15 pts 1. Briefly define each of the following terms.

- conduction -
- spiracle -
- *Bombus* -
- active transport -
- hypothalamus -

9 pts 2. Briefly distinguish between the following pairs of terms.

- Malphighian tubule -
  vs.
- chloride cell -
- urea -
  vs.
- uric acid -
- hemolymph -
  vs.
- blood -

6 pts 3. Draw two functions on the accompanying graph. Function "A" should represent a New England porcupine in the summer and function "B" should represent a New England porcupine in the winter.
5. The accompanying schematics represent two alternatives pathways for blood flow in a wolf paw. Arrows indicate the direction of blood flow. Label one schematic as "cold wolf" to represent an animal attempting to conserve body heat at an environmental temperature of -40°C and the other as "warm wolf" to represent an animal at -20°C that has just sprinted 500 m in pursuit of a caribou. In each schematic, fill in each box with a number indicating the approximate temperature (°C) of the blood.
6. Sketch and label a graph showing body temperature as a function of environmental temperature for an overwintering woodchuck and an overwintering woodfrog in the same New Hampshire environment.

7. What physiological mechanism is employed by arctic ground squirrels to terminate hibernation at the appropriate time in the spring?

8. How do Golden-crowned kinglets survive the winter in northern New Hampshire?

9. Describe the osmoregulation problem of ephidrid fly larvae (Diptera) in the Great Salt Lake of Utah and suggest the likely physiological solutions that they employ.

Problems -

Solutions -

10. Circle any of the following organisms that rely on fattening to survive the winter.

Moose     Red squirrel     Paper birch

Explain why some but not all organisms rely on fattening to survive the winter.
10 pts  11. Refer to Fick's Law of Diffusion, summarized below, and briefly describe features of the fish respiratory system that tend to increase $R$ by influencing each parameter on the right-hand side of the equation.

$$ R = D \cdot A \cdot \frac{\Delta p}{d} $$

Where:
- $R$ = Rate of diffusion (moles/sec)
- $D$ = Diffusion constant; value depends upon material through which diffusion is occurring (cm$^2$/sec)
- $A$ = Area across which diffusion is occurring (cm$^2$)
- $\Delta p$ = Difference in partial pressures or concentration across diffusion surface (mm Hg or moles/cm$^3$)
- $d$ = Distance a molecule must travel to reach the area of lower concentration ($\mu$m)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>One physiological attribute that tends to increase $R$ by influencing this parameter</th>
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<tbody>
<tr>
<td>$D$</td>
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<td>$A$</td>
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<tr>
<td>$\Delta p$</td>
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<td>$d$</td>
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6 pts  12. Explain why the physical gill of a notonectid does not function for as long when they are exposed to an environment of pure $O_2$ instead of normal air.

9 pts  13. Give three examples of sensory organs in animals that each perceive different environmental information. For each, name the organ, an animal that displays it, and the environmental factor that it senses.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Animal</th>
<th>Environmental factor</th>
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<tbody>
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<td>1.</td>
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<td>2.</td>
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<td>3.</td>
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14. Some varieties of cotton produce relatively high concentrations of condensed tannins in their leaves. The tannins increase larval mortality in insect pests. Unfortunately, these well defended genotypes have lower growth rates and yield less cotton in the absence of pests. It has been proposed that pesticide use could be reduced by inter-planting cotton genotypes that produce different concentrations of condensed tannins in their leaves (while keeping the average concentrations of tannins the same).

Identify the general conditions under which cotton fields with high variance in tannins (but the same average tannin concentration) would have less susceptibility to insect pests.

15. Interpret the figure at right according to the work of Anu Valtonen.

Based on her results, how would we expect climate warming to influence the phenology of her study community?