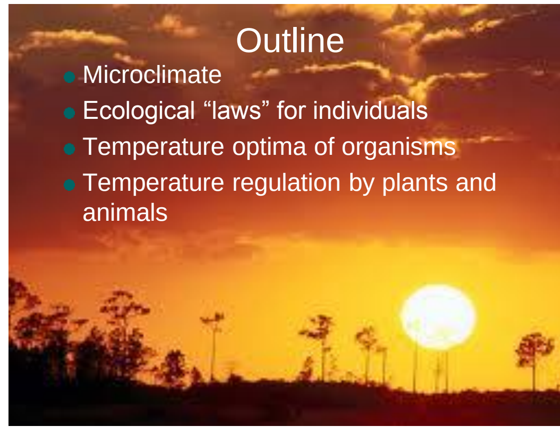
Temperature relations

Hot enough for you?

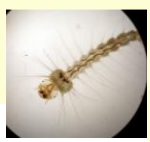


Outline

- Microclimate
- Ecological "laws" for individuals
- Temperature optima of organisms
- Temperature regulation by plants and animals

Microclimates

- What environmental conditions are most important for organisms?



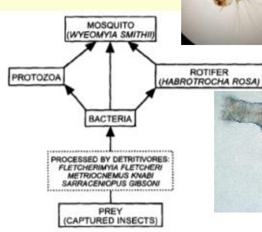


Figure 9 Simplified food web structure of *Sarracenia purpurea*-inquline communities.

Northern pitcher plant

Ellison et al. (2003)

Physiological ecology

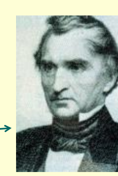
- AKA ecophysiology
- How <u>individual</u> organisms respond to the abiotic environment:
  - Temperature
  - Water
  - Light
  - Nutrients

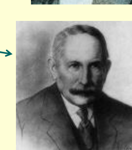
Underlying mechanism

- So, how do individual organisms ultimately respond to their environment?
- **"Nothing in biology makes sense except in the light of evolution."** The American Biology Teacher (1973)
  - Theodosius Dobzhansky (1900 – 1975)

Ecological "laws" (1)

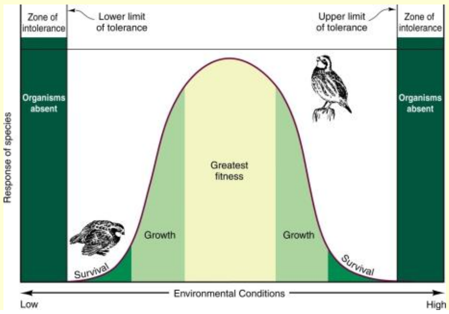
- Patterns describing how individuals interact with their environment
  - **Law of the minimum** (von Liebig):
    - Always the same?
    - Co-limitation?
  - **Law of limiting factors** (Blackman):





Ecological "laws" (2)

- **Law of tolerance** (Shelford)



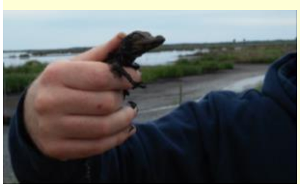
Victor Shelford

Ecological "laws" (3)

- 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

Life and temperature

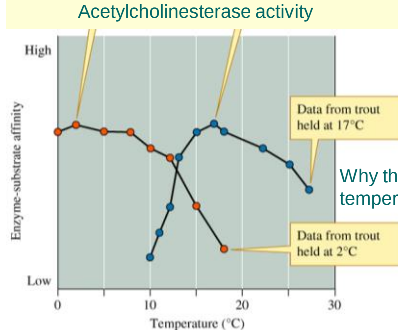
- Life requires a certain temperature (or range of temperatures) for optimal metabolism
  - Cold environments & metabolic rate: prediction?
  - Hot environments & metabolic rate?
  - Why?
  - Overall result?



Trout and an enzyme

- Do trout show an optimum temperature for activity?

Acetylcholinesterase activity



Rainbow trout have 2 forms of this enzyme

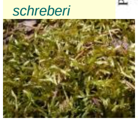
Why these 2 temperatures?

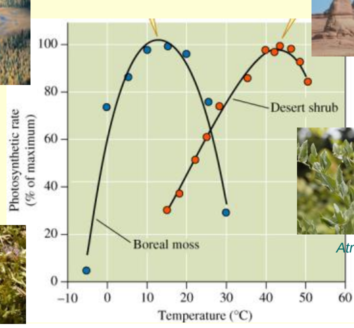
Recent concerns?

Fig. 5.8 *

Plants and temperature optima

Pleurozium schreberi





Atriplex lentiformis

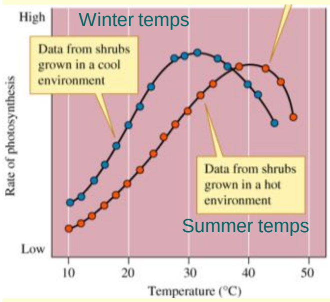
Fig. 5.11

Shorter-term adjustments to environmental changes

- 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**

Acclimation by desert shrubs

An evergreen shrub



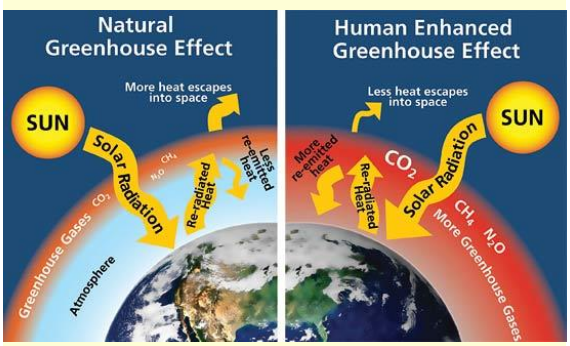
All experimental shrubs were grown from cuttings; so, we do not have to worry about differences due to?

Fig. 5.12

Temperature regulation

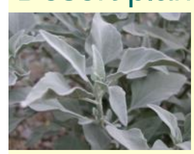
- Organisms must balance gains and losses of heat energy
- Direction of heat transfer?
- Types of heat transfer
  - **Short-wave radiation**
  - **Long-wave radiation**
  - **Metabolism**
  - **Evaporation**
  - **Conduction**
  - **Convection**

Global heat transfers



National Park Service

Desert plants & heat



Brittlebush

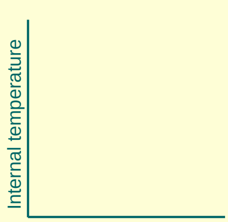
Jojoba

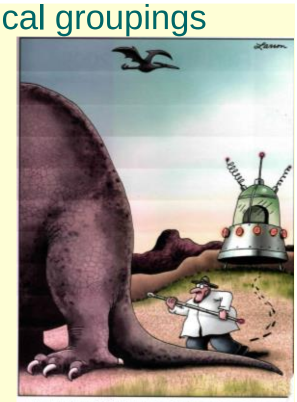
Creosote bush

Also see Fig. 5.16

Physiological groupings

- Ectotherms
- Endotherms
- Heterotherms





An instant later, both Professor Waxman and his time machine are obliterated, leaving the cold-blooded/warm-blooded dinosaur debate still unresolved.

*

Ectotherms (1)

- High thermal conductance
- **Metabolic rate** increases ________ with increasing temperatures

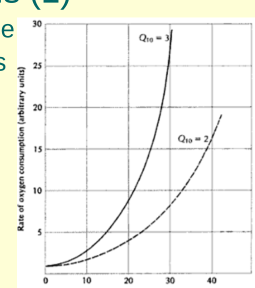


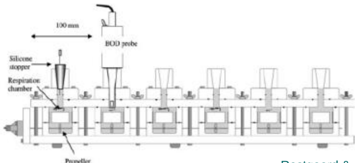
Figure 6.1 Many temperature-dependent rate processes proceed more and more rapidly as temperature increases. See text for further discussion.

Fig. 5.9: Eastern fence lizard

Schmidt-Nielsen 1997

Ectotherms (2)

- **Q_{10}**
  - $Q_{10} = R_T / R_{T\text{-}10}$
    - Where R_T = the rate at any given body temperature T
    - $R_{T\text{-}10}$ = rate at body temperature T – 10ºC
- Typically Q_{10}'s are around **2**, which means?



Rostgaard & Jacobsen 2005

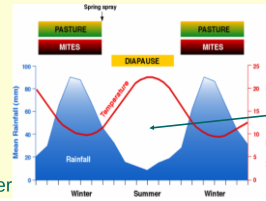
Figure 1. Sectional view of respiration chambers with invertebrates in place for measurement. Upper conical parts of chambers were sealed with silicone stoppers during the respiration period. BOD probe inserted in one chamber.

Ectotherms (3)

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

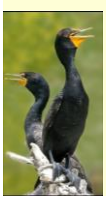
Red-legged earth mite

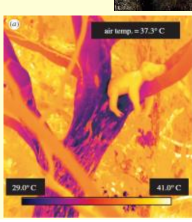
Invasive crop pest down under



Diapausing eggs

Endotherms





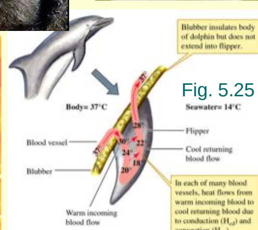
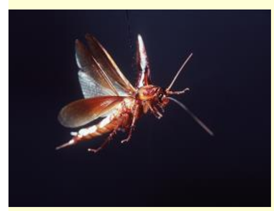


Fig. 5.25

Heterotherms (1)



Roach

Hawkmoth

Heterotherms (2)

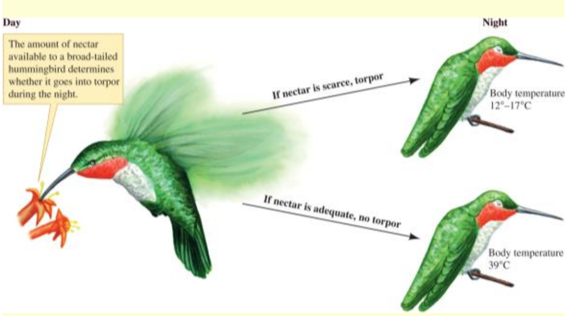
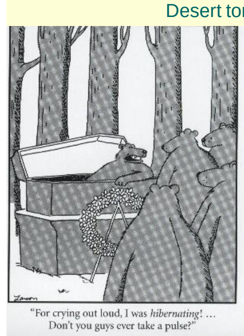


Fig. 5.32

Heterotherms (3)

Desert tortoise



Dormouse