Answer to 1: Although it may appear that the pseudocoelom in Nematodes and Rotifers is a “return” to a more primitive body cavity form, it is actually more likely that this type of body cavity has evolved several times in Animalia, and may be a very primitive means of body cavity formation in triploblastic organisms.

Answer to 2: Note that Platyhelminthes are acoelomate, although they are placed in the Lophotrochozoan clade in the textbook. Platyhelminthes are not currently assigned to Lophotrochozoa in the most recent animal phylogenies; their affinities remain uncertain. So it’s not likely that they actually lost a body cavity. Also note that Nematodes likely retained the pseudocoelom from an ancestral condition; pseudocoelom is a character that appears throughout Animalia (note Rotifers!), and may be retained from a very primitive version of body cavity formation in a Bilaterian, fully triploblastic ancestor.

Refer to: [http://www.tolweb.org/Bilateria/2459](http://www.tolweb.org/Bilateria/2459) for a more up-to-date phylogeny.
A. Identification of synapomorphies defining major animal taxa

Note the characters in the Table FF-1 below. Each should be placed on the phylogenetic tree above with a hashmark, to indicate where it first evolved (making it a synapomorphy uniting all the taxa above it on the tree). Enter only the letters, since writing the character states would be a bit cumbersome!

a. lophophore feeding apparatus  
b. mesoderm lines parietal side of body wall  
c. body cavity contains non-cellular mesogloea  
d. coelom formed via enterocoely  
e. mesoderm derived from endoderm  
f. body cavity contains cellular mesenchyme  
g. cellular division of labor  
h. complete digestive system  
i. diploblasty  
j. triploblasty  
k. coelom formed via schizocoely  
l. bilateral symmetry  
m. radial symmetry  
n. cnidoblast stinging cells  
o. true tissues  
p. nervous system embryonically dorsal  
q. secondary opening becomes the anus  
r. secondary opening becomes the mouth  
s. trochophore larva  
t. pseudocoelom a persistent blastocoel

1. What does this tree imply about evolutionary relationships among the Lophotrochozoa? The unresolved clade indicates that the affinities among Lophotrochozoans are still uncertain.

2. What are the common names of each of the taxa in the tree?

<table>
<thead>
<tr>
<th>Silicea</th>
<th>Glass sponges</th>
<th>Brachiopoda</th>
<th>Lamp Shells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcarea</td>
<td>Calcareous sponges</td>
<td>Mollusca</td>
<td>Mollusces</td>
</tr>
<tr>
<td>Ctenophora</td>
<td>Comb jellies</td>
<td>Annelida</td>
<td>Segment worms</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>Cnidarians</td>
<td>Nematoda</td>
<td>Roundworms</td>
</tr>
<tr>
<td>Acoela</td>
<td>Acoels (flatwormy)</td>
<td>Arthropoda</td>
<td>Arthropods</td>
</tr>
<tr>
<td>Platyhelminthes</td>
<td>Flatworms</td>
<td>Echinodermata</td>
<td>Echinoderms</td>
</tr>
<tr>
<td>Rotifera</td>
<td>Wheel Animalcules</td>
<td>Chordata</td>
<td>Chordates</td>
</tr>
<tr>
<td>Ectoprocta</td>
<td>Bryozoans</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. List common examples in each of the following taxa:

- **Cnidaria**  
  *Hydra, Portuguese Man o’ War, corals, sea anemones, jellyfish*

- **Platyhelminthes**  
  *Turbellarians (free-living), flukes, tapeworms*

- **Mollusca**  
  *Chitons, snails, slugs, clams, mussels, octopus, squid, Nautilus*

- **Annelida**  
  *Earthworms, polychaetes (marine), leeches*

- **Nematoda**  
  *Heartworm, hookworm, Ascarid worms, Caenorhabditis elegans!*

- **Arthropoda**  
  *Horseshoe crabs, spiders, ticks, scorpions, insects, crabs, lobsters, crayfish, barnacles…*

- **Echinodermata**  
  *Starfish, sea urchins, sea lilies, sea cucumbers, brittle stars*

- **Chordata’**
Sea squirts/tunicates, amphioxus/lancelets, lampreys, vertebrates: fish, amphibians, reptiles, birds, mammals

B. Ancestry, Form and Function
1. Consider the synapomorphies that protostomes and deuterostomes share. Based on this information, what do you think the most recent common ancestor of these groups might have looked like?
   Possibly little more than a benthic vermiform creature. Possibly triploblastic, with an incomplete digestive system. Might have looked somewhat like an acoel or flatworm.
2. Based on the description of this common ancestor, which organ system(s) in these animals are likely the most primitive?
   Integumentary, digestive, nervous
3. Consider the synapomorphies exhibited by all Ecdysozoans. Based on this information, what do you think the most recent common ancestral ecdysozoan might have looked like? What characteristics did it have?
   Possibly triploblastic with a pseudocoelom; vermiform with chitin tunic that was shed as the animal grew. Spiral, determinate cleavage and other relevant protostome characters.
4. Consider the synapomorphies exhibited by all Lophotrochozoans. Based on this information, what do you think the most recent common ancestral lophotrochozoan might have looked like? What characteristics did it have?
   Possibly triploblastic (or with very simple “promesodermal” mesenchyme), vermiform, trochophore-like larval stage, typical protostome characters.
5. For each of the following taxa, list the synapomorphies that set them apart from the hypothetical ancestral Ecdysozoan
   a. Nematoda – primarily molecular; high degree of ecdysozoan character loss is evident from recent research.
   b. Arthropoda – articulated exoskeleton; complex endocrinology for ecdysis; highly developed tagmosis with specialized appendages.
6. How does the main body cavity of a nematode differ from that of an arthropod? List at least three key features.
   It is lined only on the parietal side by mesoderm
   Unlike the arthropod coelom, it is not derived via schizocoely
   Unlike the arthropod coelom, it is not segmental, but continuous throughout the body cavity.
   In the adult arthropod, the coelom is reduced to form only the pericardium and the gonocoel.
7. For each of the following taxa, list the synapomorphies that set them apart from the hypothetical ancestral Lophotrochozoan
   a. Mollusca – headfoot; mantle, shell, visceral mass
   b. Annelida – molecular differences; paired appendages on each segment
8. Both Mollusks and Arthropods have (1) an open circulatory system and (2) a reduced coelom that functions as the pericardium and gonocoel. If the hypothetical relationships in the tree above are correct, what does this suggest about these two characters in these two phyla?

They may be convergent. (But note that the same homeotic genes that direct the development of these structures may be operating in these divergent taxa to produce the same type of structures. This is yet to be fully understood.

a. what defines a true coelom?
Lined on both the parietal and visceral surfaces with mesoderm.

b. what is a pericardium?
Coelomic lining surrounding the heart.

c. what is a gonocoel?
Coelomic lining surrounding the gonads and associated structures.

9. Consider the synapomorphies exhibited by all Deuterostomes. Based on this information, what do you think the most recent common ancestral deuterostome might have looked like? What characteristics did it have?

A triploblastic, gastrea-like organism with a complete digestive tract; coelom formed via enterocoely; radial, indeterminate cleavage, embryonic nervous system dorsal; embryonic circulatory system ventral.

10. For each of the following taxa, list the synapomorphies that set them apart from the hypothetical ancestral Deuterostome.

a. Echinodermata – secondarily derived pentaradial symmetry; water vascular system; loss of excretory system

b. Hemichordata – pharyngeal gill slits

c. Chordata – notochord; post-anal tail; segmentally arranged muscle bundles; pharyngeal gill slits;

C. Practical Applications

1. A drug called lufenuron (Program) interferes with the activity of an enzyme known as chitinase, which is involved in the normal formation of chitin. Lufenuron prevents normal maturation of animals that use chitin as structural support. Which of the following do you think would most likely be adversely affected by medicating an infected host mammal with lufenuron?

   a. fleas       d. heartworm (a nematode)       g. tapeworms
   b. ear mites   e. ringworm fungus           h. ticks
   c. leeches     f. liver flukes              i. caterpillars

2. It turns out that although lufenuron is effective against insects, it will not kill ticks.

   What could possibly explain this?

   Ticks may have chitinase sufficiently different from that of other arthropods such that the drug does not disable it.

   Ticks may have a mechanism to inactivate lufenuron.
3. Animal phyla have long been classified into putatively monophyletic assemblages on the basis of their body plans. Unfortunately, as we are now discovering with more sophisticated identification techniques such as DNA sequencing and metabolic studies, this can sometimes create artificial taxa that are paraphyletic or polyphyletic. Consider the following phylogenetic trees. The one on the left shows a classification based upon molecular (DNA sequencing) data. The one on the right shows a "traditional" classification based upon body plans and morphology.

Now consider the following:
Ivermectin is a macrolide antibiotic produced from a fungus (*Streptomyces avermitilis*) first isolated from a soil sample in Japan. Ivermectin is an agonist for the neurotransmitter gamma-aminobutyric acid (GABA), a major inhibitory neurotransmitter. In mammals, GABA-containing neurons and receptors are found in the Central Nervous System, while in arthropods and nematodes GABA is found primarily in the Peripheral Nervous System. This difference in location of GABA receptors may be the reason why ivermectin can be safely administered to mammals for treatment of arthropod and nematode parasites.

The binding of ivermectin to a neuronal membrane increases the release of GABA, which binds to the GABA receptor-chloride channel complex of postsynaptic neuronal membranes. This causes an influx of chloride ions that hyperpolarize the neuronal membrane making them less excitatory and decreasing nerve transmission.

The hyperpolarization of neuronal membranes mediates a flaccid paralysis in arthropods and nematodes. Discuss the implications of this characteristic in arthropods and nematodes. Do you believe it is evidence of convergent evolution, or of homology? Support your answer.

*Probably homology, given the many synapomorphies (notably molecular) shared by nematodes and arthropods*
**Discussion**
Can you think of other examples of characteristics used to devise phylogenies that might also have relevance in treatment of disease, solution of environmental problems, or other practical applications? Discuss! And discuss some more!

**Possible avenues to stroll:**
Recall the dangers of assuming that evolutionary relationship automatically presumes similar physiology. Example given: fipronil (active ingredient in Frontline) is safe for all mammals except lagomorphs (rabbits and hares), in which it causes fatal neurological damage.

Consider relevance of pesticide strategies that target the physiology of various related parasites/agricultural pests.

Insect growth regulators are a HUGE issue in pest management: finding a substance that inhibits the growth/metamorphosis of insect pests without harming vertebrates or other beneficial animals (e.g., arachnids, such as spiders) means finding the unique “Achille’s Heel” of a particular taxon. Synapomorphies of physiology can be a valuable tool in this ongoing battle.

(For example—Trypanosomes (not Animals, but you get the point) have a unique type of RNA known as guide RNA (gRNA). Investigators hope to learn the mechanisms of action of this gRNA (which appears to direct the rapid change of surface proteins in the parasite’s plasma membranes) and disable it, crippling the parasite. Because the hosts don’t have gRNA (it’s not in their evolutionary package), such a directed pesticide could be a safe treatment for African Sleeping Sickness. (Though we must always beware of unexpected susceptibilities, such as described in the fipronil example above.)

Drive this discussion by trying to get students to see the economic value of understanding evolutionary relationships as a potential KEY to unlocking the door to selective control of undesirable competitors, parasites, and pests.