FISH310: Biology of Shellfishes

Lecture Slides #2
Environmental Considerations and Physiology

Today

- Review
- Physiology
- Water *(tangent on Life History Strategies, - density)*
- Ecology
- Recap Major Points

Review Lecture Slides #3
BEFORE class on Friday

Collaboration

- Take ownership of your educational experience
- Share / Post
- Ask questions
- Read

Tophat

What is a benefit of learning about aquatic invertebrates?

Why care?

Today

- Review (*but not too much*)
- Physiology
- Water
- Ecology
- Recap Major Points

Purpose:
•Class Same Page
•Really think about what is different about water

Physiology

study the function of organisms

how life works

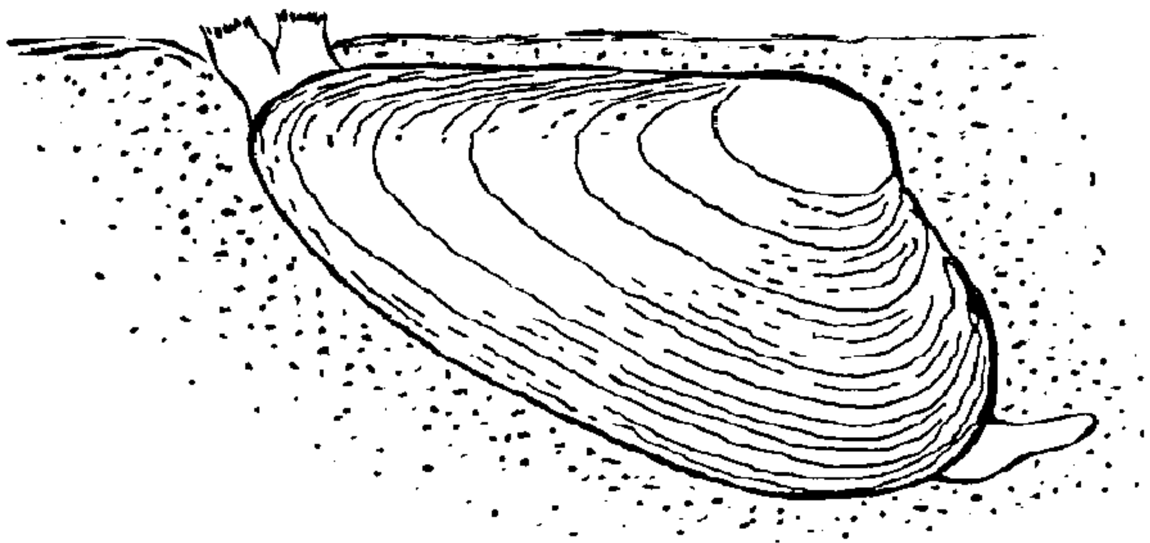
Explanations of physiological processes

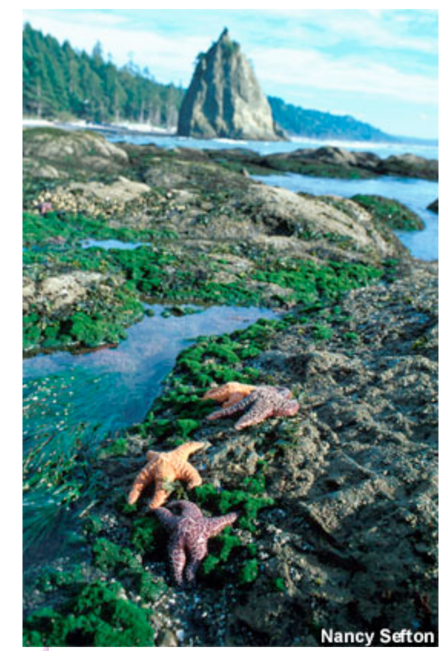
- mechanistic - *How does it work?*
- evolutionary - *How did it evolve this way?*

Explanations of physiological processes

Evolutionary Implications

Genotype





Phenotype

Natural Selection

Homeostasis

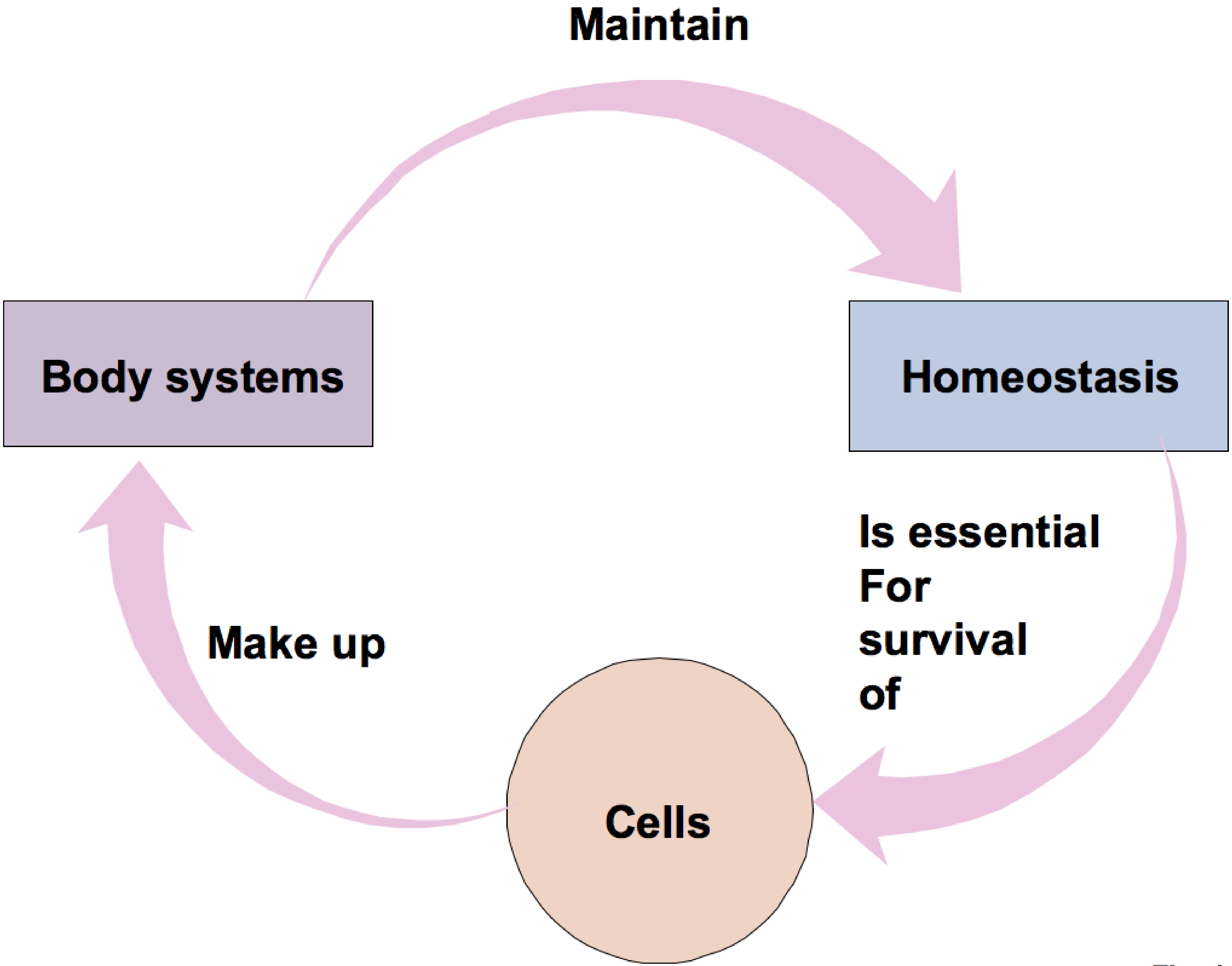


Fig. 1-6, p.11

Homeostasis

Factors of internal environment often regulated

?

Homeostasis

Factors of internal environment often regulated

- Concentration of energy rich molecules
- Concentration of O_2 and CO_2
- Concentration of waste products
- pH
- Concentration of water, salt, and other electrolytes
- Volume and pressure
- Temperature
- Social Parameters

Homeostasis

- Most intrinsic and extrinsic control systems generally operate on the principle of negative feedback
- Inadequacies in basic negative feedback systems can be improved with feedforward systems and acclimatization systems.
- Pathophysiological states ensue when one or more of organisms systems fail to function properly.

Water characteristics

What's different?

Water characteristics

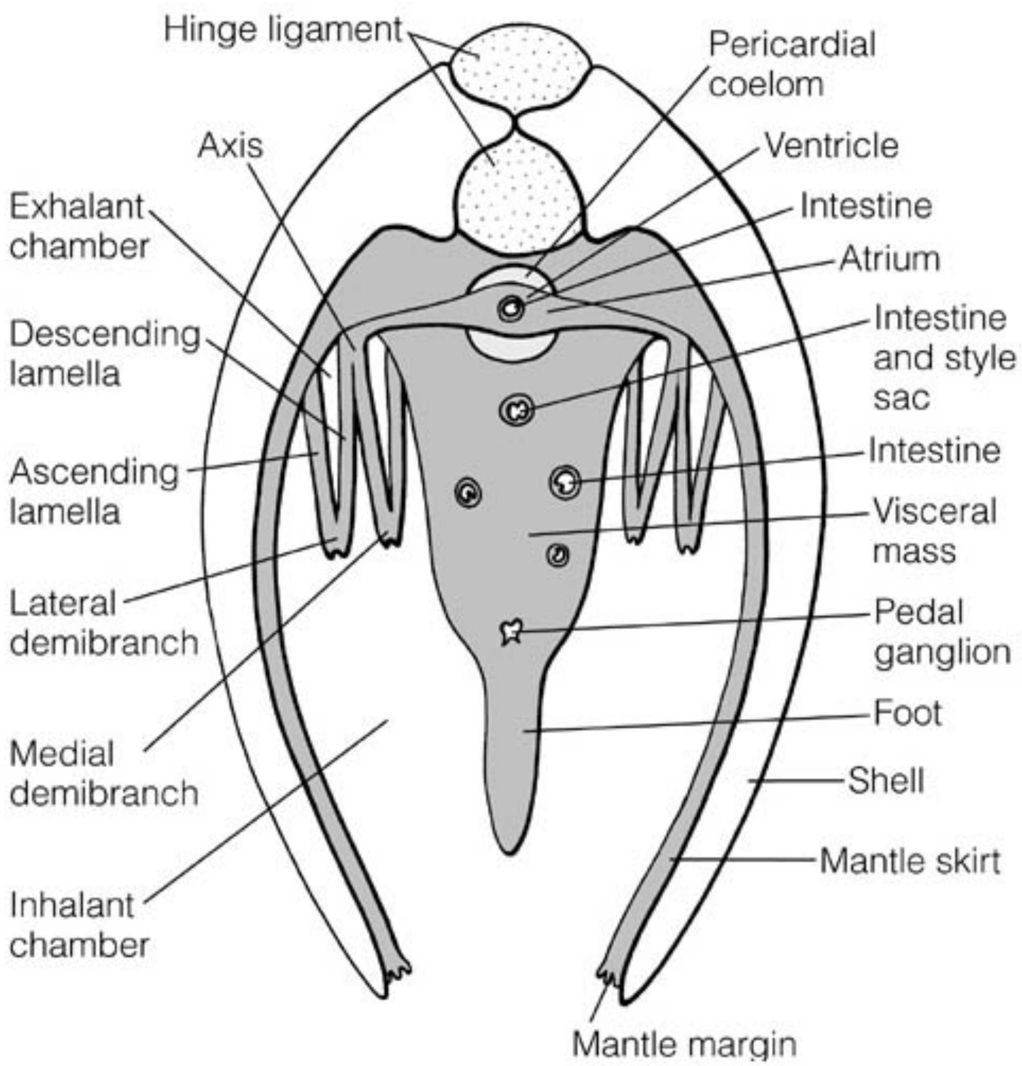
What do you think is most important?

Water is wet

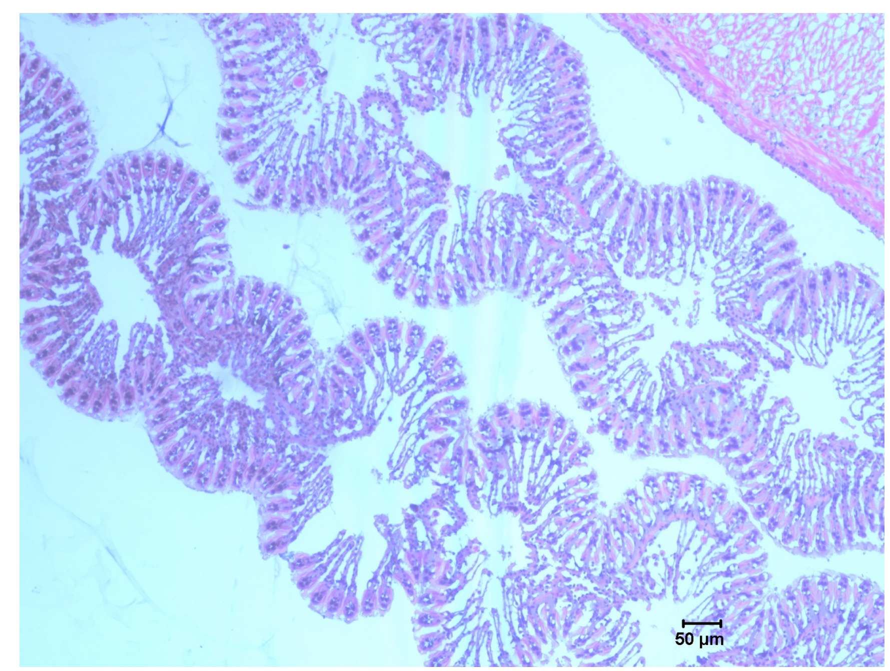
- Aquatic Environment: Desiccation is generally not a problem
  - \- Gas exchange across body surface
    - Thin, permeable body wall
    - External respiratory tissue/organ in direct contact with water

- Gills look complex but = vascularized extensions of body wall (increases surface area for exchange)

Aquatic Respiratory Structures

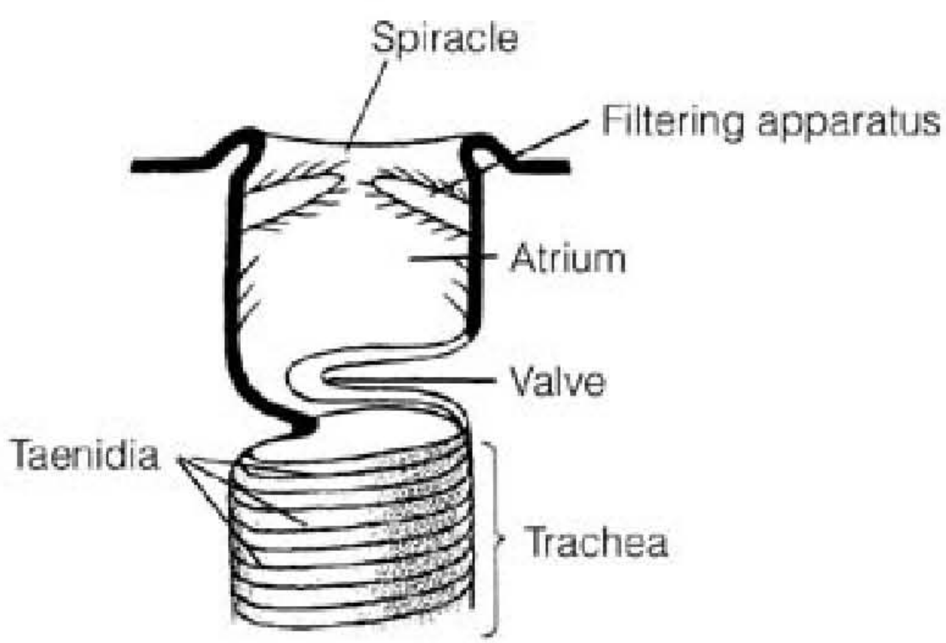


Cross section of a generalized lamellibranch



Humidity

- Terrestrial Environment: Desiccation problematic
  - Organisms use complex structures for gas exchange
  - If rely on diffusion across unspecialized body surfaces, must maintain moisture (ie secrete mucus such as annelid earth worms)
  - Truly terrestrial animals have impermeable outer body wall & gas exchange via specialized respiratory structures (ie trachea and or book lungs)



A

Figure 21-10:

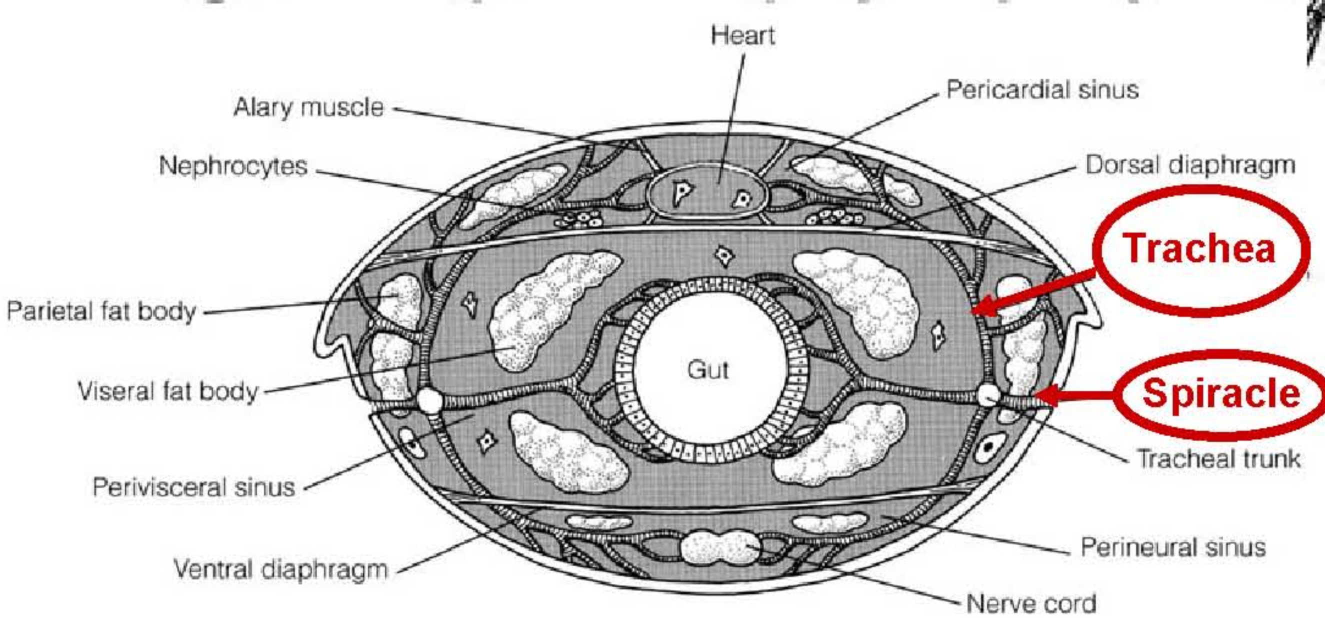
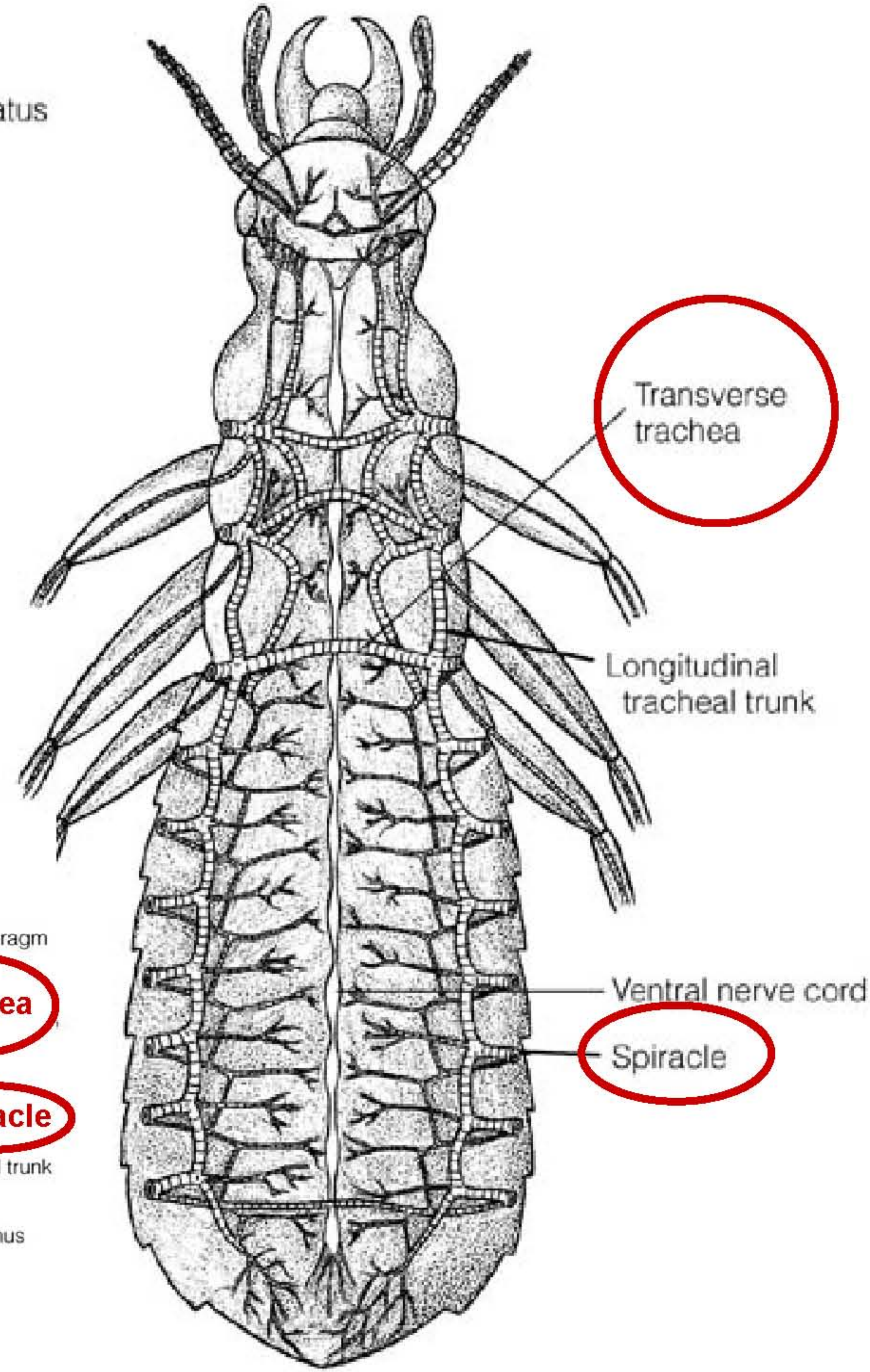


Figure 16-7: **Cross section of the abdomen of a typical insect.**



B

What else

Temperature

Temperature

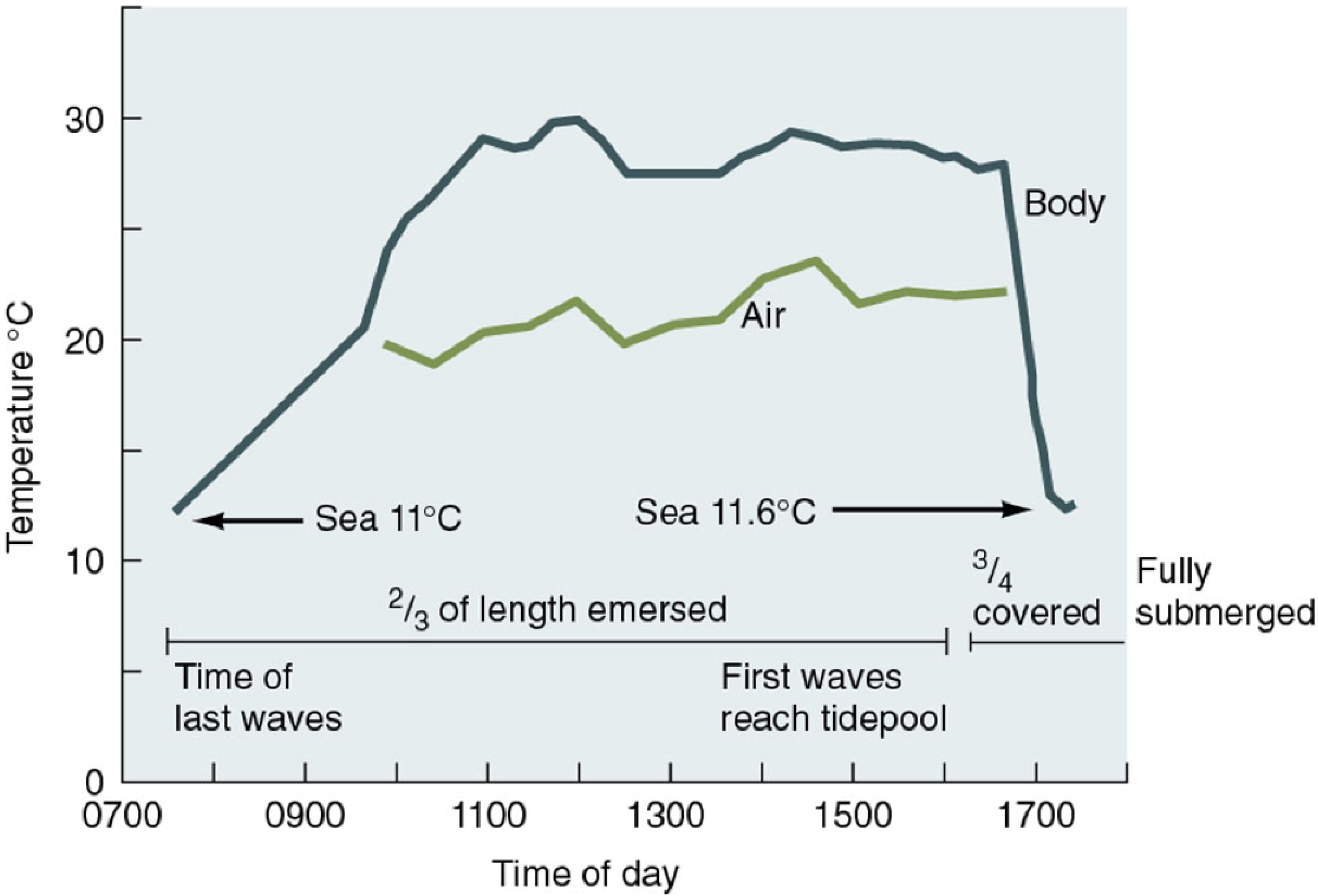
- Range for vital life process (metabolism)

0°C - 40°C

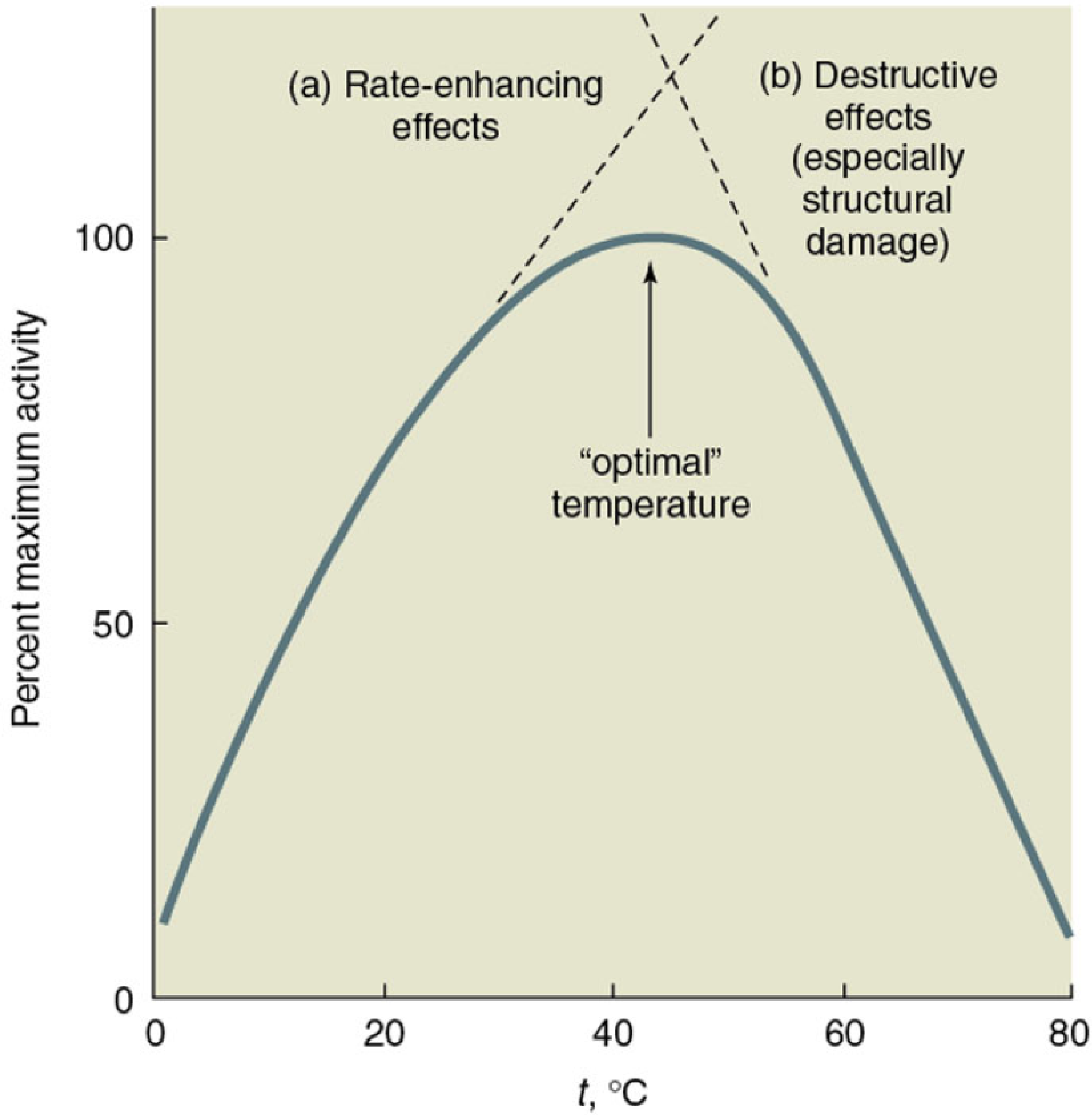
Metabolic processes increase by factor of 2 for each 10°C rise in temperature

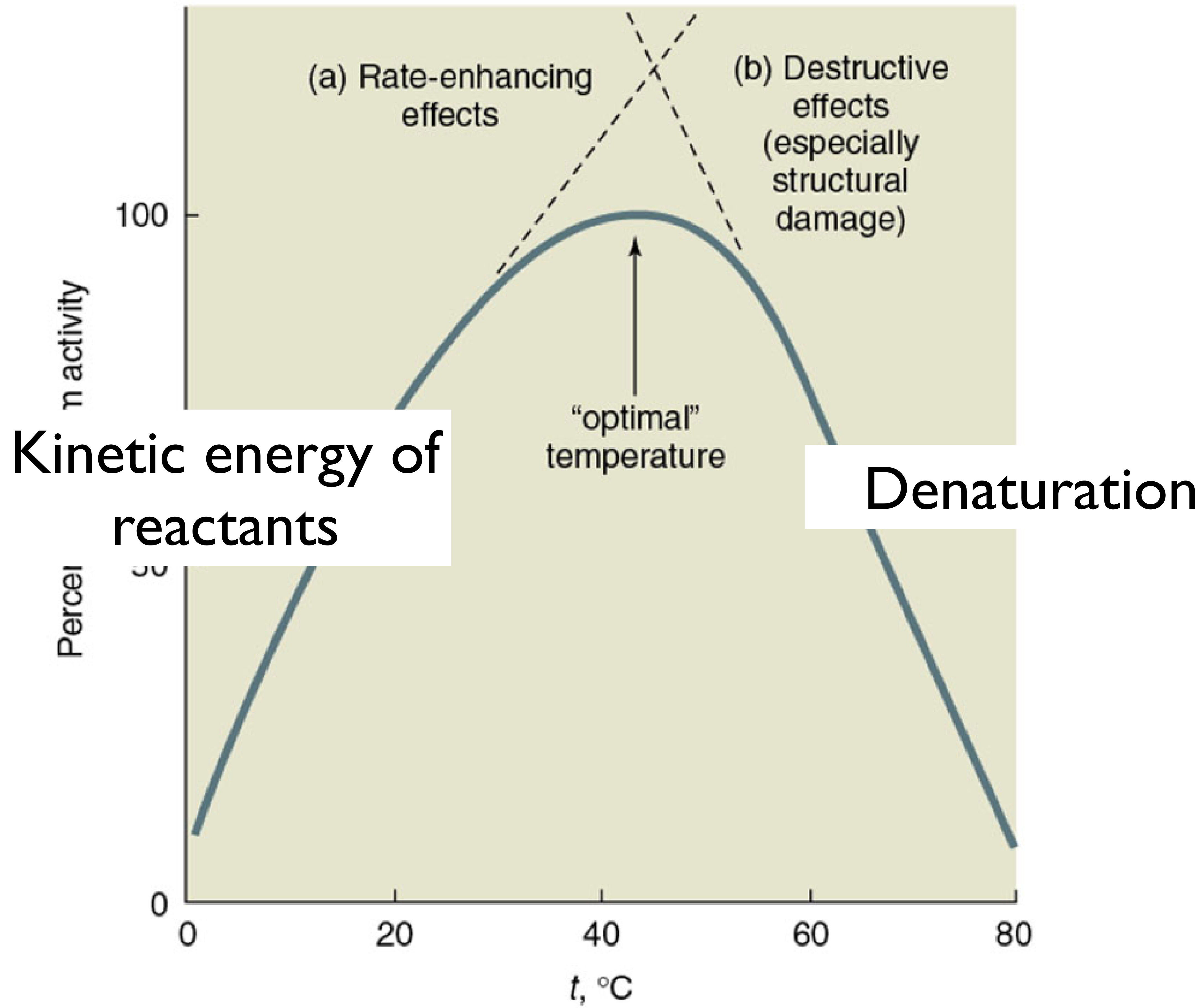
Shellfish are poikilothermic

Ectotherms



© 2005 Brooks/Cole - Thomson


(a) Rate-enhancing effects
(b) Destructive effects (especially structural damage)
"optimal" temperature
100
50
0
Percent maximum activity
0
20
40
60
80
t, °C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100
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40
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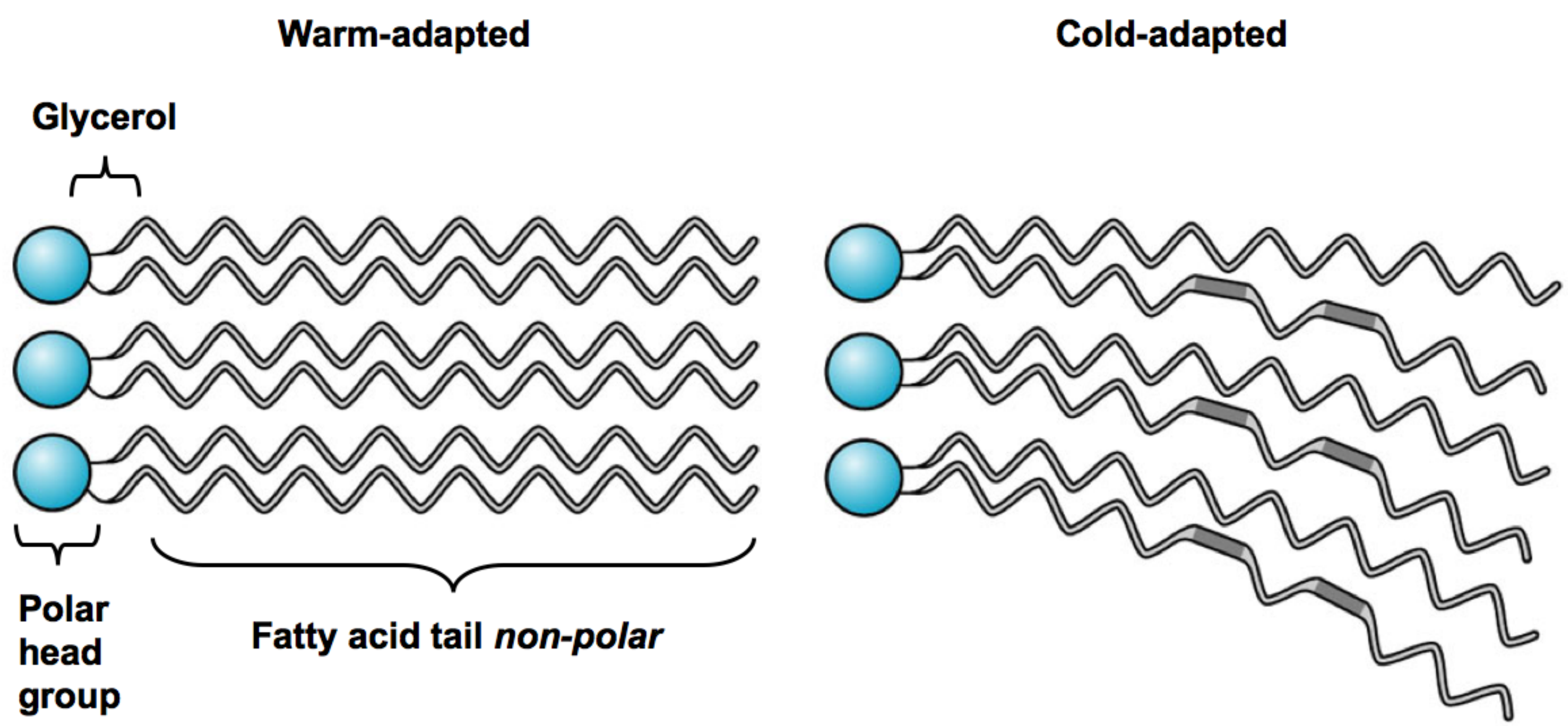
80
t, °C
Perce
n activity
Kinetic energy of reactants
Denaturation

Membranes



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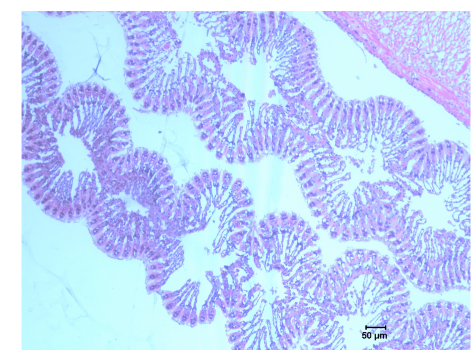
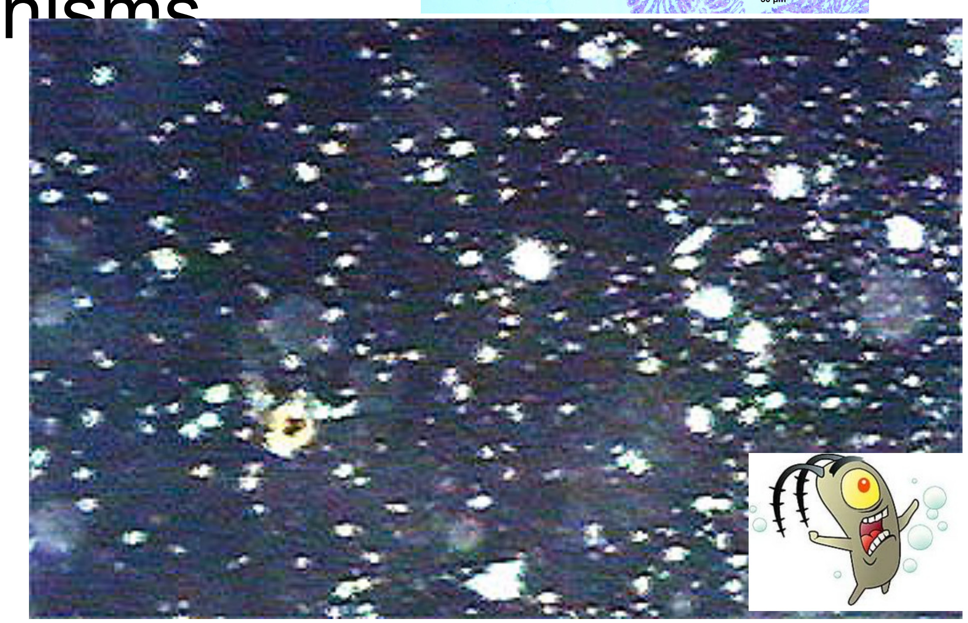
how does this change?

How else?

Density

- Greater density (800x compared with air)
  - large animals can be suspended
  - Ability to have gills and other fragile structures that would collapse in air
  - whole communities of floating organisms
  - motile larvae





Life History Strategies

- Fertilization
  - Internal – more difficult (terrestrial and aquatic)
  - External – easier (aquatic)

Life History Strategies

- Fertilization
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- Abundance influenced by
  - Reproduction
  - Recruitment of larvae or juveniles
  - Migration
  - Mortality

Strategies

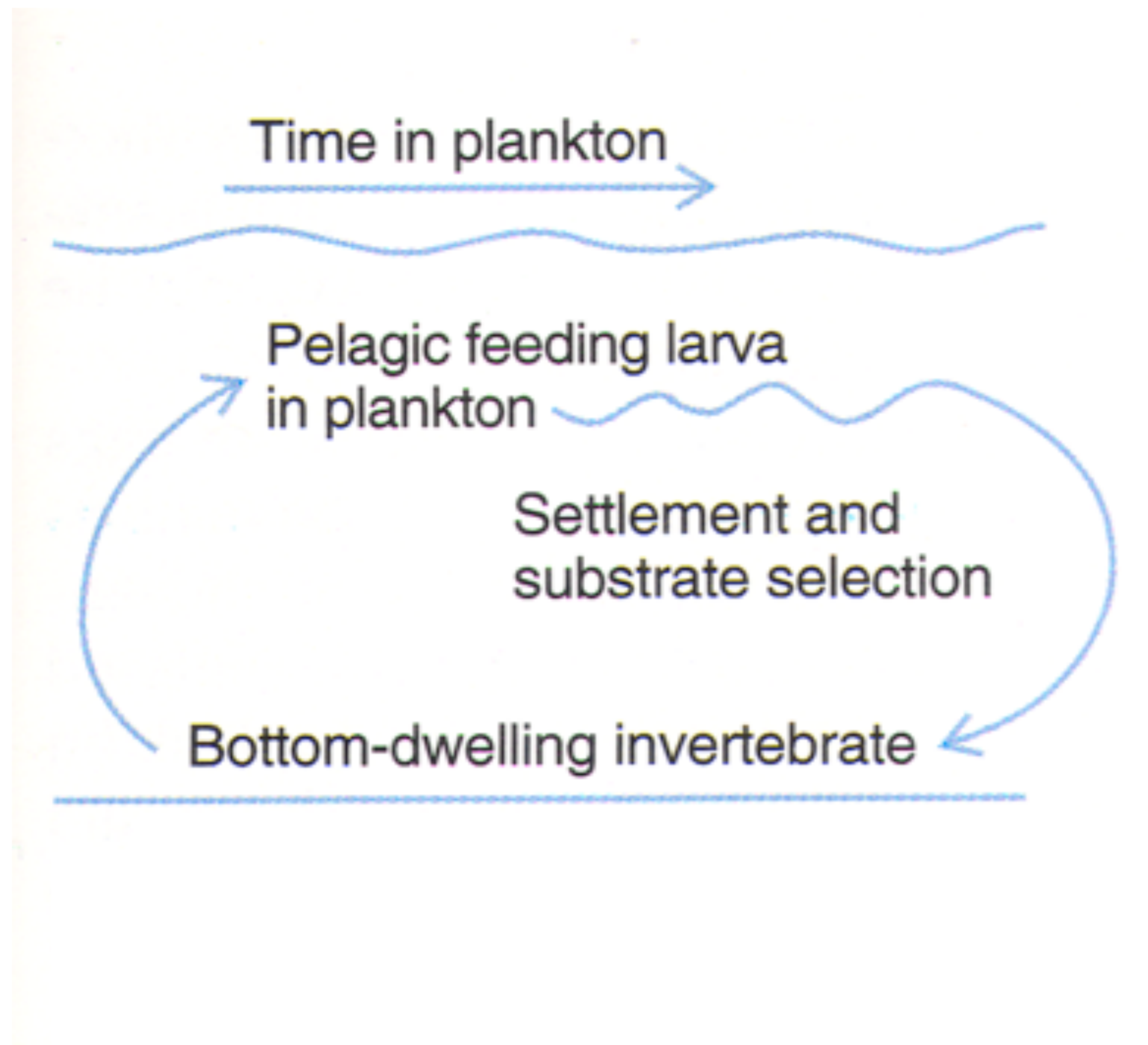
- Planktotrophic
- Lecithotrophic
- Direct Development - nonpelagic

Planktotrophic

Large # small eggs

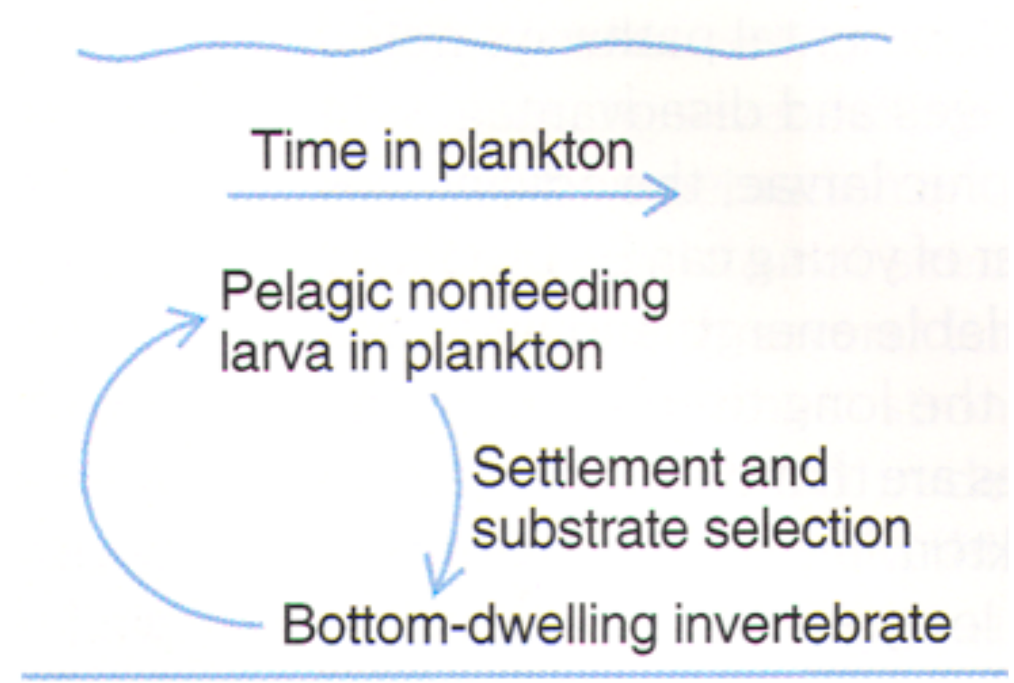
Limited yolk

- where does nutrition come from?

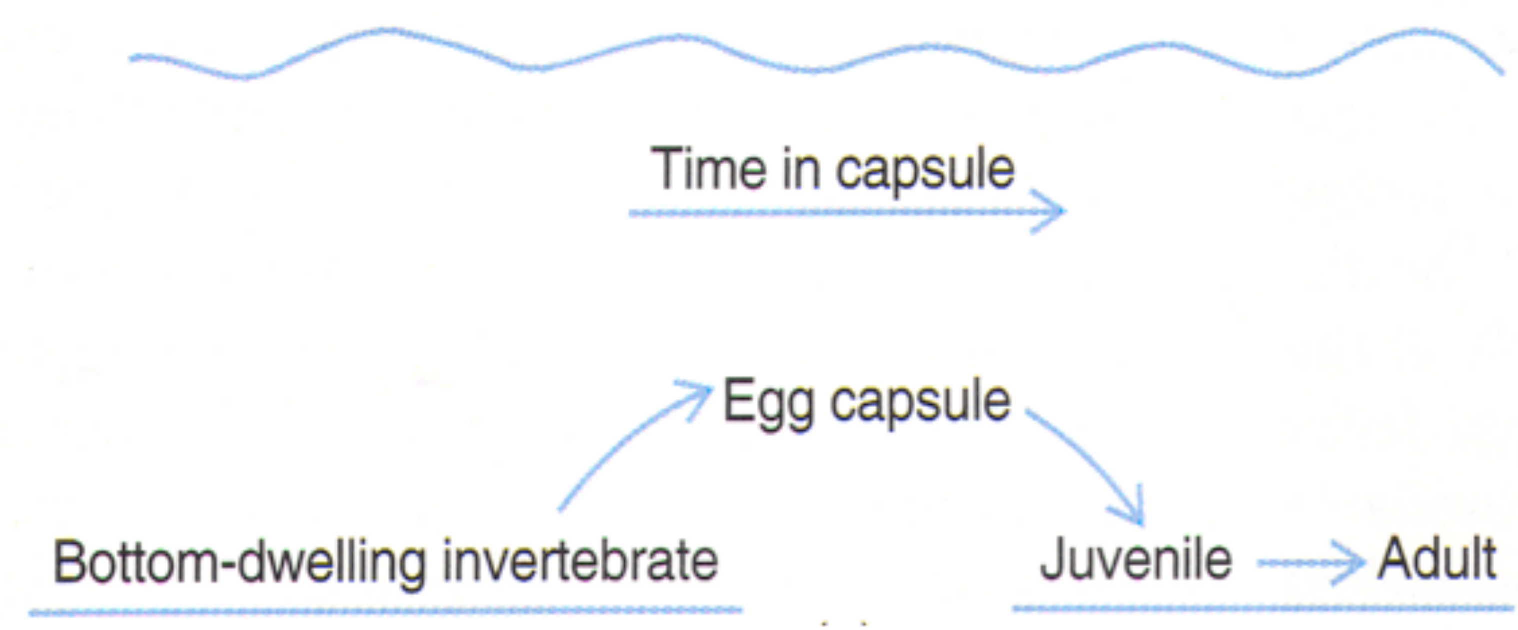


Lecithotrophic

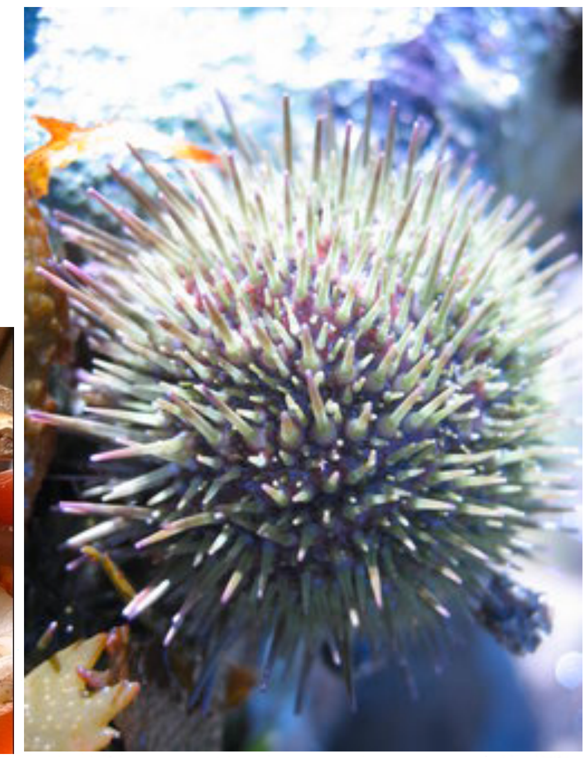
Produce fewer young
more energy in yolk



Non-Pelagic



Time in capsule
Egg capsule
Bottom-dwelling invertebrate
Juvenile
Adult

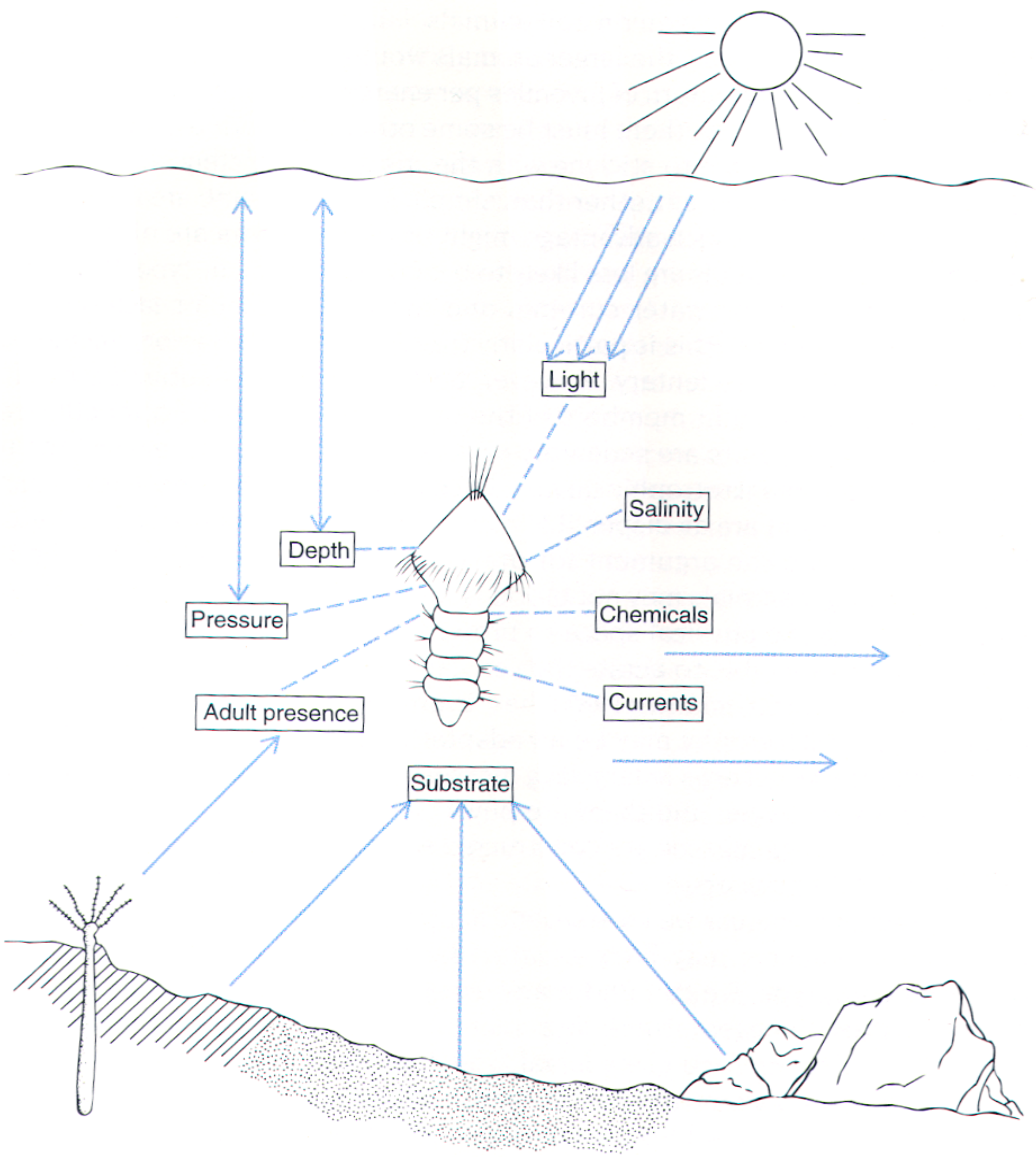


Planktotrophic

Lecithotrophic

Nonpelagic

Planktonic



they can delay

General Life History

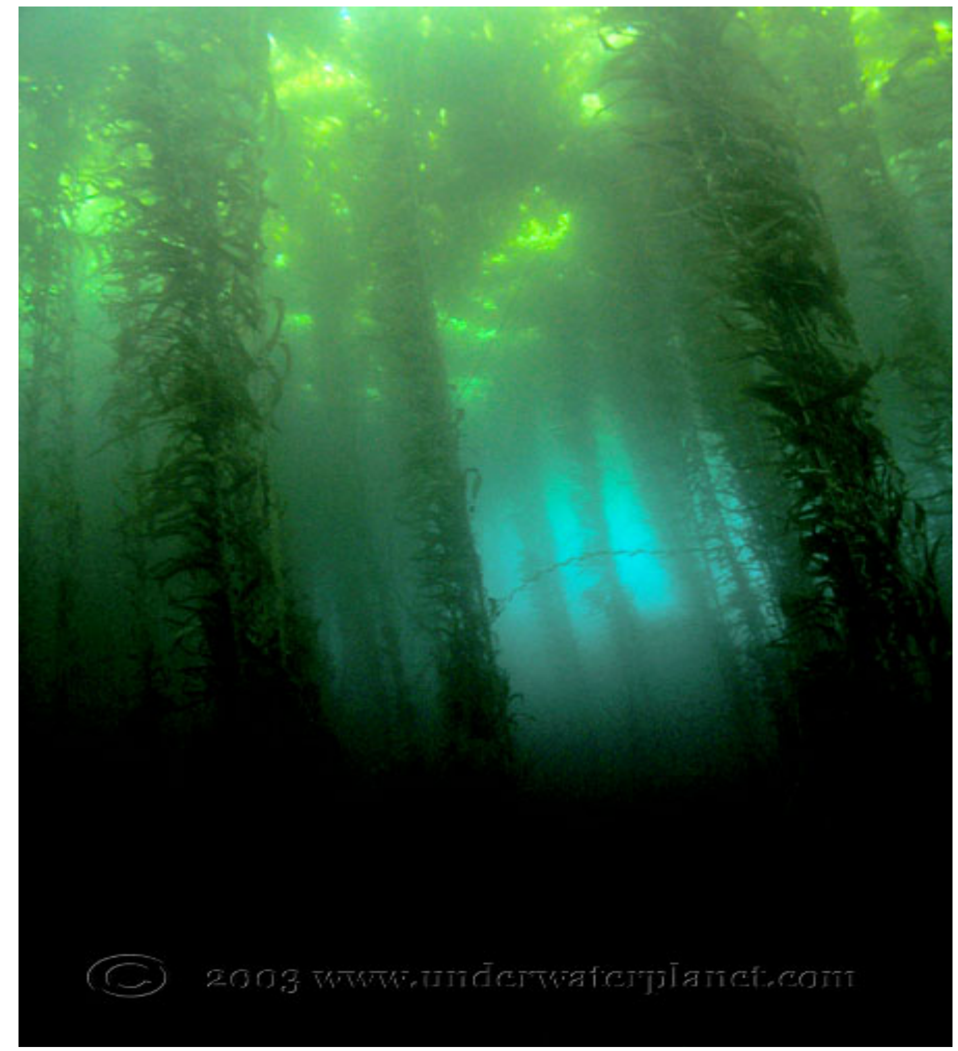
- K-selected species
  - live near carrying capacity of their environment
  - numbers controlled by availability of resources
  - density dependent species
    - food availability = 1 resource controlling population size
  - long maturation time (breed relatively late in life)
  - long lived
  - **produce relatively few offspring**
  - large newborn offspring
  - low mortality rates of young
  - extensive parental care

General Life History

- r-selected species
  - opportunistic
  - short maturation time (breed at a young age)
  - short lifespan
  - **produce many offspring quickly**
  - small offspring
  - high mortality rates of young
  - nonexistent parental care

back to WATER

- Water strongly absorbs light
  - Autotrophic and primary productivity are limited at depth
- Sound travels faster
- Greater density means higher pressure at depth



http://www.underwaterplanet.com/kelp%20forest%206.jpg

Adaptations

- Deep-sea
  - Most mesopelagic jellyfish are dark reddish-purple
  - Crustaceans and squid are often brilliant red
  - WHY?

http://www.glaucus.org.uk/Pelagia-notiluca-JG.jpg

Figure. Left and right side views of ***Stigmatoteuthis hoylei*** as the squid holds onto large forceps in a ship-board aquarium.

Adaptations

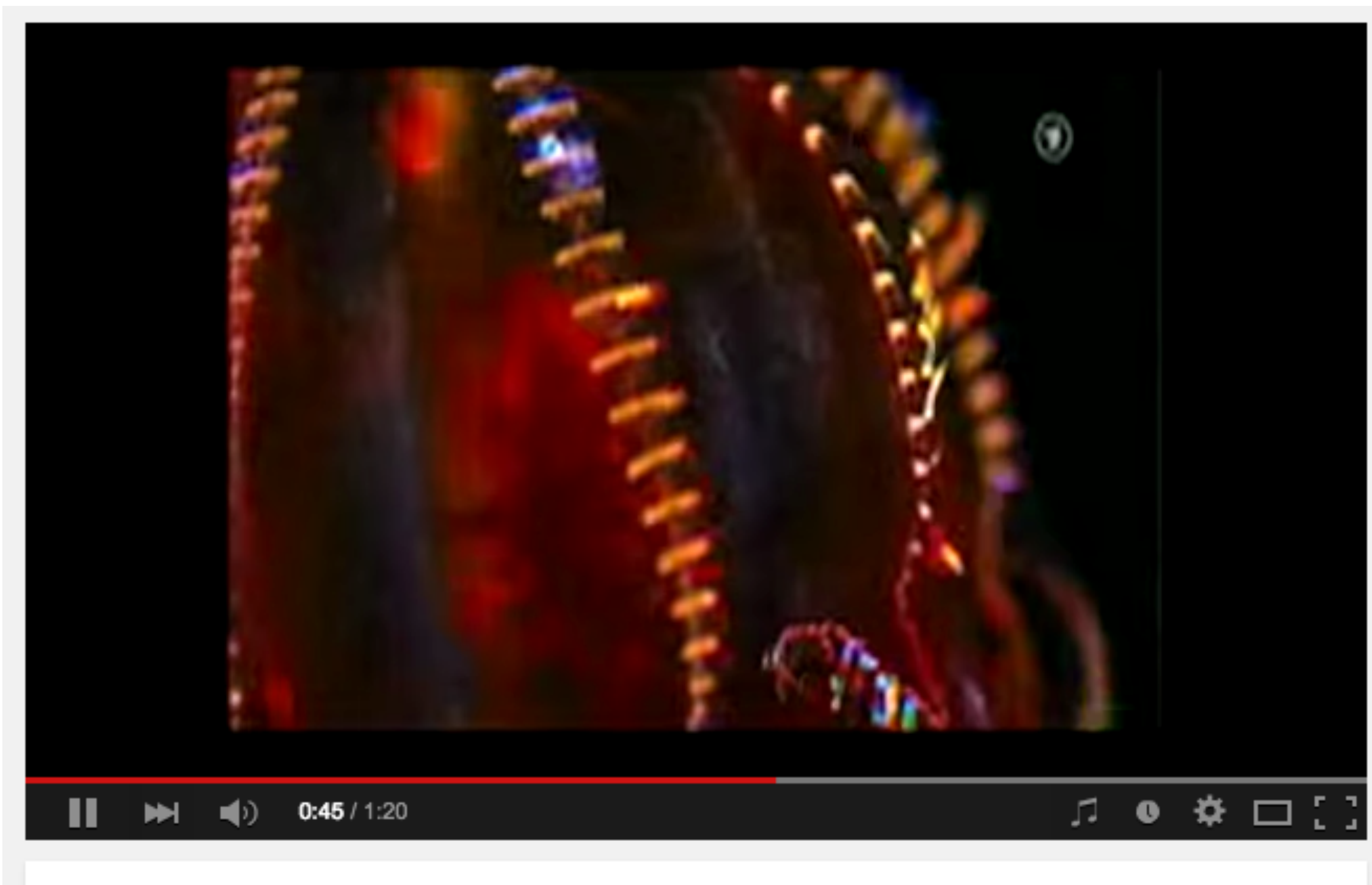
- Deep-sea
  - Bioluminescence
    - Squid (Genus *Abraliopsis*)

http://www.lifesci.ucsb.edu/~biolum/organism/pictures/abraliopsisBL.html

Top View

Mid-water squid
What is the benefit?

http://neurophilosophy.wordpress.com/2007/02/14/giant-squid-dazzles-prey-with-fireworks/



https://www.youtube.com/watch?v=XD7thJVRKmQ

Water as a Universal Solvent

- DOM – Organisms, especially larvae, can absorb DOM directly from ambient water by diffusion or active uptake
  - Amino acids
  - Salts
  - Carbonates
  - Terrestrial embryos must obtain all nutrients from parent and have thick wall to avoid ____________

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  - – Terrestrial embryos must obtain all nutrients from parent and have thick wall to avoid _____________
- Pollutants – often dissolve in water → toxic
  - – In direct contact with body via gills/mantle
  - – Smaller organism surface/body ratio is high
    - larvae

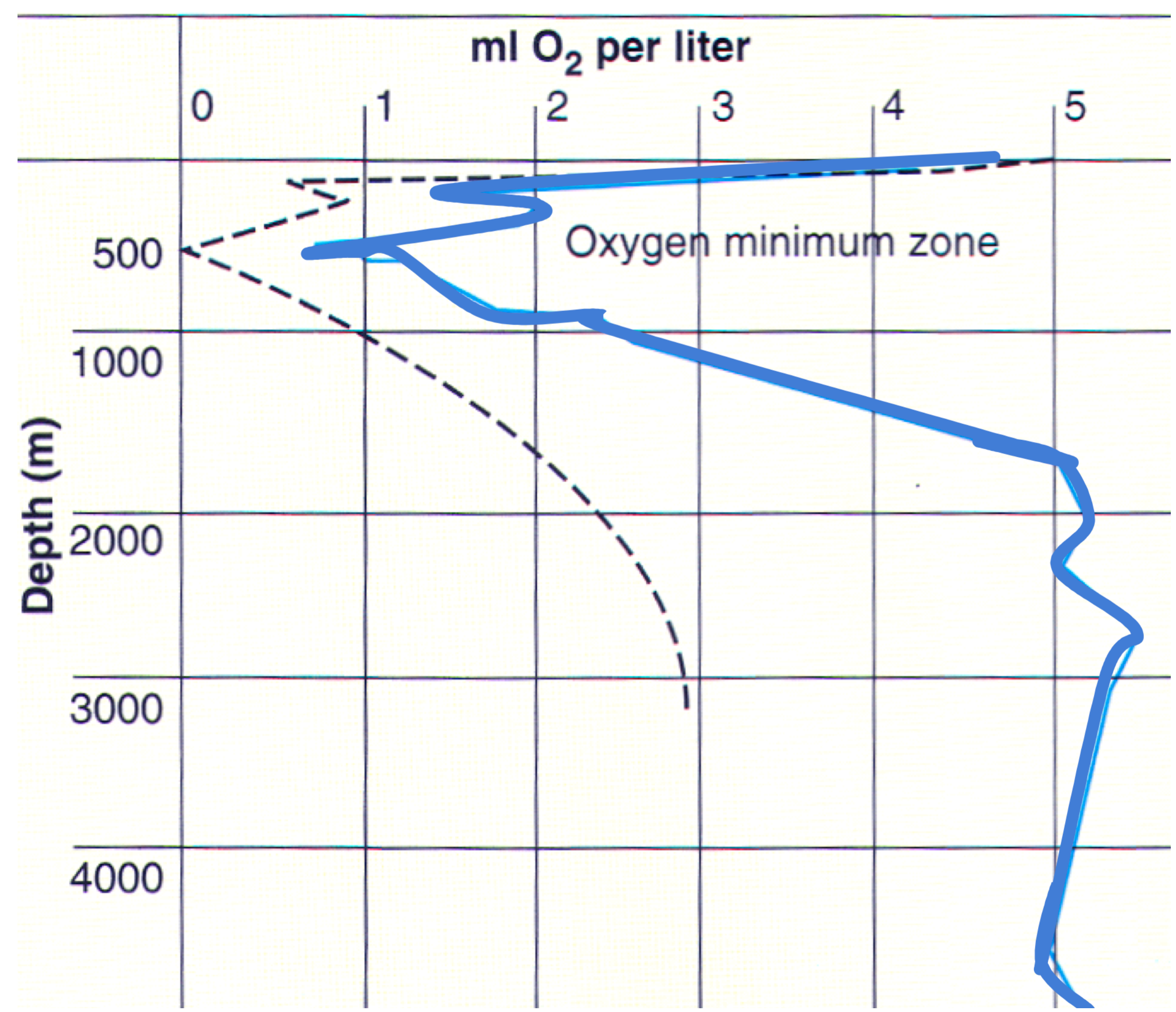
Water and oxygen

At 0°C, 35 psu water contains 8 ml O_2 / liter

air contains 210 ml O_2 / liter

- Stratification
  - High at surface
  - O_2 minimum zone
  - Elevated at depth

- Due to slower diffusion of gas in water than air animals must move or move water for gas exchange



Water and carbon dioxide

$$CO_2 + HOH \rightleftharpoons H_2CO_3$$

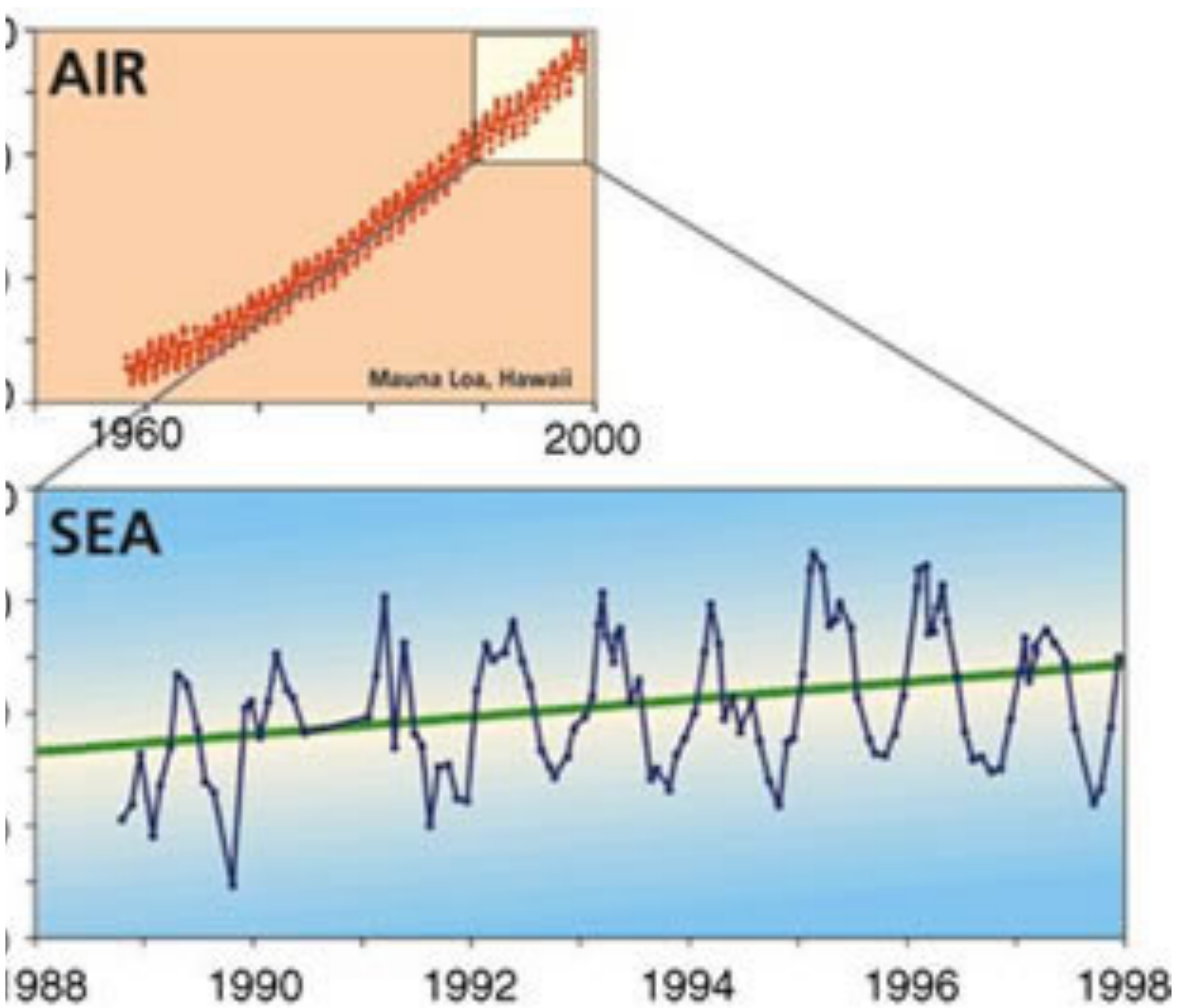
Carbonic acid further dissociates into a hydrogen ion and a bicarbonate ion:

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

Bicarbonate may further dissociate into another hydrogen ion and a carbonate ion:

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

Water and carbon dioxide



CO_2 levels expected for the year 2100 - 740 parts per million (ppm) reduced mussel and oyster ability to produce shells by 25% and 10%, respectively,

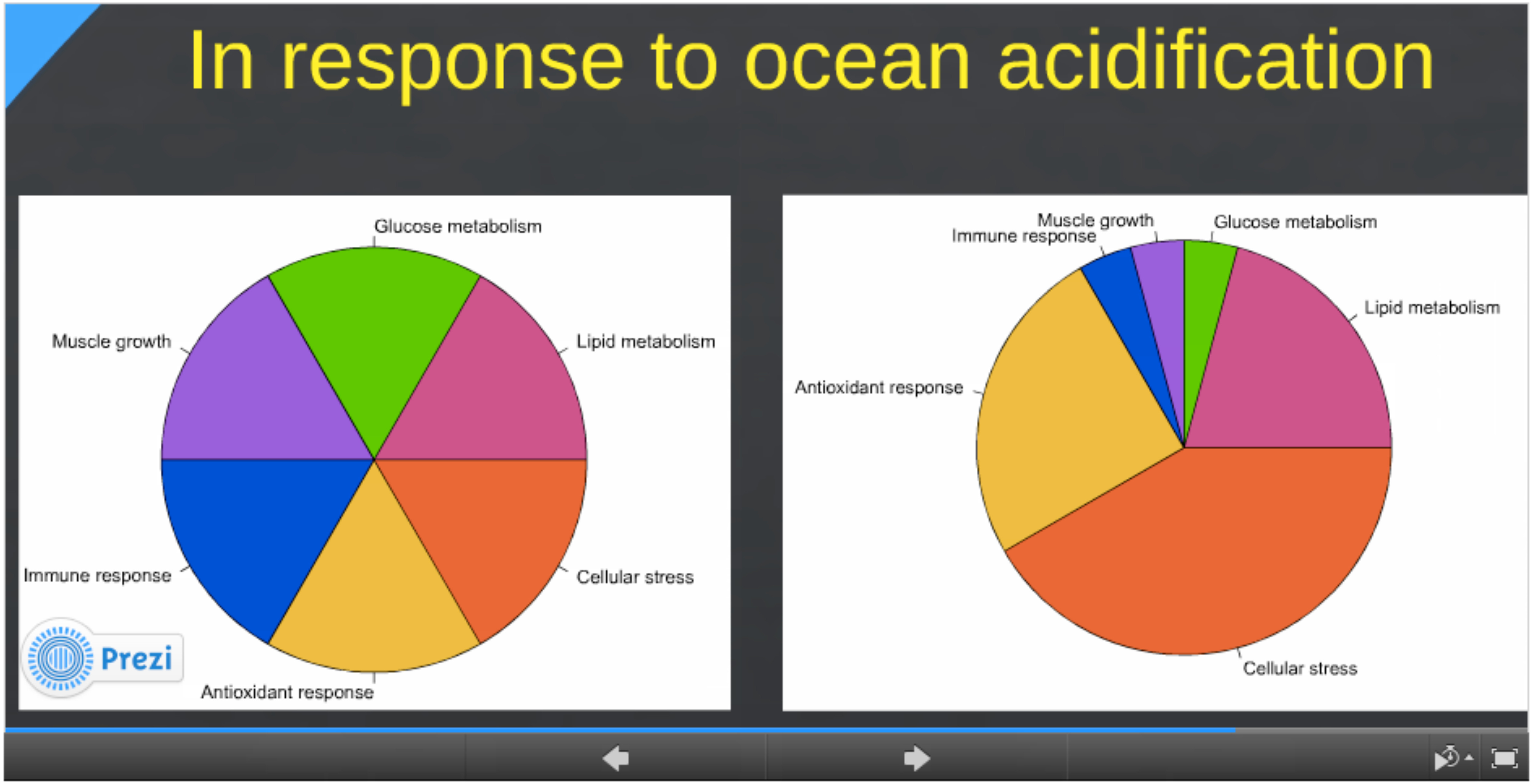
When CO_2 reached 1,800 ppm, mussel shells completely dissolved

WHY?

Ocean Acidification

- As pH decreases, so does:
  - Carbonate availability →
    - Rates of calcification (Gattuso et al. 1999)
    - Shell dissolution (Feely et al. 2004)
    - Metabolic depression → reduced growth (Michaelidis et al. 2005)
    - Reduced locomotion
    - Increased predation
    - Altered trophic interactions

homeostasis



staff.washington.edu/emmats/

Summary Table

* marine

Property	Water	Air
Humidity	**High:** Exposed respiratory surfaces; external fertilization* & development; ammonia excretion	**Low:** Internal resp. surfaces; internal fert; protected devel.; urea & uric acid excr.
Density	**High:** rigid skeleton supports unnecessary; filter feeding possible; external fert; dispersing developmental stages*	**Low:** Rigid skeleton necessary; must move to find food; internal fert; sedentary develop. stages
Compressibility	**Low:** Transmits pressure changes uniformly & effectively	**High:** Less effective pressure change transmission
Specific Heat	**High:** Thermal stability	**Low:** Wide temp flux
Oxygen Solub.	**Low:** 5-6 ml O_2/L water	**High:** 210 ml O_2/L air
DO Diffusion	**Low:** Must move (or move water) for DO exchange	**High:** ~10,000x higher
Viscosity	**High:** Orgs sink slowly; more frictional resistance to movement	**Low:** Faster falling rates; less frictional resistance
Nutrient Content	**High:** Direct absorption of salts & nutrients directly from water for all life stages*; adults may make minimal nutrient investment per egg*	**Low:** No nutrients for direct absorption; adults supply eggs with all nutrients & salts
Light Extinction Coefficient	**High:** Animals may be far from sites of surface-water primary production	**Low:** Animals never far from sites of primary production

moving out of the water

Major Types ("Hard-bottom" vs "Soft-bottom")

- ***Rocky Intertidal***
- ***Sandy Beach***
- ***Mud-Flat***
- ***Ephemeral (many freshwater habitats)***

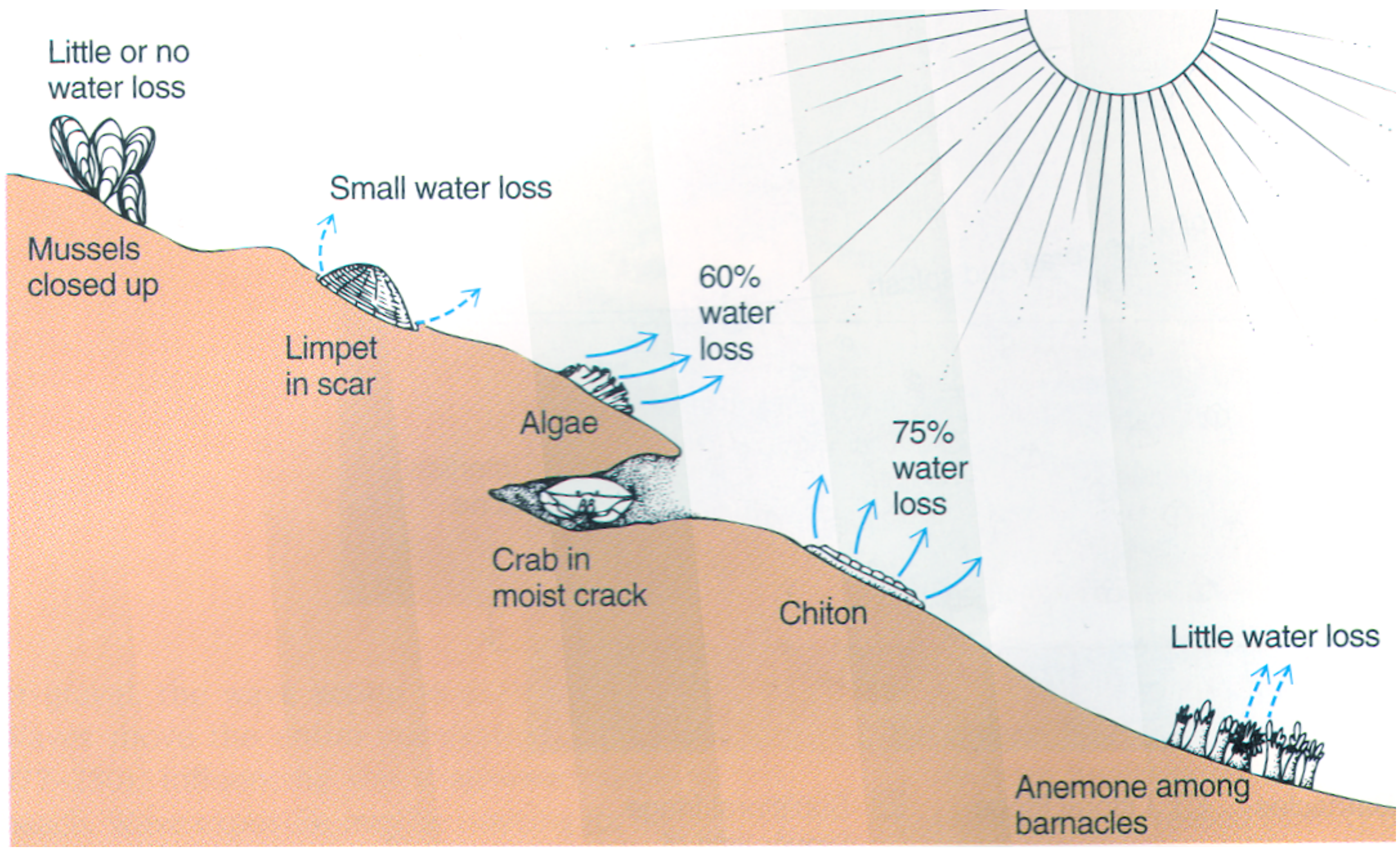
General Characteristics

- Tendency for extreme variation (T,S, 0_2, H_2O)
- Tendency for vertical zonation
- Tendency for stress caused by waves and currents

moving out of the water

- Intertidal
  - Water loss
    - Mobility (Crabs moving from exposed surfaces)
    - Anemone covers itself with shell fragments (*Anthopleura*)
    - Closing shell at low tide (ie mussels)
    - Limpets have ‘home scar”

moving out of the water



Ecology

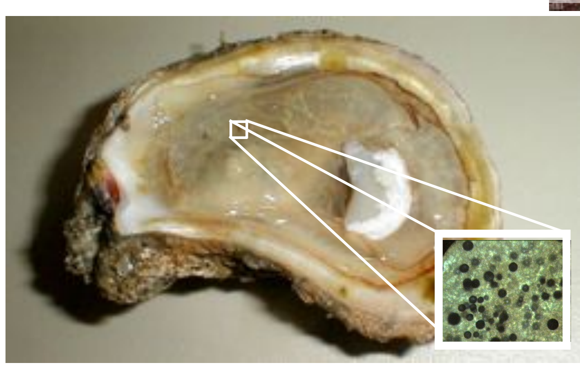
- Ecosystem- functional unit of variable size composed of living and nonliving parts that interact
- producers-consumers-decomposers

Ecological Control and Regulation

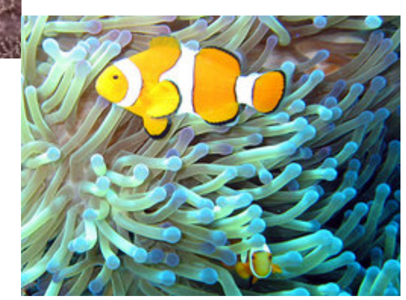
Competition

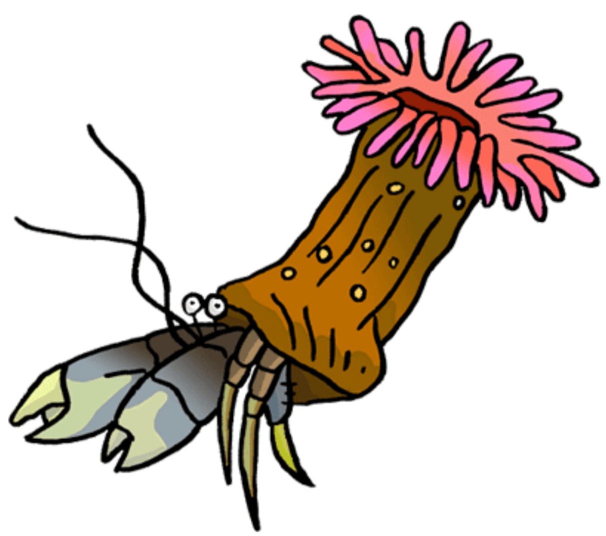
Predation

Parasitism



Mutualism





Commensalism

Organism Interactions

Review Lecture Slides #3
BEFORE class on Friday