1) Water transport begins as water evaporates from the walls of mesophyll cells and leaves and into the intercellular spaces. This water vapor escapes by transpiration though open stomata, the minute passageways in the leaf surface. As water molecules exit the leaf, they are replaced by others from the mesophyll cell cytoplasm. The water loss gradually reduces the water potential in a transpiring cell below the water potential in the leaf xylem. Now, water from the xylem in the leaf veins follows the gradient into cells, replacing the water lost in transpiration.

In the xylem, water molecules are confined in narrow, tubular xylem cells. The water molecules form a long chain, like a string of weak magnets, held together by hydrogen bonds between individual molecules. When a water molecule moves out of a leaf vein into the mesophyll, its hydrogen bonds with the next molecule in line stretch but do not break. The stretching creates *tension* – a negative pressure gradient – in the column. Adhesion of the water column to xylem vessel walls adds to the tension. Under continuous tension from above, the entire column of water molecules in xylem is drawn upward, in a fashion somewhat analogous to the way water moves up through a drinking straw. Botanists refer to this root-to-shoot flow as the transpiration stream.

Transpiration continues regardless of whether evaporating water is replenished by water rapidly taken up from the soil. Wilting is visible evidence that the water-potential gradient between soil and a plant’s shoot parts has shifted. Remember that as soil dries out, the remaining water molecules are held ever more tightly by the soil particles. In effect, the action of soil particles reduces the water potential in the soil surrounding plant roots, and as this happens the roots take up water more slowly. However, because the water that evaporates from the plant’s leaves is no longer being fully replaced, the leaves wilt as turgor pressure drops. Reducing the water potential in soil by adding solutes such as NaCl and other salts can have the same wilting effect. When the water potential in the soil finally equals that in leaf cells, a gradient no longer exists. Then movement of water from the soil into roots and up to leaves comes to a halt.

2) Because seedless vascular plants reproduce sexually by releasing spores, and they have swimming sperm that require free water to reach the egg.

3) Phloem sap forms as active transport loads sucrose into companion cells and then into sieve members, against concentration gradient. As sucrose becomes more concentrated in the sieve tube, the water potential in the sieve tube falls, so water from xylem enters the tube by osmosis, increasing turgor pressure. Under high pressure, phloem sap moves by bulk flow between a source and a sink. Water moves into and out of the system all along the way. Pressure and sucrose concentrations gradually decrease as the sink takes up sucrose from phloem, by active transport from sieve tube members into companion cells and then into sink cells.

4) Pollen, Ovules, and Seeds.

* Pollen
  + Sperm develop inside a pollen grain, a male gametophyte produced from a microspore that typically has walls reinforced with the polymer sporopollenin. All but a few gymnosperms have nonmotile sperm. Usually, two of these nonswimming cells develop inside each pollen grain – very different from the flagellated, swimming sperm of algae and plants that do not produce seeds.
* Ovule
  + A structure in a sporophyte in which a female gametophyte develops, complete with an egg. Physically connected to the sporophyte and surrounded by the ovule’s protective layers, a female gametophyte no longer faces the same risks of predation or environmental assault that can threaten a free living gametophyte.
* Seed
  + A structure that forms when an ovule matures after a pollen grain reaches it and a sperm fertilizes the egg. It consists of three basic parts:
    - The embryo sporophyte
    - Tissues around it containing carbohydrates, proteins, and lipids that nourish the embryo until it becomes established as a plantlet with leaves and roots.
    - A tough, protective outer seed coat.

This complex structure makes seeds ideal packages for sheltering an embryo from drought, cold or other adverse conditions. As a result, seed-making plants enjoy a tremendous survival advantage over species that simply release spores to the environment. Encased in a seed, the embryo also can be transported far from its parent, as when ocean currents carry coconut seeds hundreds of kilometers across the sea.

5) More efficient transport of water and nutrients

* Where gymnosperms have only one type of water-conducting cell (tracheids), angiosperms have an additional, more specialized type (called vessel elements). As a result, an angiosperm’s xylem vessels move water more rapidly from roots to shoot parts. Also, modifications in angiosperms phloem tissue allow it to more efficiently transport sugars produced in photosynthesis through the plant body

Enhanced nutrition and physical protection for embryos

* A two-step *double fertilization* process in the seeds of flowering plants gives rise to both an embryo and a unique nutritive tissue (called endosperm) that nourishes the embryonic sporophyte. The ovule containing a female gametophyte is enclosed within an **ovary**, which develops from a carpel and shelters the ovule against desiccation and against attack by herbivores or pathogens. In turn, ovaries develop into the fruits that house angiosperms seeds.

Coevolution with animal pollinators

* Angiosperms coevolved with pollinators – insects, bats, birds, and other animals that withdraw pollen from male floral structures and inadvertently transfer it to female reproductive parts.