Questions.

1. Plants transitioned from freshwater to land in the Ordovician; vertebrates, in the Devonian. List and compare the adaptations with regard to gas exchange and support that enabled each group to make the switch.

**Air and Gas Exchange.** In both plants and animals water loss is prevented by a water-impermeable outer covering – waxy cuticle in plants; integument, in reptiles. In plants, this necessitated the evolution of stomata through which air could be exchanged with the environment. In tetrapods, exchange with the environment is via the mouth and throat, which, of course, existed in their lobefin ancestors. Likewise in plants, gas exchange occurs in the leaves; in tetrapods, in the lungs. In short, the ways in which plants and tetrapods exchange air and gases are quite different. There is, however, an interesting parallel.

Contemporary amphibians respire in part, or principally, through the skin, which is moist and highly vascularized. This condition was achieved via the loss of scales, which their lobefin ancestors most certainly possessed. Early tetrapods (and living frogs and salamanders) were thus similar to non-tracheophytes with gas exchange proceeding principally through a moist outer covering. But tetrapods
also had lungs and circulatory systems. When they evolved a water-impermeable integument, lung and circulatory capacity expanded.

Had lungs and circulatory systems *not* existed pre-transition, tetrapods might conceivably have evolved an insect-like anatomy in which air enters through spiracles and is delivered to the tissues via a branching network of trachea. Of course, tetrapod ancestors *did* have lungs, and these became larger and more highly vascularized. Additionally, by the time one gets to birds and mammals the circulation of oxygenated and de-oxygenated blood is kept separate. Other structures (secondary palette, diaphragms, air sacs, *etc.*) also evolved to further augment fresh air acquisition.

**Support.** In plants, support is provided by lignified xylem, which doubles as part of the plant “circulatory
system.” In tetrapods, support is provided by the skeleton, which was progressively strengthened and specialized (limbs) as they transitioned from water to land.

2. List and compare the adaptations regarding reproduction that enabled vertebrates and plants to transition from freshwater to land.

In tetrapods, the amniotic egg and internal fertilization ended reproductive dependence on water. In plants, the corresponding adaptations are pollen and seeds. Two interesting differences between tetrapods and plants involve embryos. In plants, embryonic development in a “womb” comes early on; in animals, quite late, *i.e.*, in mammals. Second, the embryos of seed plants manifest arrested development. No corresponding tetrapod resting stage that I can think of.
3. Compare dispersal in plants and animals.

Animals, at least the motile ones, can move around themselves. In such cases, it is the young of the year that typically disperse.

Especially in sedentary marine forms, there is often a free-swimming or planktonic larval form that gets distributed by the currents. Spores and seeds are the plant equivalents, being dispersed by wind, water and animals.

Seed plants can also move their genotypes around via pollen, which can be wind- or animal-dispersed. There is really no animal equivalent, the picture of the giant clam in your text notwithstanding.
4. Physical constraints – inability to transport water to a height of greater than about 120 m – limit the maximum height of trees. Why should trees be tall in the first place? Why don’t they allocate some of the energy that goes into trunk tissue to making more leaves?

The short answer is competition. Absent overtopping, plants should be hemispheres of photosynthetic tissue, with a minimum of resources allocated for support. But if your neighbor overtops you, photosynthetic activity drops. So many plants invest in stems and tree trunks, which is why there are forests. Of course, not all plants pursue this strategy. Some have evolved to make do in low-light intensity environments. Others (weeds) live in habitats where intermittent disturbance creates gaps in the forest, in environments subject to continuing disturbance that prevents the forest from ever growing up or in environments where a lack of resources such as water prevents canopy formation.

*Cecropia*, a fast growing, shade-intolerant tropical tree, is typically found along roadsides and in openings in the forest.
5. What are phytoliths? In what kinds of plants are they found? How do they help the plant defend against herbivores?

Phytoliths are tiny accumulations of silica, \( \text{(SiO}_2 \text{)} \), within or between plant cells. They are widely distributed and form when dissolved silica absorbed by the roots is distributed to other parts of the plant where it precipitates to form small concretions. In some cases, phytoliths are species-specific and can be used to infer the composition of communities long gone, for example, at archaeological sites and in fossiliferous deposits.


Silica is an abrasive, and phytolythys can serve to deter, or at least wear down the teeth of, herbivores. Though not restricted to grasses, phytolythys are characteristic of the group, and played a role in the evolution of high crowned cheek teeth in grazers such as horses, antelope and deer.
Phytolyths recovered from 12,000 year old ground sloth remains enable paleontologists to deduce what these animals ate.