

I. Reading: Chapter 3, pp 125-141

II. INTRODUCTION -- CH. 4 HAS TWO MAJOR SECTIONS:

A. "WARM BODIES IN COLD" -- strategy of H_____ which employ both...

1. P_____ THERMOREGULATION

2. P_____ THERMOREGULATION

B. "COLD-BLOODED GAMBLING" -- POIKILOTHERMS [insects, amphibians, etc.]

III. CHALLENGES

A. HOMEOTHERMS -- challenges of high ($T_b - T_a$), food scarcity, acclimatization, homeostasis

B. POIKILOTHERMS – A_____ or T_____ TISSUE FREEZING

C. SPECIFICALLY, IN INSECTS – which tend to be freeze avoiders

1. PREVENT INTRACELLULAR FREEZING -- some allow extracellular freezing

> *i.e.* INTERSTITIAL FLUIDS (ISF) =

> FUNCTION OF ISF = provides corporate homeostasis among cells by close assn. of intra- and extra- cellular fluids

2. FREEZE-RESISTANCE – because ISF normally has a high _____

3. BUT – if ISF Freezes --> "Freeze Concentration" --> Amplifies solute --> "osmotic shock"

> OSMOTIC SHOCK = $\begin{matrix} \text{Salt Imbalance} \\ \text{in ISF} \end{matrix} \longrightarrow \begin{matrix} \text{Dehydration} \\ \text{of cytoplasm} \end{matrix} \longrightarrow \begin{matrix} \text{Membrane protein} \\ \text{denaturation} \end{matrix}$

> RESULT = Isolates (disconnects) cells from needed "corporate homeostasis"

IV. FREEZE AVOIDANCE -- in arthropods that cannot tolerate ice formation

A. BASIS

1. WATER IN SMALL VOLUMES (in test tubes or cells) CAN S_____

2. Arthropod's amplify this tendency to supercool by the following mechanisms (B.)

B. STRATEGIES

1. BEHAVIORAL -- overwinter in _____
 2. MORPHOLOGICAL – waxy exoskeleton _____
– same applies to cocoons
 3. CHEMICAL/BIOCHEMICAL
 - a. REMOVAL OR INACTIVATION OF I _____ - _____ FROM...
-- GUT -- starting in Fall
-- ISF -- remove lipoprotein nucleators
 - b. DECREASE WATER CONTENT -- partly by...
 - c. "ANTIFREEZE PROTEINS" -- interfere with...
 - d. "ANTIFREEZE COMPOUNDS":
Sugar/ Sugar Alcohols; (GLYGOGEN ---> GLYCEROL)

> MECHANISM = binds water and _____

> REDUCES freezing point (in free water samples) and SCP (in tissues)
- C. RISK -- this supercooled state is vulnerable to _____
-- this strategy is favored where a) temps. aren't extreme; b) ice-nucleators absent

V. FREEZE TOLERANCE

- A. EXAMPLES: INSECTS -- Coleoptera, Diptera, Hymenoptera, Lepidoptera
OTHER -- intertidal mollusks, barnacles, terrestrial frogs
garter snakes, painted turtle hatchlings
- B. STRATEGY -- e _____, c _____, g _____ freezing of ISF
 1. INDUCE ICE FORMATION JUST BELOW 0°C
 - a. EXTRACELLULAR INP's ACT --> physically to provide sites for crystallization

--> energetically to lower the "hump" to crystallization
 - b. EARLY crystallization, but SLOW development of SMALL crystals in "ISF"
 - c. ALLOWS TIME for osmotic adjustment --> H₂O leaves by osmosis --> inc. F.P. inside

2. RESTRICT ICE FORMATION TO E_____ SPACES
3. LIMIT AMOUNT OF ICE --> avoid excessive "freeze concentration" of solutes
 - a. ANTIFREEZE PROTEINS -- A_____ to INP's to limit crystal growth
 - b. CRYOPROTECTANTS -- polyols [glycerol, etc.] bind water from freezing
4. PROTECT MEMBRANES -- *e.g.* sugars

VI. ENVIRONMENTAL STIMULI

- A. Low temperature (+5 to -5°C ("5°C trigger")) --> synth. of G_____ (& other polyols)
- B. Daylength and temperature via hormonal actions --> _____ or _____

VII. FROGS – i.e. terrestrial- "hibernating" species [spring peeper, etc.] under leaves/snow

- A. NOT "A_____" as in INSECTS [see Parts IV.B. and VI. above]
- B. MECHANISM OF STIMULUS/RESPONSE
 1. BODY TEMPERATURE DROPS BELOW SCP --> FREEZING OF ISF
 2. GLUCOSE RELEASE FROM LIVER GLYCOGEN --> 200X | in blood <diabetic>
 3. HEART RATE INCREASES concurrently with...
 4. ...BODY TEMP. RISE FROM CRYSTALLIZATION [2°C increase!!!]
 5. HEART RATE remains high until ice content of body reaches 60-65%
 6. HEART and BREATHING stops --> anaerobic metabolism
- C. SNOWPACK THICKNESS is important in sustaining temperature above -7°C lethal temp.

VIII. "COLD SHOCK" IN INSECTS

- A. DEFINED: Injury or death when exposed to sudden subfreezing temperatures above SCP perhaps due to membrane phospholipid "gelling"
- B. SOME INSECT SPECIES avoid injury by --> glycerol production in minutes