Evolution of Circulatory and Respiratory Systems Concept Questions

1. Why do some organisms require a circulatory system while others do not? (Unicellular and small multicellular organisms can rely on diffusion because most or all of their cells are in direct contact with the external environment. Large, multicellular animals require a circulatory system because diffusion is too slow to provide exchange of gas and molecules for all cells.)

2. a) Seaweeds live in water and are large compared to mosses which live on land. Neither have vascular tissue. Provide an explanation for this difference. (Seaweeds are surrounded by water, so most or all cells can exchange gases and molecules directly with the environment. All cells of mosses are not surrounded by water, so their size is limited because they must rely on diffusion.)
   b) Explain how the transition to a terrestrial lifestyle for plants required the evolution of vascular tissue. (In order to live further from water and grow larger, vascular tissue is needed.)
   c) Why is long-distance transport important for vascular plants? (Vascular plants must transport minerals and water absorbed by the roots to all the other parts of the plant. They must also transport sugars from sites of production to sites of use.)

3. What three important features are used by botanists to divide plants into four groups? (Presence or absence of vascular tissue, reproduction using seeds or spores, enclosed or naked seeds.)

4. Root hairs are small structures on roots that increase the surface area of the root. Why is it important for root hairs to develop soon after germination? (Root hairs have a large surface area in order to maximize absorption. They need to develop soon after germination because the seed does not have enough water or nutrients within it to sustain growth. The plant must begin absorbing water immediately.)

5. Explain why xylem and phloem together can be considered a transport system. (Xylem moves water from the roots to the leaves while phloem moves food from leaves (or any source) to the roots (or any sink). Together they move material through a plant, forming a transport system.)

6. Cork is a tough, waterproof tissue that replaces the epidermis in some plants. Older roots become covered in cork as they mature. Explain. Would you expect both young and old roots to have vascular tissue? Explain. (Older roots transport water and the cork forms in order to prevent any water loss to the surrounding soil. Young roots do not have cork and are responsible for absorbing water. Both old and young roots have vascular tissue because they transport water and also require sugar from the photosynthetic parts of the plant.)

7. How does the cooperation of transpiration-cohesion-tension theory and root pressure result in water moving throughout the entire plant? (Water molecules are lost from the leaves by transpiration. Cohesion causes these molecules to pull on adjacent water molecules and so on in a continuous chain throughout the xylem. The root is maintained at a higher solute concentration than the surrounding soil so the process continues as long as water molecules can enter the vascular tissue in the roots by osmosis.)

8. a) If you were able to inject some air bubbles into the xylem vessels of a tree, what would happen? (Cohesion would be broken so the transport of water would stop. This would prevent photosynthesis from continuing and ultimately lead to death of the tree.)

   b) How does your answer to (a) explain why, if you buy cut flowers, it is best to cut the stems underwater and then transfer the flowers to a vase while the cut ends are still wet? (After the

flowers are cut, transpiration from any leaves and from the petals (which are modified leaves) will continue to draw water up the xylem. If cut flowers are transferred directly to a vase, air pockets in xylem vessels prevent delivery of water from the vase to the flowers. Cutting stems again underwater, a few centimeters from the original cut, will sever the xylem above the air pocket. The water droplets prevent another air pocket from forming while the flowers are transferred to a vase.)

9. Explain how the pressure flow hypothesis accounts for the movement of food in a plant. (Energy is used to load sugar into phloem cells at a source. Water follows by osmosis. As the pressure in the phloem cell increases, the contents are pushed into the next cell. At a sink, sugar molecules are removed from the phloem and either used or stored. This process moves photosynthetic products from source to sink in the plant.)

10. Why are maple trees tapped in early spring rather than in summer or autumn? (In the spring there is a sudden rush of sap with a high sugar concentration. The sap is meant to fuel the growth of the leaves, and in the summer the leaves are already present and functioning, while in the fall they are gone.)

11. Explain the compromise a plant has to make between photosynthesis and water conservation. (The stomata must open to photosynthesize (in order to acquire CO_2 and release O_2) but they will lose water (in the form of water vapor) at that time.)

12. Why are open circulatory systems found mostly in animals that are small? (Open circulation is less efficient because blood cannot be directed to specific parts of the body. It would be difficult to circulate blood throughout a large body cavity.)

13. Some organisms have a circulatory system with blood, but the blood has no hemoglobin.
    a) What is the function of the blood in these organisms? (The function of the blood is still to distribute oxygen and nutrients.)
    b) Why is it an advantage to have hemoglobin in the blood? (Hemoglobin makes this more efficient by carrying more oxygen. This allows organisms to be larger and more active.)

14. How is circulation through two loops (as in amphibians, birds, and mammals) superior to circulation through just one (as in the fishes)? (The heart can pump blood to the lungs and body separately, resulting in a higher blood pressure in both loops.)

15. The blood that enters the lungs of an amphibian has relatively (more* or less (choose one)) oxygen than the blood that enters the gills of a fish. The reason for this is that the blood that goes from an amphibian's heart to its lungs is _____ (a mixture of oxygenated and deoxygenated). The blood that is carried to all organs of a fish's body is _____ (oxygenated). The blood that is carried to the fish's gills is _____ (deoxygenated). The blood that is carried to the organs of an amphibian is (mixed).

16. Why is the three chambered amphibian heart not as efficient as a four chambered heart? (Oxygenated and deoxygenated blood mix in the ventricle, so that blood going to the body is not fully oxygenated.)

17. What purpose is served by the respiratory system? (To get oxygen from the environment for cells to use in cellular respiration and to remove CO_2.)

18. Why do organisms require oxygen? (Oxygen is sued in cellular respiration, the process that organisms use to produce the energy they need.)

19. a) Why do some organisms require a respiratory system while others do not? (Unicellular and small multicellular organisms can rely on diffusion because most or all of their cells are in direct contact with the external environment. Large, multicellular animals require a respiratory system because diffusion is too slow to provide exchange of gas and molecules for all cells.)
    b) Describe the importance of surface area to the respiratory surface. (In order to provide sufficient gas exchange, a large surface area is required to provide contact between the circulating fluid and the external environment. The respiratory surface provides this surface area.)

20. Why are gills necessary in more complex organisms such as molluscs? (Diffusion cannot satisfy the higher oxygen requirements and is too slow for a larger organism.)

21. There is far more O_2 in the air than in an equal volume of water. Despite this fact, the gills of a fish are able to extract sufficient O_2 from the water but not from the air. Hence, a fish out of water suffocates. Explain why this is so. (In the air, the gill filaments clump together, drastically reducing the surface area.)

22. a) What is a tracheal respiratory system? (A network of air tubes that branch throughout the body.)
    b) Why is it an advantage? (A tracheal system branches inside the body, distributing O_2 to more cells more efficiently than diffusion alone.)
    c) Why is this especially important for flying insects? (Flying requires more oxygen.)

23. a) Why are amphibians considered to be transitional between fishes and terrestrial vertebrates? (Their life cycle is split between water and land.)
    b) What adaptations allowed amphibians to colonize the land? (They have legs for improved on land and lungs for getting oxygen from the air.)
    c) What features of the frog restrict them to living near the water? (Eggs must be deposited in water and the skin must be kept moist for diffusion of oxygen because their lungs are not sufficiently complex to allow for enough gas exchange.)
    d) State the advantage and disadvantage of using the skin as a respiratory surface. (The extra surface area for breathing increases the amount of oxygen that can be obtained but it must be kept moist which requires water.)

24. How has the respiratory system of birds developed over that of other vertebrates? (The air sacs allow continuous air flow through lungs, both while inhaling and exhaling.)

25. Why is the respiratory surface for terrestrial organisms inside rather than outside the body? (The respiratory surface must remain moist for diffusion of gases. Outside the body water loss would be too great.)