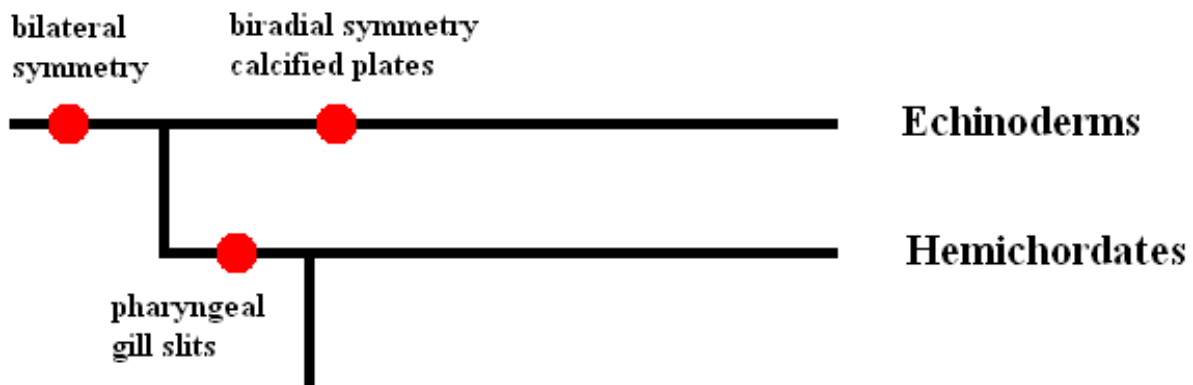


Lecture III.5a. Questions.

1. Suppose that echinoderms were originally bilaterally symmetric. How would that change the synapomorphies in the cladogram on page 2?



2. If echinoderms were originally bilaterally symmetric, what factor(s) might have selected for the evolution of “radial,” *i.e.* pentameral symmetry in adults?

1st echinoderms (crinoids) sessile, *i.e.*, attached to the substrate by a stalk. Radial symmetry facilitates for sampling all quarters of the environment. No need for bilateral symmetry – animals didn't swim, crawl, *etc.*



3. How do tube feet work? See assigned readings ([here](#) and [here](#)).

Hydrostatic pressure generated by the water vascular system causes the tube feet to extend – the protruding parts called “podia”. Most textbooks stop there. Some, Freeman included, refer to gripping and releasing the substrate; others, to suction. In fact, it now appears that both attachment and release are mediated by chemicals secreted by special cells in the tube feet. First a film is released; then a mesh that “bulks up” reminding me, at least to me, of “Gorilla Glue”. At this point, the foot is firmly attached to the substrate. Substrate release is mediated by release of a third chemical. Chemical adhesion, it should be noted, is consistent with the observation that starfish can walk on porous substrates – screens for example – to which the tube feet couldn’t attach by suction.

The papers (Hennebert *et al.*, 2008; 2012) on which the assigned readings are based available found at

<http://www.sciencedirect.com/science/article/pii/S1047847708001640> and

<http://www.mapress.com/zoosymposia/content/2012/v7/f/v007p025-032.pdf>

4. How does a starfish (sea star) eat a clam?

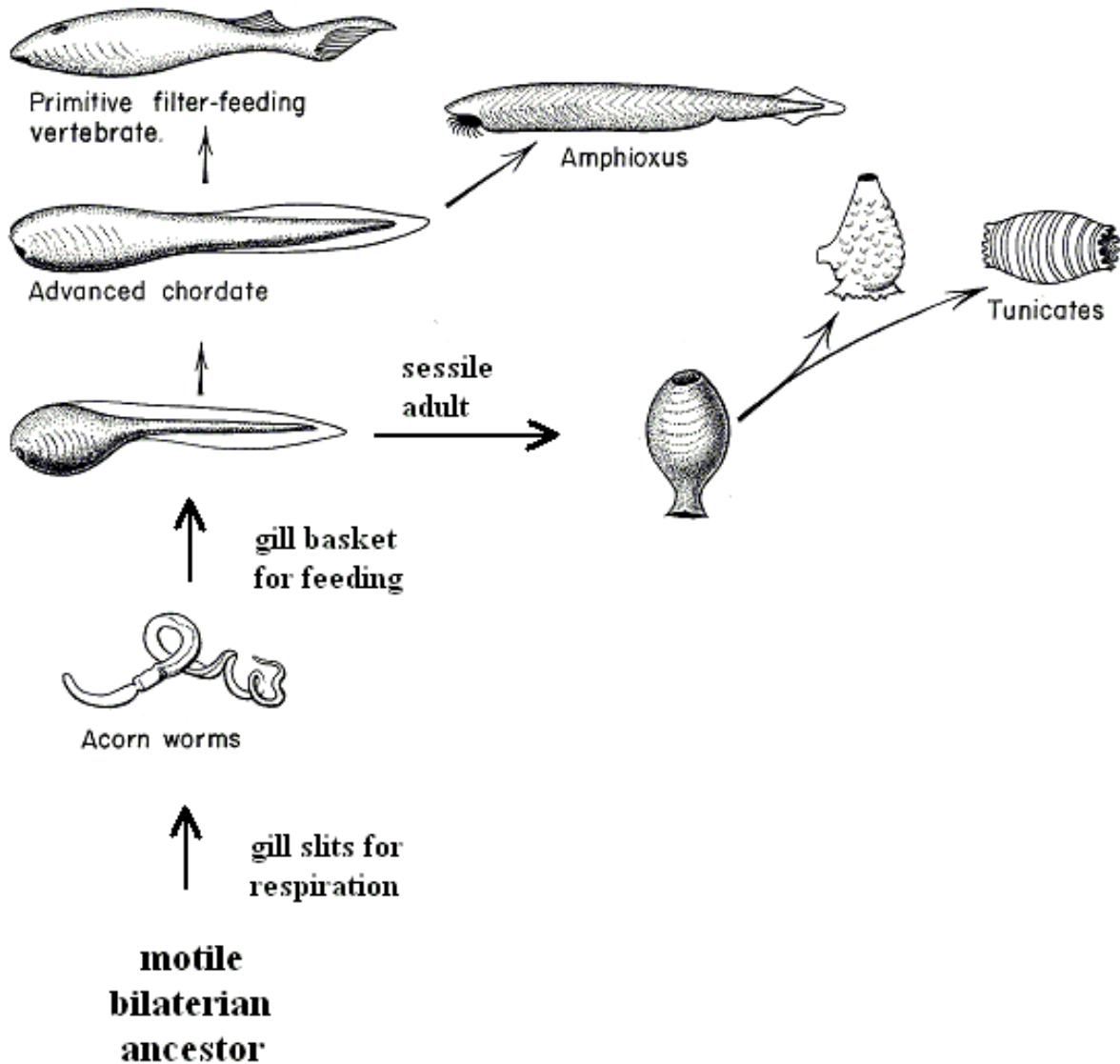
- a. Pries the valves apart – just a tiny bit – with tube feet.**
- b. Everts part of its stomach.**
- c. Slips the stomach between the valves.**
- d. Digests the clam *in situ*.**



5. Crossopterygian fishes crawled out of Devonian streams and ponds some 370 million years ago.¹ Give two reasons why they might have done so.
- a. Access to abundant food supply, especially arthropods in the surrounding woodlands which may have been partially flooded.**
 - b. Escape from ponds / streams that dried up seasonally.**

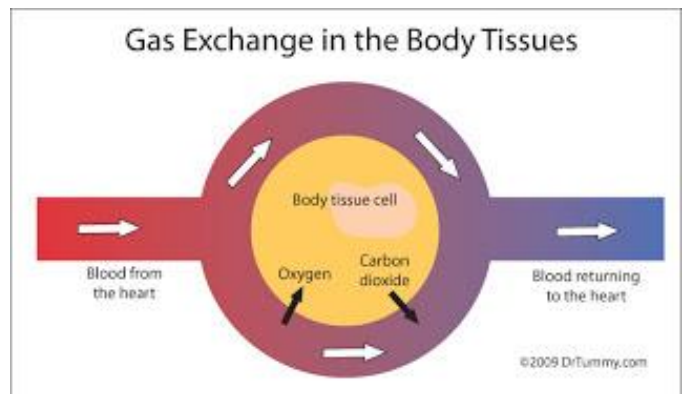
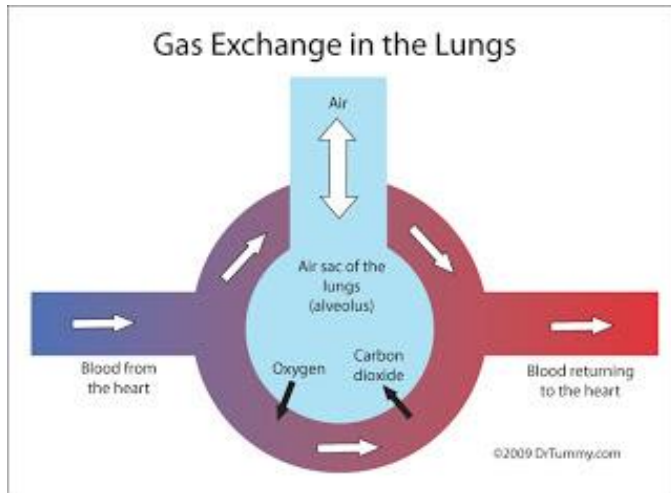
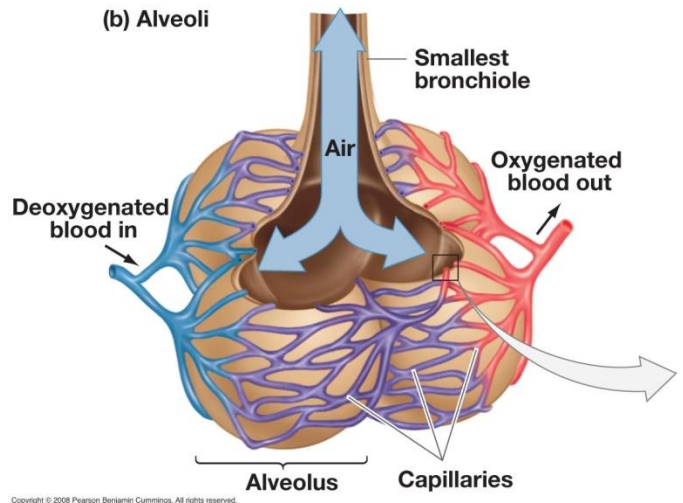
¹ Only the adults were terrestrial. Reproduction still occurred in the water, necessitating an aquatic juvenile stage.

6. Redraw the scenario on the page 23 assuming a motile, bilaterian ancestor. **Something like this:**



7. Tetrapods and insects both obtain oxygen from the air. Compare gas exchange and transport in these two groups. Relate to insect size past and present. (Requires outside reading).

In tetrapods, gas exchange and transport are intimately linked. Exchange with the environment takes place in the lungs, where blood and air passages break down into small, thin-walled capillaries (blood) and



alveoli (air). This facilitates the exchange of CO_2 and O_2 , the exchange being between red blood cells (RBCs) in the capillaries and air in the alveoli. More precisely, the RBCs release CO_2 and take up oxygen. Oxygen transport to the tissues (and CO_2 transport from the tissues) is via the circulatory system, where the blood vessels again break down into capillaries. At this point, the RBCs release O_2 and take up CO_2 .

RBC uptake and release of gases is mediated by hemoglobin.

Inhalation / exhalation is facilitated by the diaphragm in mammals and by muscular contraction in crocodilians. In birds, “continuous flow” respiration involves a series of air sacs as discussed in Lecture III.5b.

In insects, gas transport is independent of the circulatory system. Air enters through spiracles and is delivered to the directly to the tissues via a system of branching tubes (tracheae, tracheoles) as shown in the accompanying figures. O_2 – CO_2 exchange occurs where the smallest air passages (tracheoles) contact the tissues.

In large insects, diffusion is supplemented by abdominal pumping, in which case, fresh air enters through the thoracic spiracles, while stale air exits

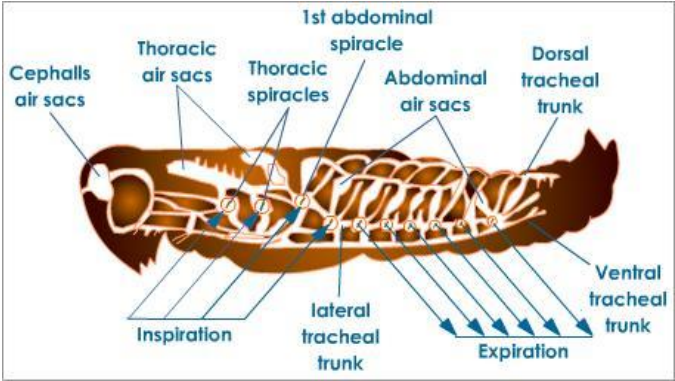
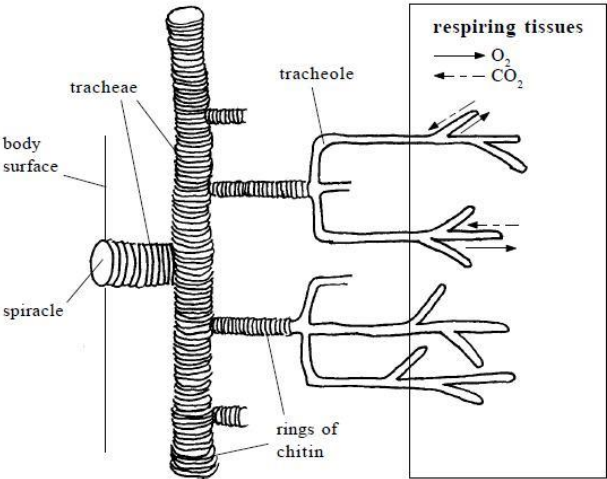


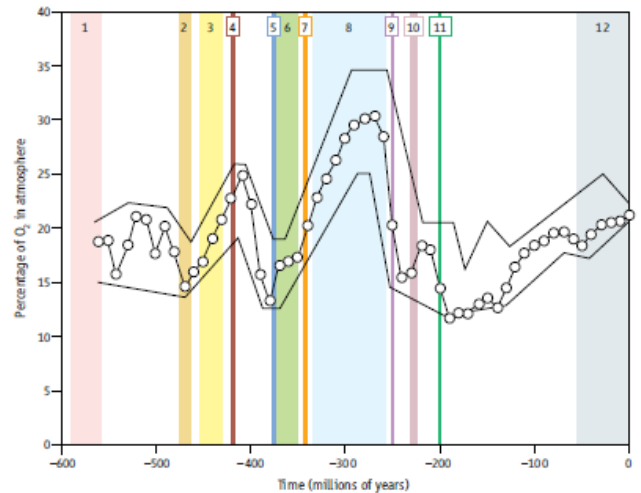
Fig 4. The insect tracheal system



Top. Respiratory system of the grasshopper. Bottom. Detail showing tracheal branching.

via the abdomen. Like birds, insects have flow-through respiration analogous, but without circulatory system involvement.

Maximum body size in contemporary insects is substantially less than in previous times. During the Carboniferous, for example, there were species of dragonflies with two foot wing spans. A possible explanation relates to the fact that atmospheric oxygen concentrations were much higher in those days (30% vs. 21%) and that insect respiratory systems, by virtue of their independence of the circulatory system, are less efficient than those of tetrapods.



Oxygen levels in the Phanerozoic as inferred from computer modeling by Berner, van den Brooks and Ward (2007). Peak O₂ concentrations correspond to the period (late Carboniferous, early Permian) of insect gigantism.