Rostgaard & Jacobsen 2005

Figure 1. Sectional view of respiration chambers with instrumentation in place for measurements. Upper vertical parts of chambers were sided with silicone stoppers during the respiration period. \( 800 \) iuO/00 ml inserted in one chamber.