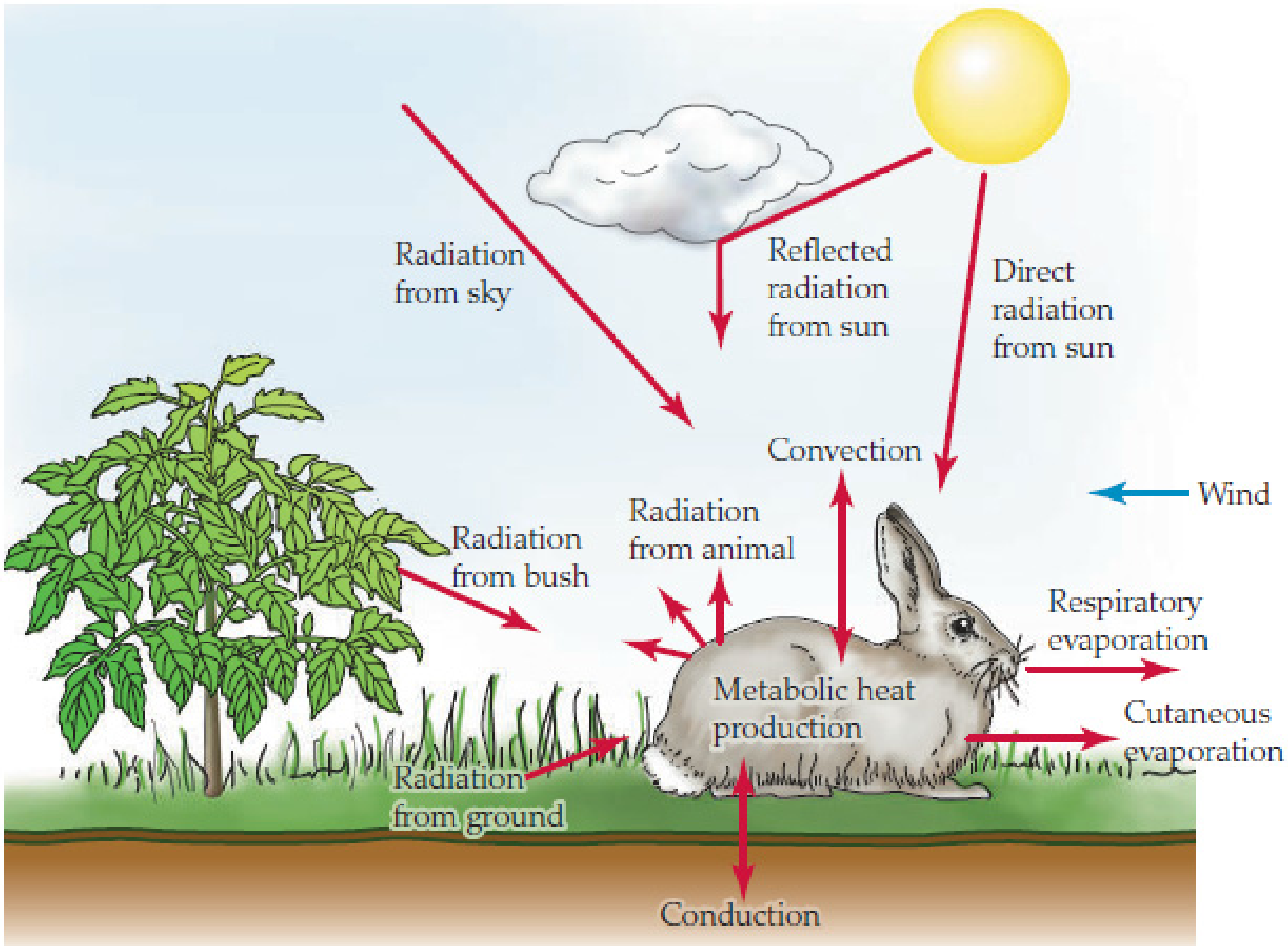
6. Thermoregulation in poikilotherms and homotherms

BIOS 0501B (Group A)

DBS, PU, Sem 5; 2015

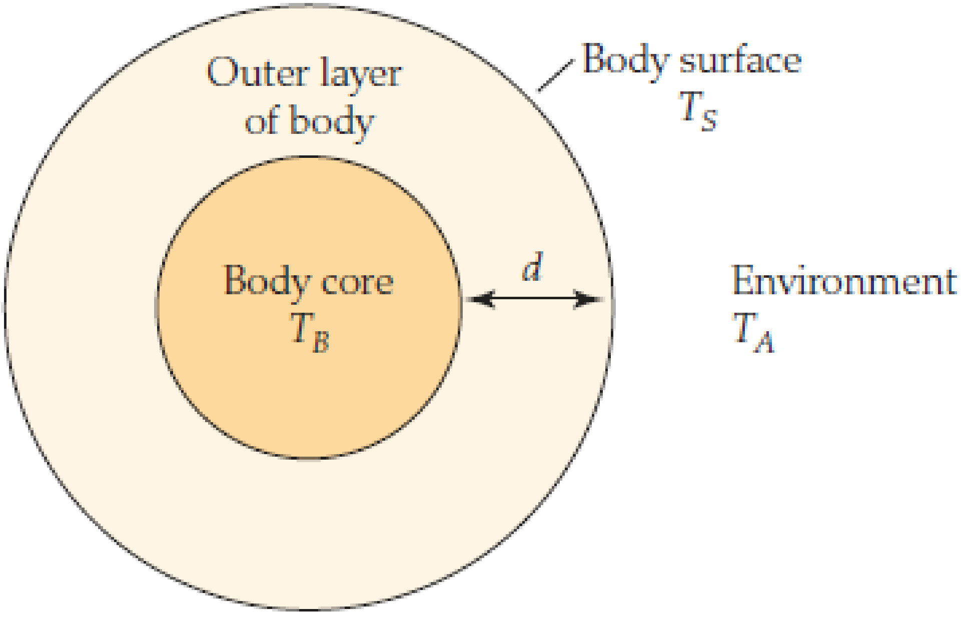
Heat

- Is the lowest grade of energy generated through metabolism
- But a determinant of metabolic rate



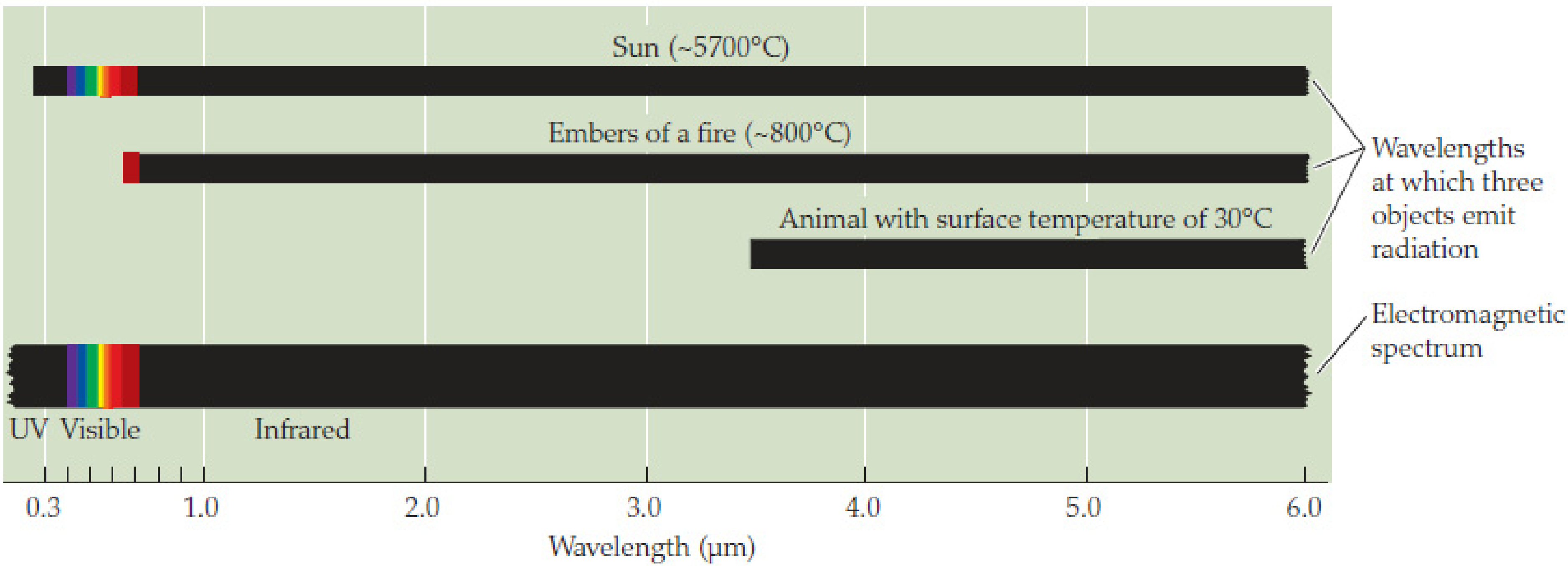
Heat exchange

- For the body temperature of an animal to be constant, the sum total of its heat gains by all mechanisms taken together must equal the sum total of all its heat losses.



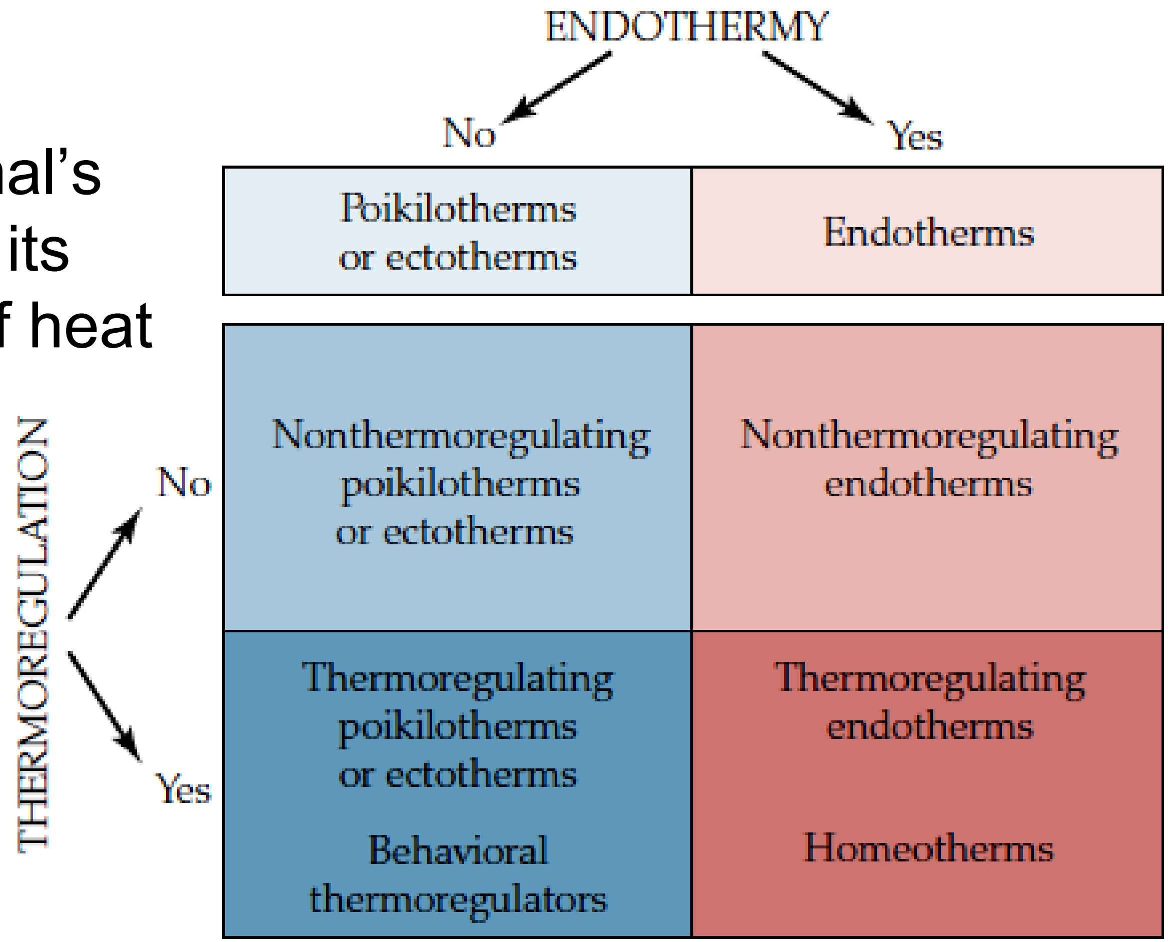
Titbit

- Thermal radiation
  - shortest wavelengths emitted by a surface at 30°C temperature are between 3 and 4 μm
  - Any two objects generate and exchange heat in this manner



Kinds of thermoregulation

- Endothermy: if an animal's tissues are warmed by its metabolic production of heat
- Ectothermy: if not
- Thermoregulation
  - Another aspect

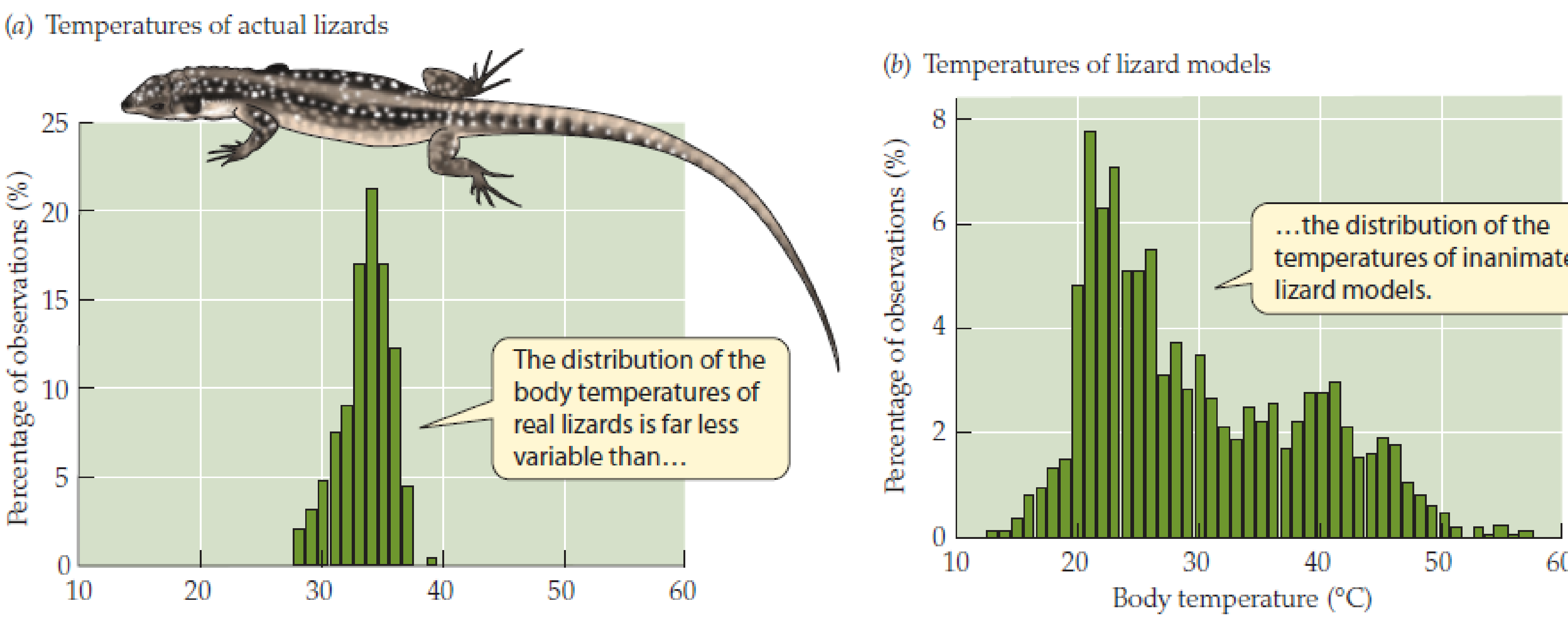


Poikilothermy (Ectothermy)

- Most common type of thermal relation exhibited by animals
- *poikilothermy* emphasizes the variability of body temperature
- *ectothermy* emphasizes that outside conditions determine the body temperature
- <u>Not</u> cold blooded

Behavioral thermoregulation

- Desert iguana keeps body temperature within 38–42°C during daylight hours, and it often keeps its temperature within 2–3°C of the mean for hours on end.
- And in the below example, living lizards in a natural setting on a Mediterranean island were found to exhibit far less variable body temperatures than lizard models placed randomly in the same environment



Have to function at variable temp

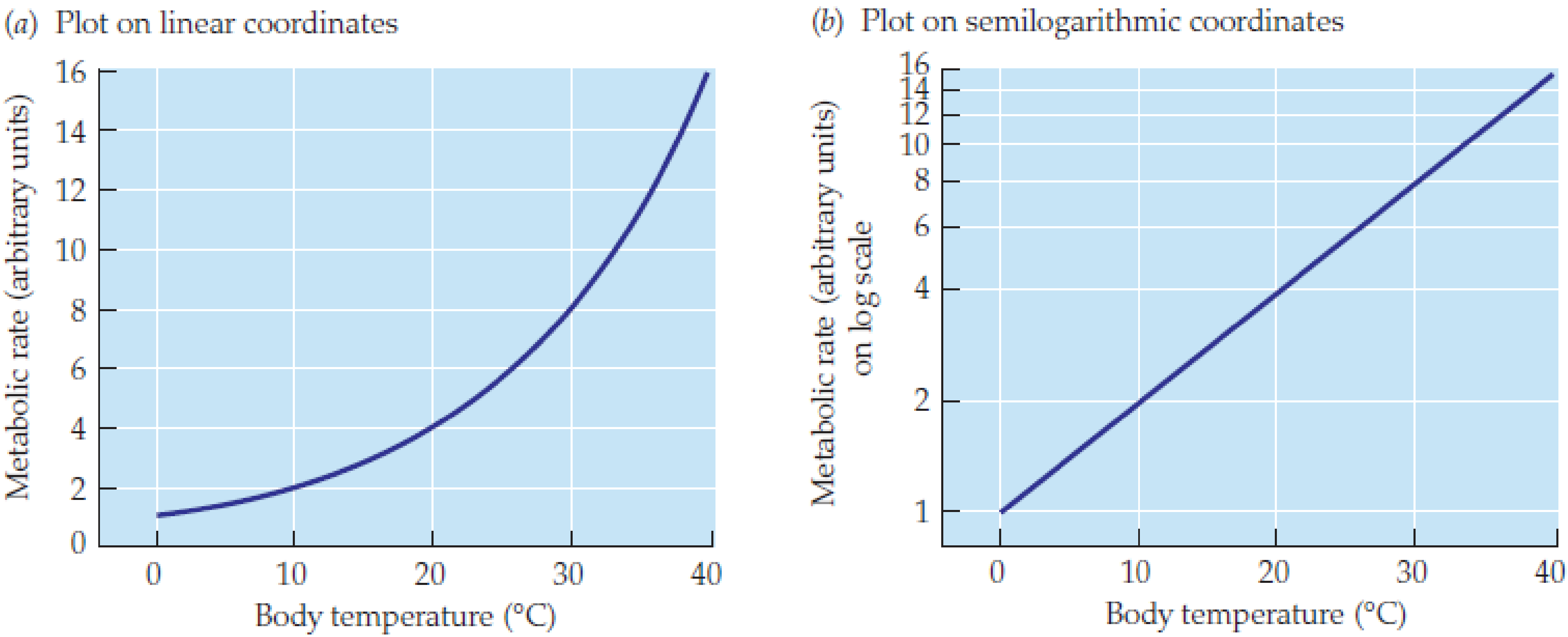
- A cool day desert iguana may never attain preferred body temperature of 38–42°C
- So they have to be able to function at variable temperature
- Eurythermal, can function over wide ranges of body temperature (goldfish, 5–30°C)
- Stenothermal, have comparatively narrow ranges of body temperature over which they can function.

Responses in time frame

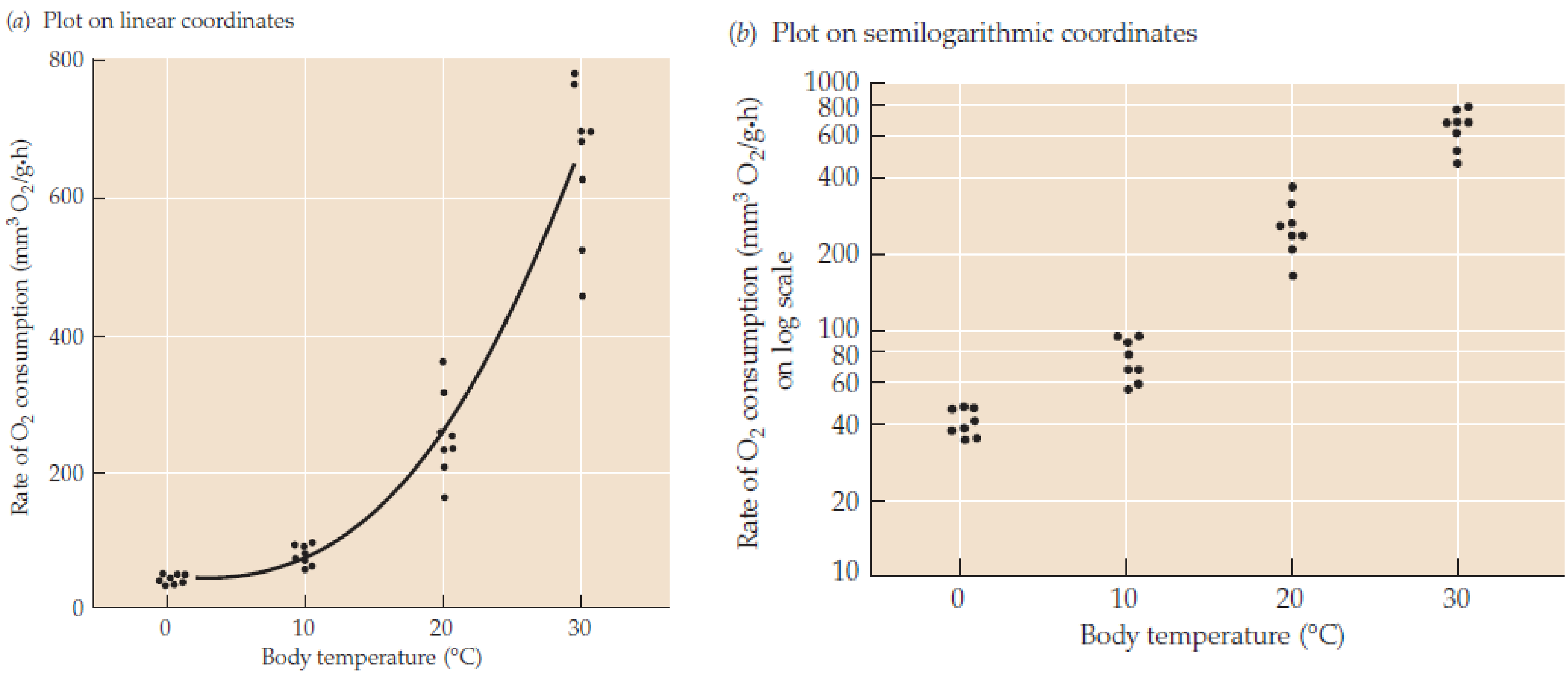
- The three major time frames of physiological response to the environment provide a useful way to organize knowledge of the relations of poikilotherms to their thermal environments
  - *acute responses*
  - *chronic responses*
    - *acclimation* and
    - *Acclimatization*
  - *evolutionary changes*

Acute responses

When the body temperature of an individual poikilotherm is raised in a series of steps and its metabolic rate is measured promptly after each upward step, the usual pattern is that the resting metabolic rate increases approximately exponentially with the animal's body temperature



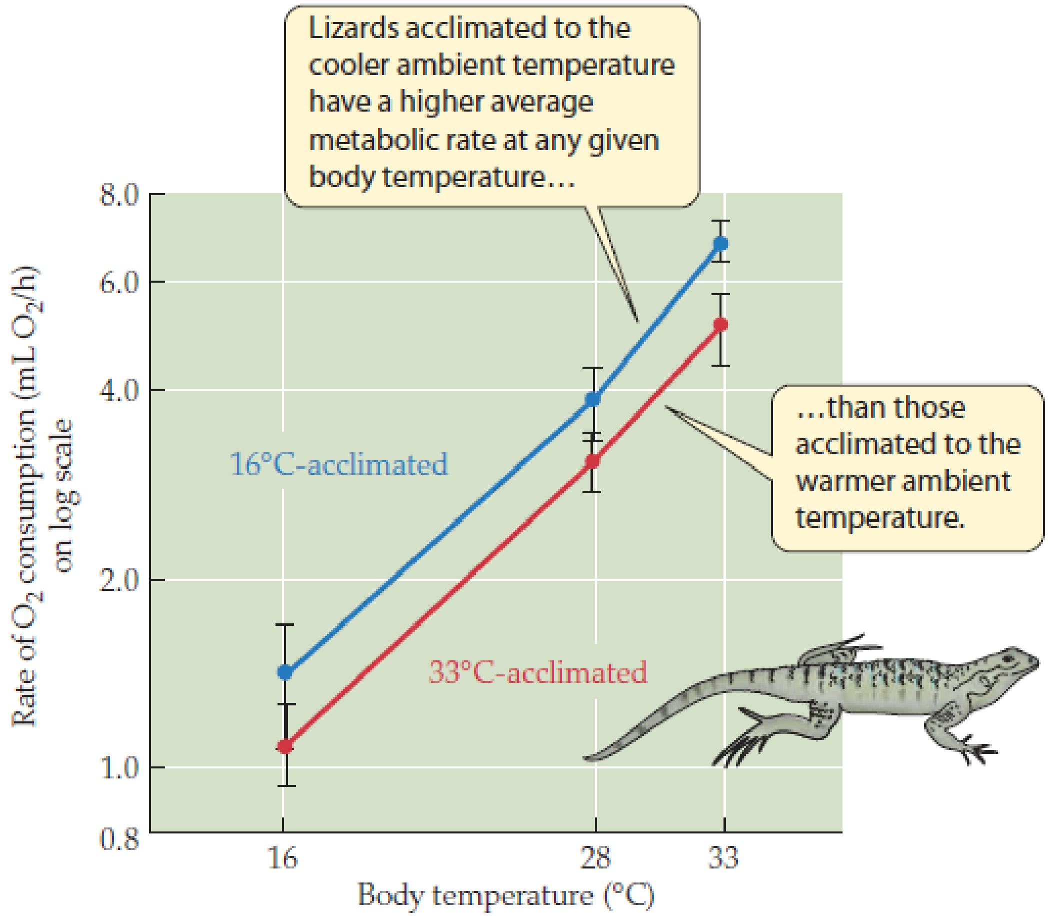
Actual data



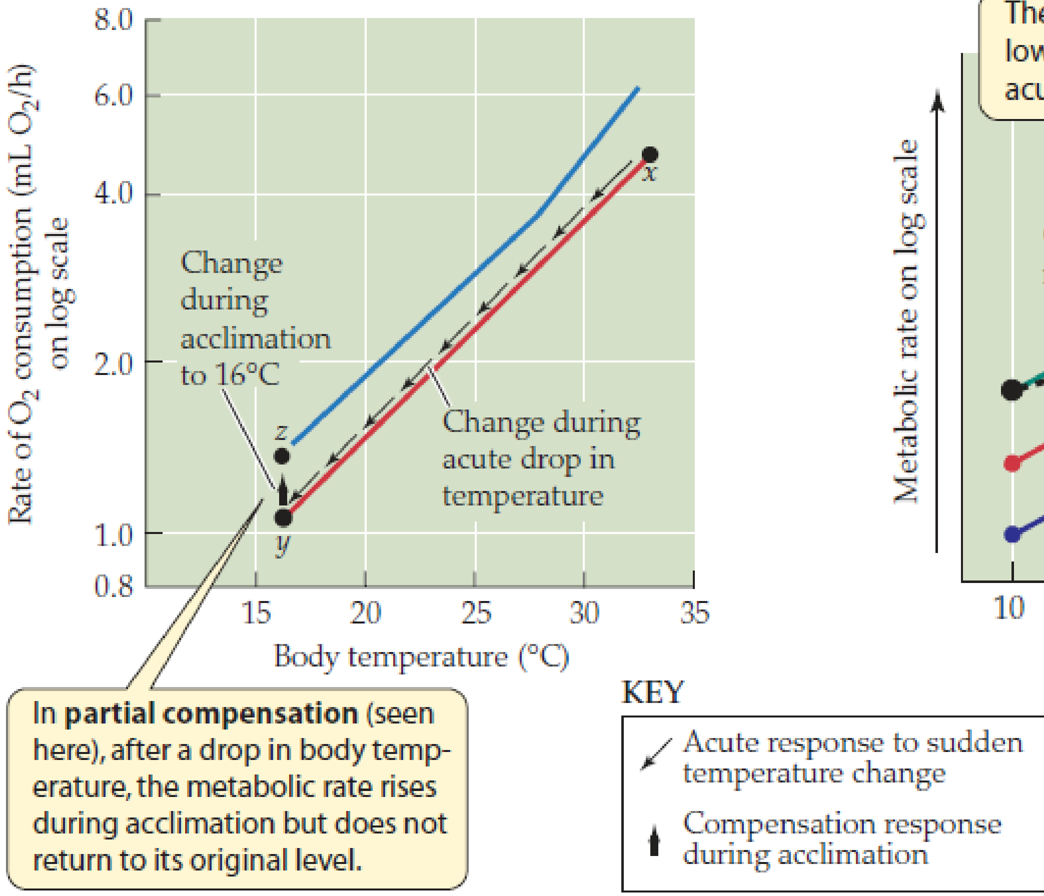
- The relation between metabolic rate and body temperature in tiger moth caterpillars (family Arctiidae), plotted in two ways

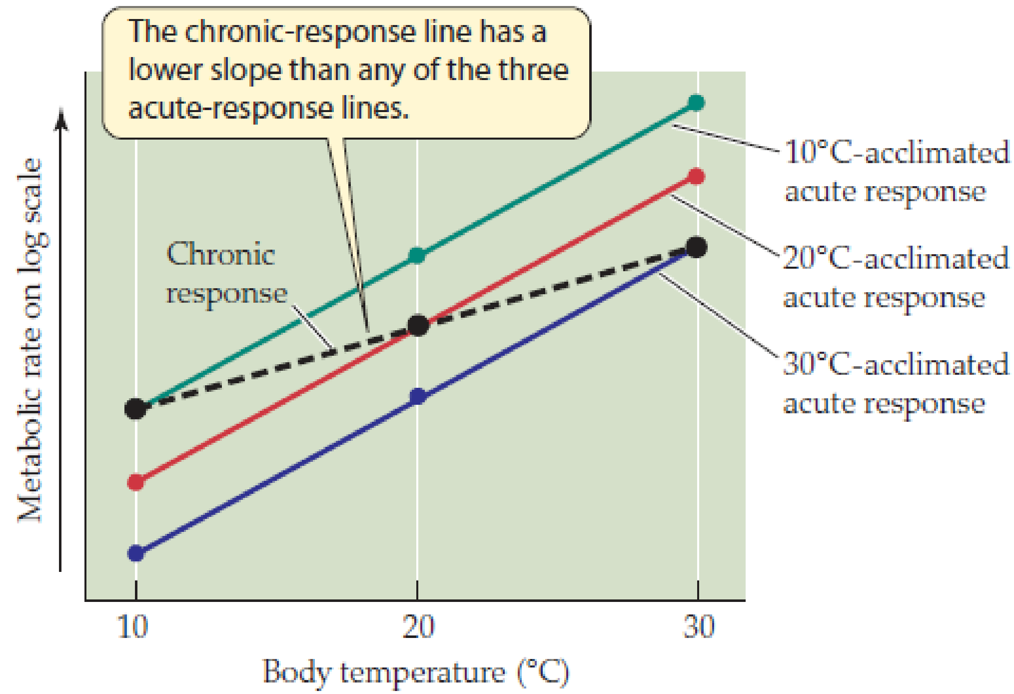
Acclimation

- “33°C-acclimated” group, was maintained for 5 weeks at 33°C
  - Then exposed acutely at16°C, 28°C, and 33°C
- Vs
- “16°C-acclimated” group, was maintained for 5 weeks at 16°C
  - Then exposed acutely at16°C, 28°C, and 33°C



5 week followed by 5 more





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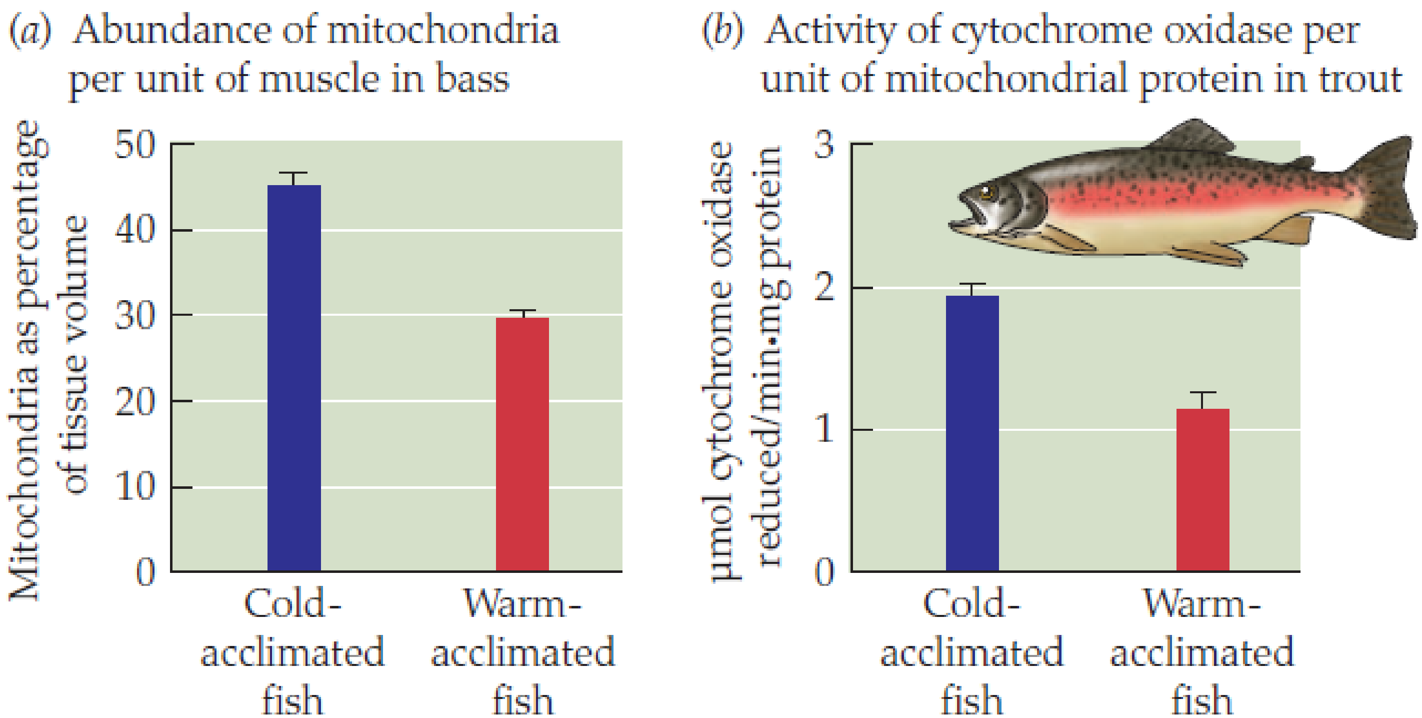
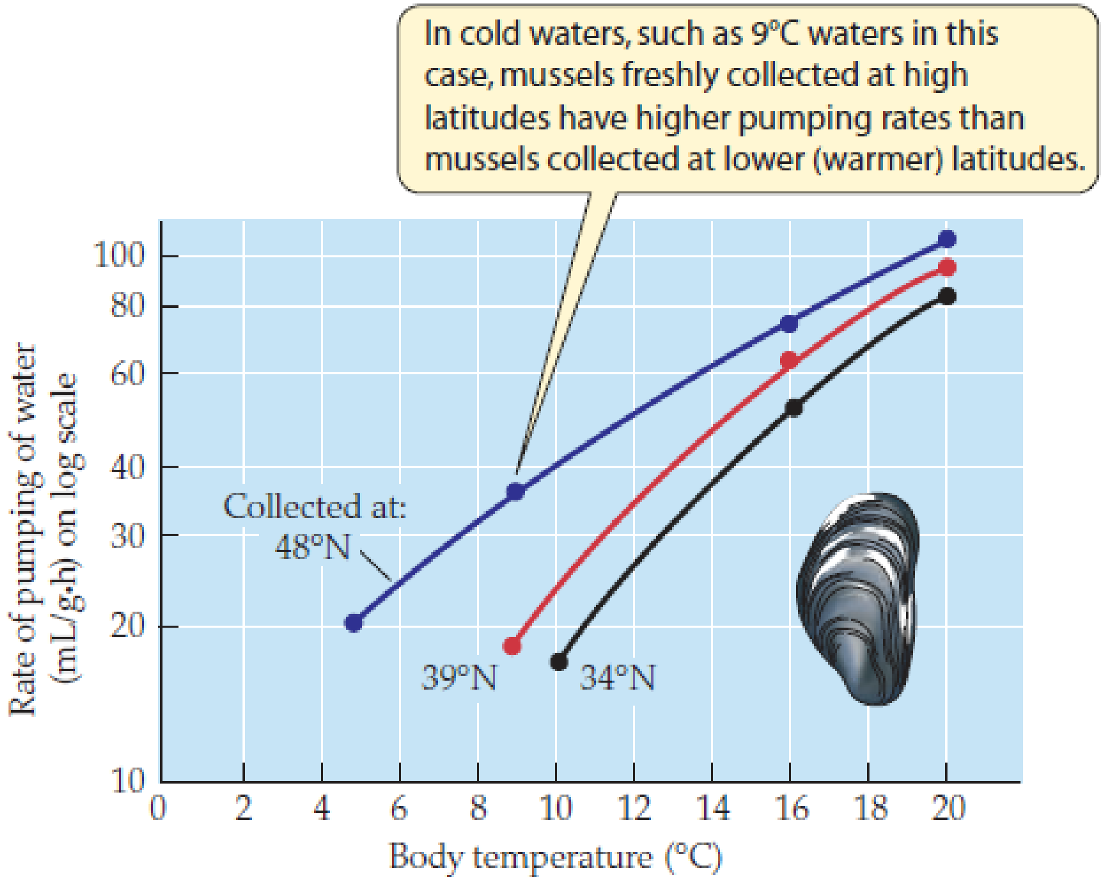
Mechanism of acclimation

- Cells modify their *amounts* of key, rate-limiting enzymes, notably enzymes of the Krebs cycle and the electron-transport chain
  - number of mitochondria per unit of red swimming muscles of fish increases in some cases
  - amounts of key enzymes per mitochondrion are increased in some



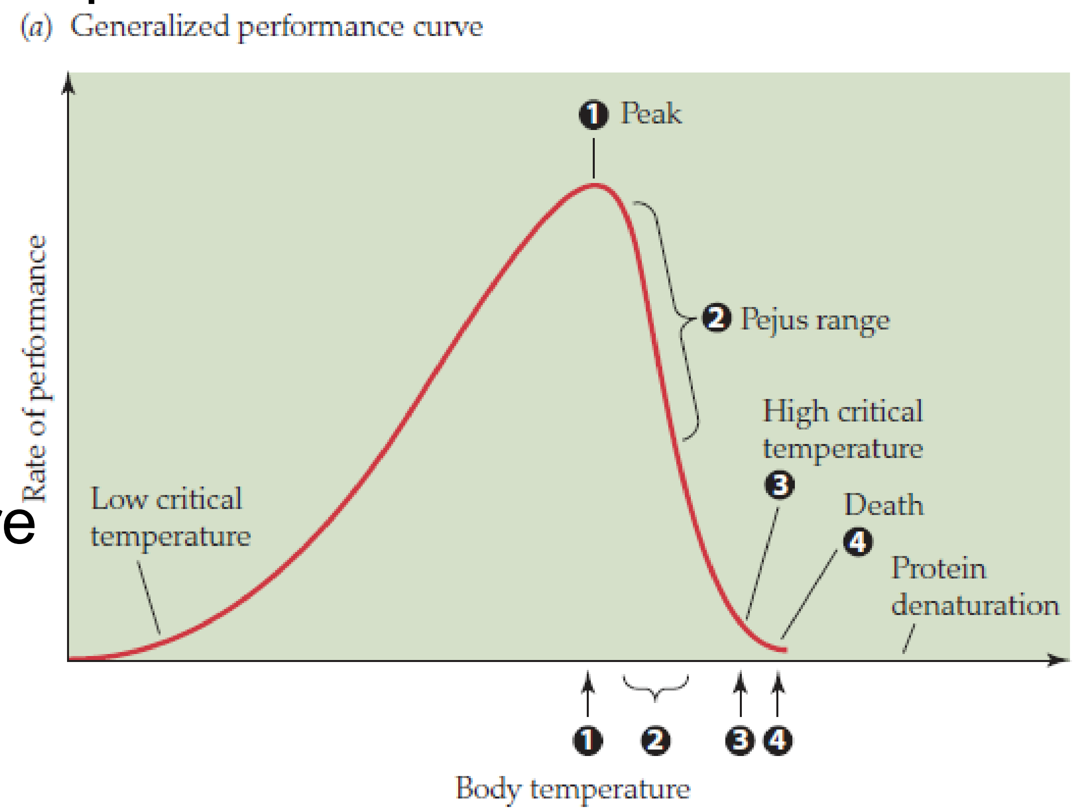
Acclimatization

- Single species that were collected at three latitudes along the West Coast of the United States.
  - the populations of mussels living in relatively cold, high-latitude waters and warm, low-latitude waters were more similar to each other in pumping rates than they otherwise would have been.
    - Acclimatization

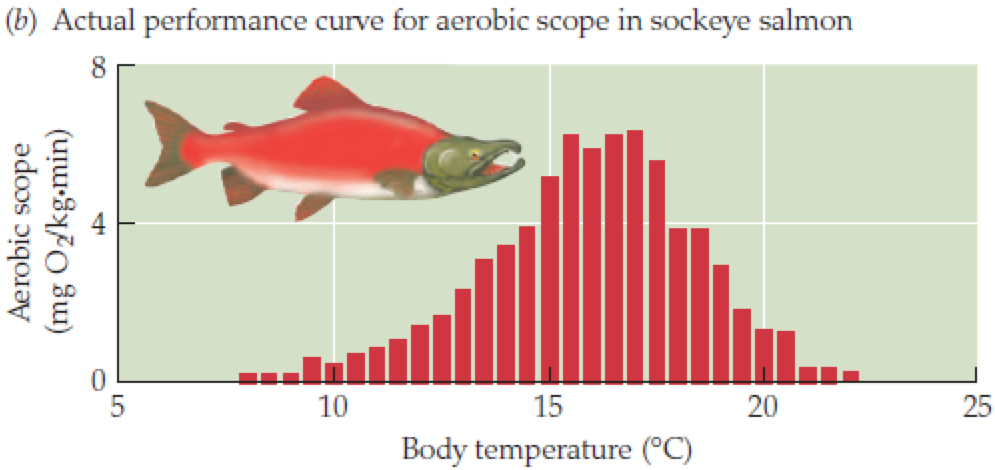


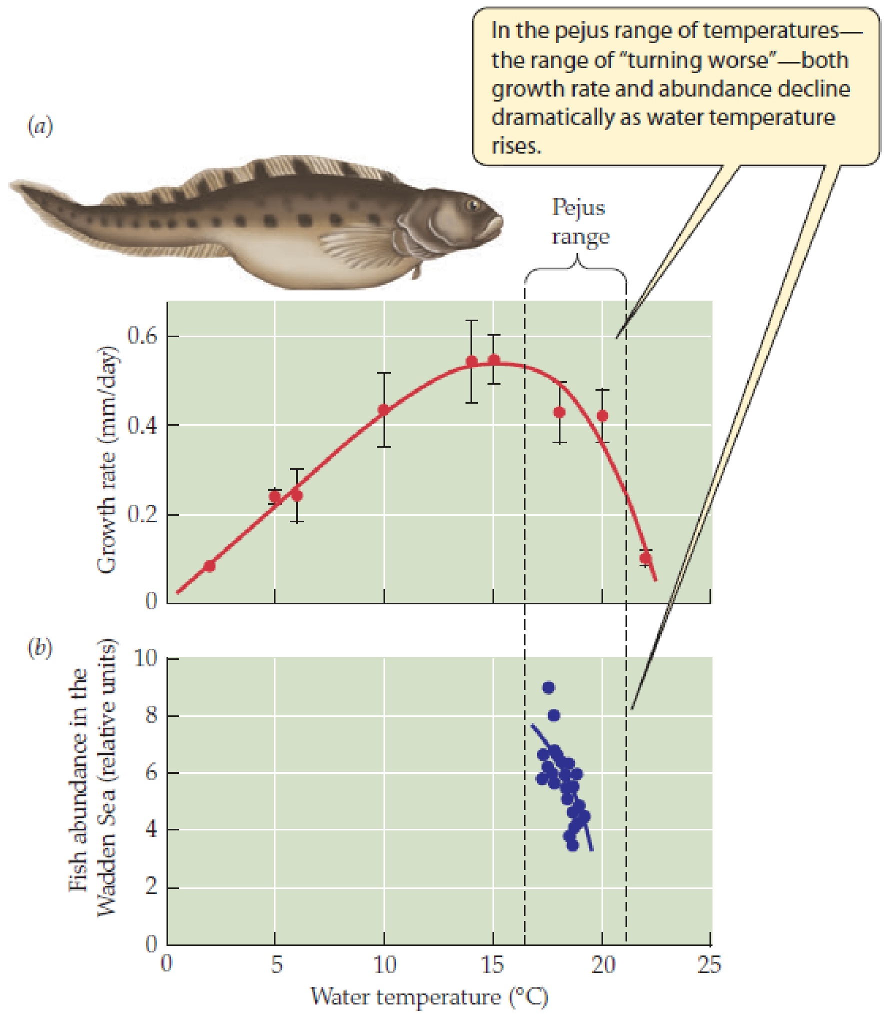
Rate–temperature relations

- When body temperature is at the level associated with ❶, the rate of performance is at its peak.
- If body temperature rises above ❶, performance will shift to the range labeled ❷.
- Point ❸ marks the body temperature at which an animal's maximal rate of O_2 consumption is little higher than its resting rate of O_2 consumption.
- Point ❹ is the temperature at which elevated body temperature is itself directly lethal.



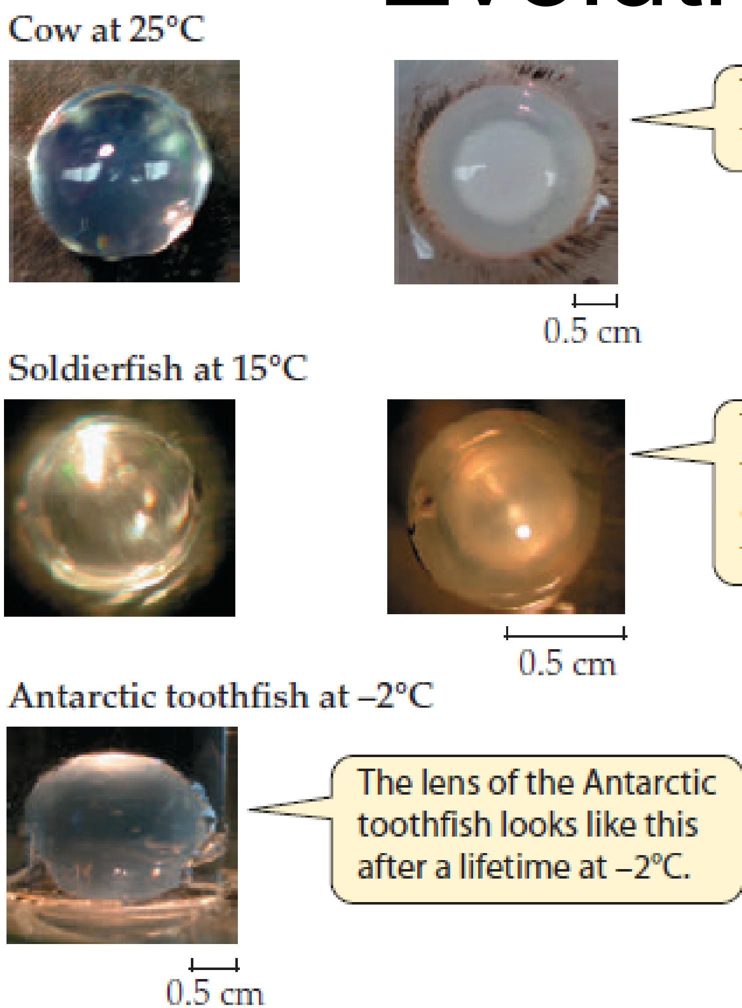
Two examples

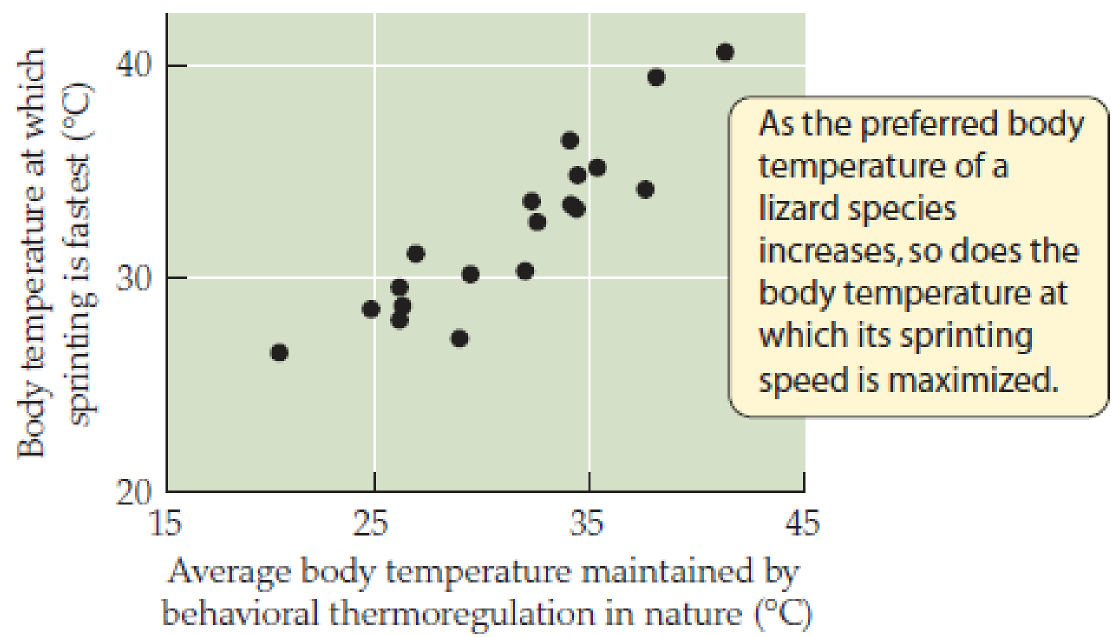




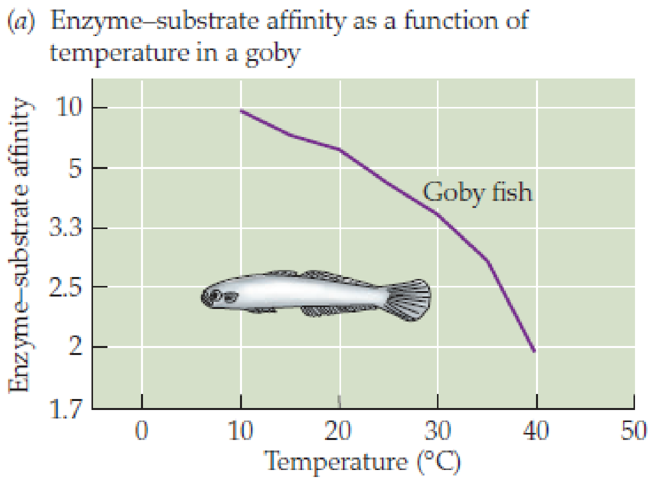
- So the situation turns worse before death
- That can very well be the cause of extinction
- The cause?
  - May be dissolved oxygen

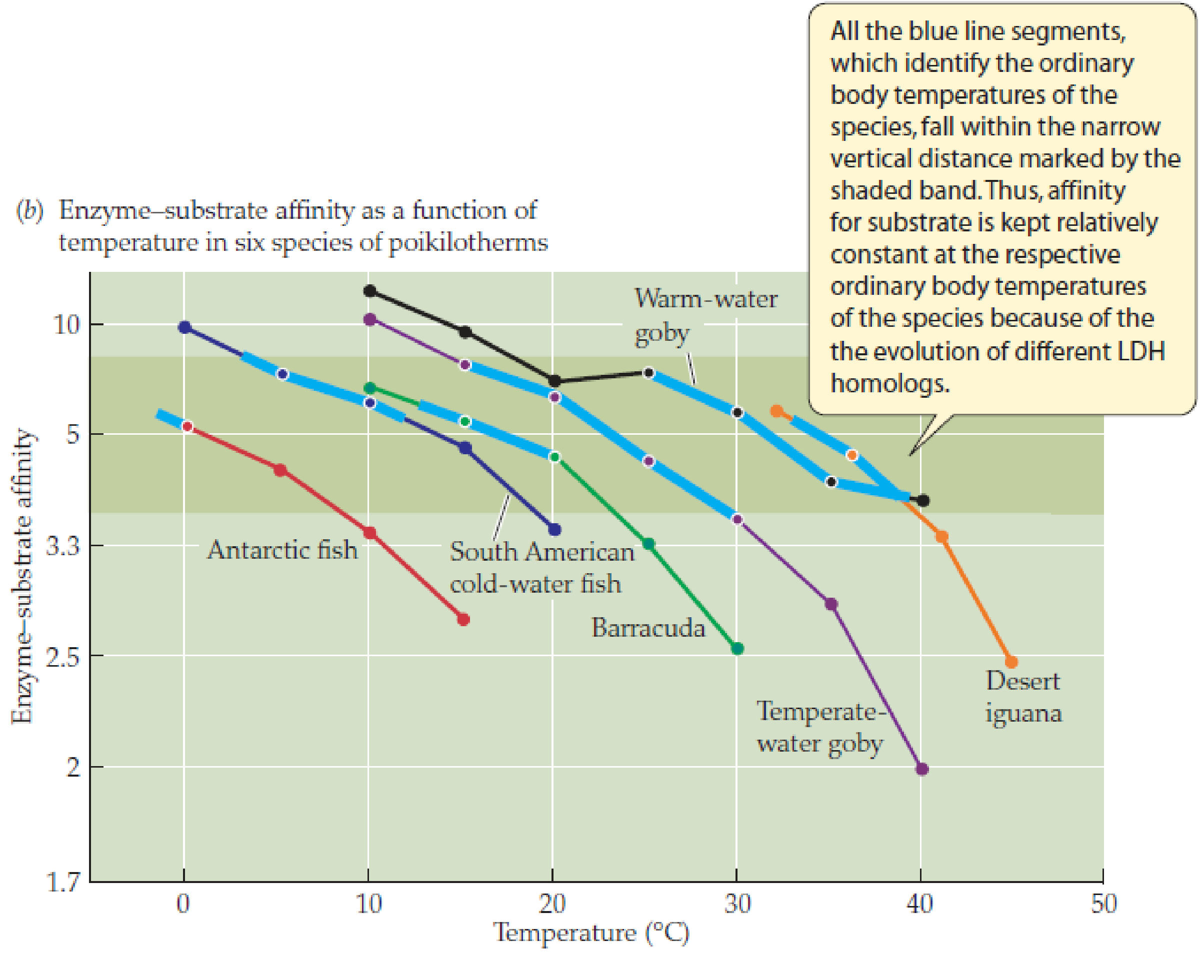
Evolutionary changes





Enzyme – substrate affinity





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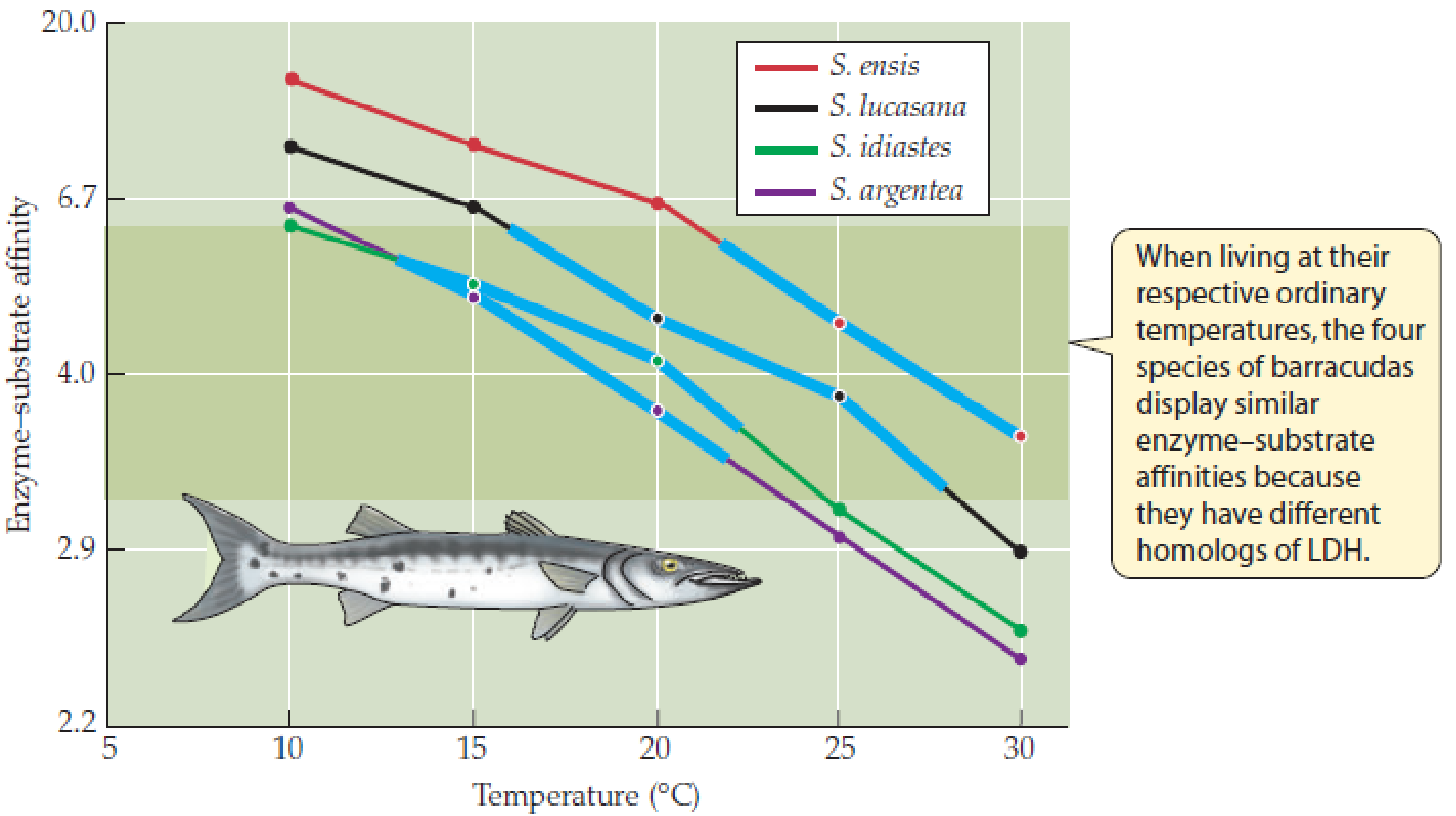
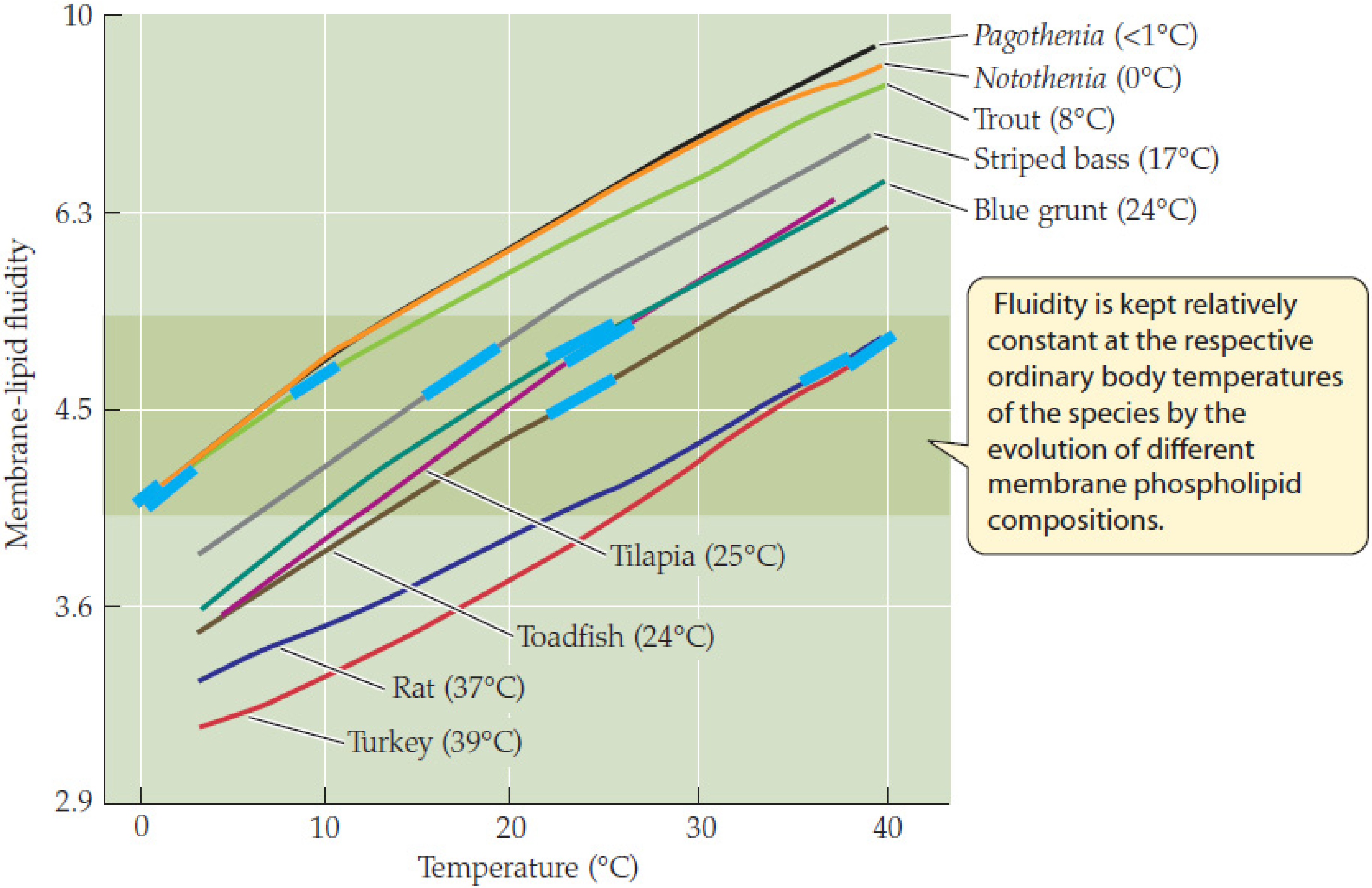


S. ensis
S. lucasana
S. idiastes
S. argentea
Enzyme–substrate affinity
20.0
6.7
4.0
2.9
2.2
5
10
15
20
25
30
Temperature (°C)
When living at their respective ordinary temperatures, the four species of barracudas display similar enzyme–substrate affinities because they have different homologs of LDH.

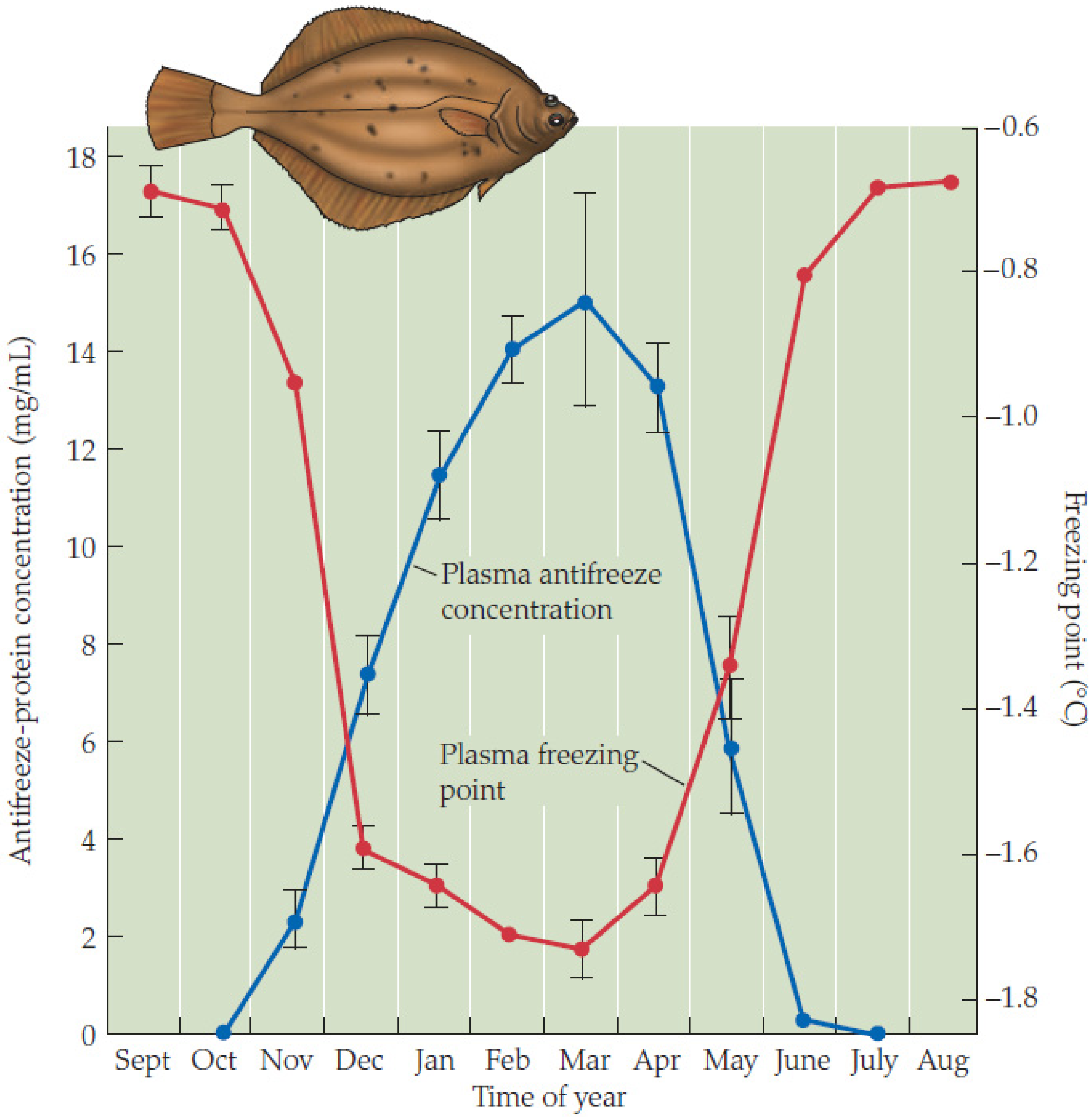
Fluidity of cell membrane



Response to cold

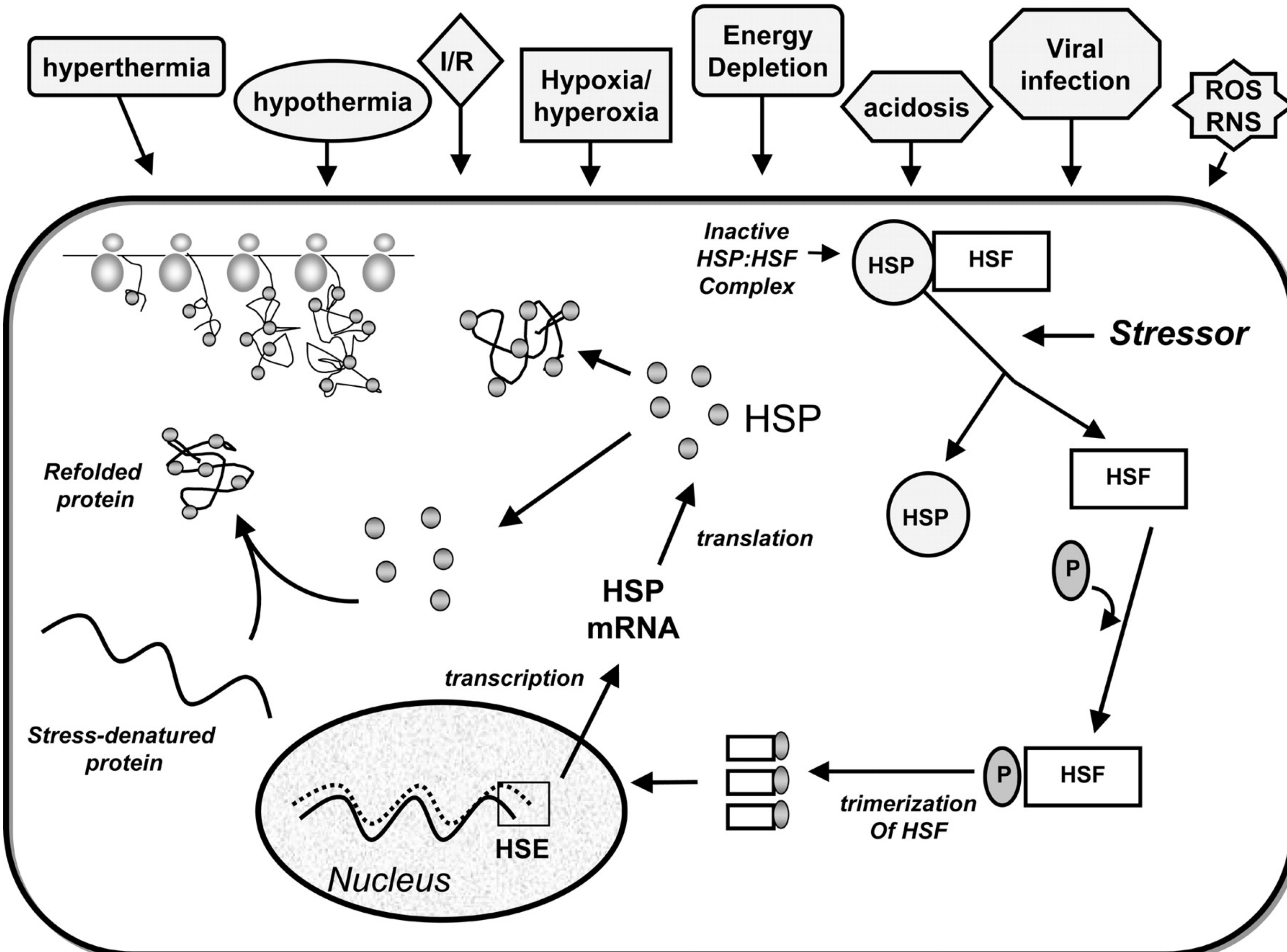
- Colligative
  - polyhydric alcohols, especially glycerol, sorbitol, and mannitol.
- Noncolligative
  - They are believed to act by binding (through weak bonds such as hydrogen bonds) to nascent ice crystals in geometrically specific ways, thereby suppressing growth of ice by preventing water molecules from freely joining any crystals that start to form. They stop nucleation.
  - Thus solutions containing these antifreezes exhibit the unusual property—termed thermal hysteresis—that their freezing points are substantially lower than their melting points.
  - Anti-freeze proteins

Seasonal change in anti-freeze



Hsp

Physiological signals that activate HSP70 expression



Text & Images

Hill

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