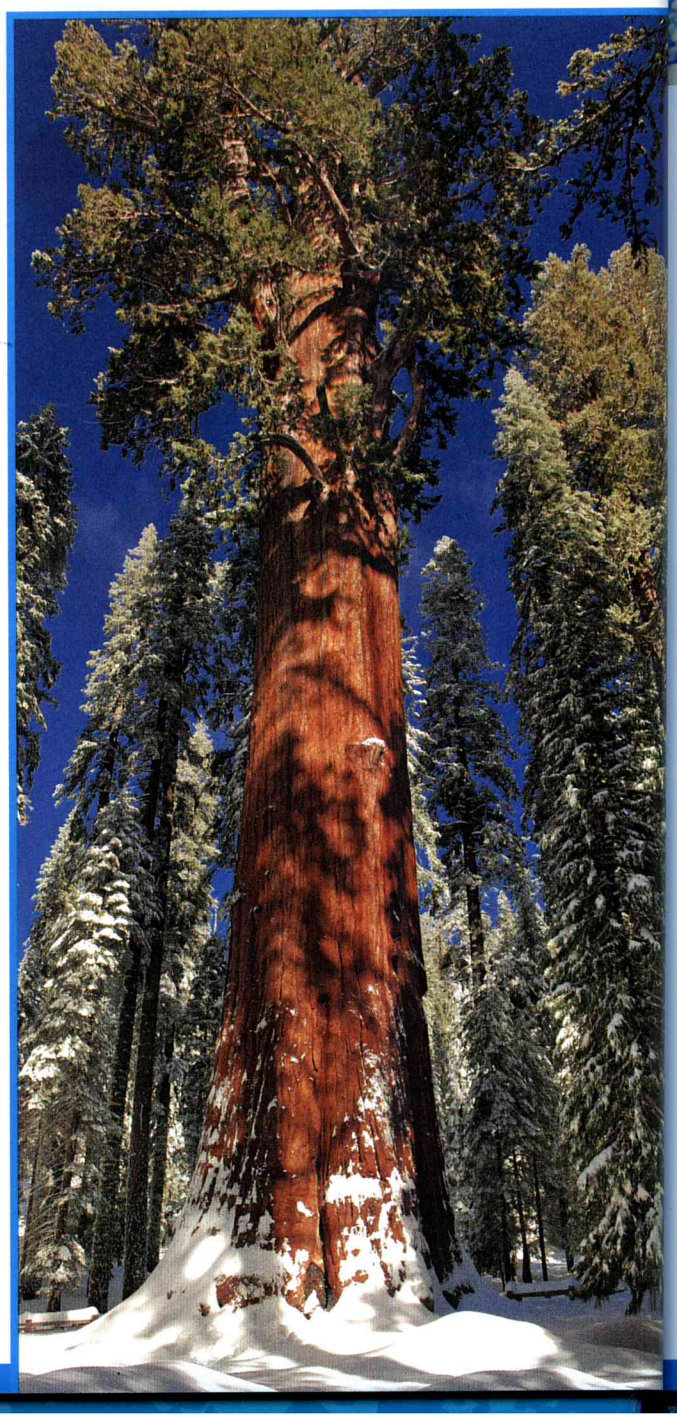
# Plant Vascular Systems

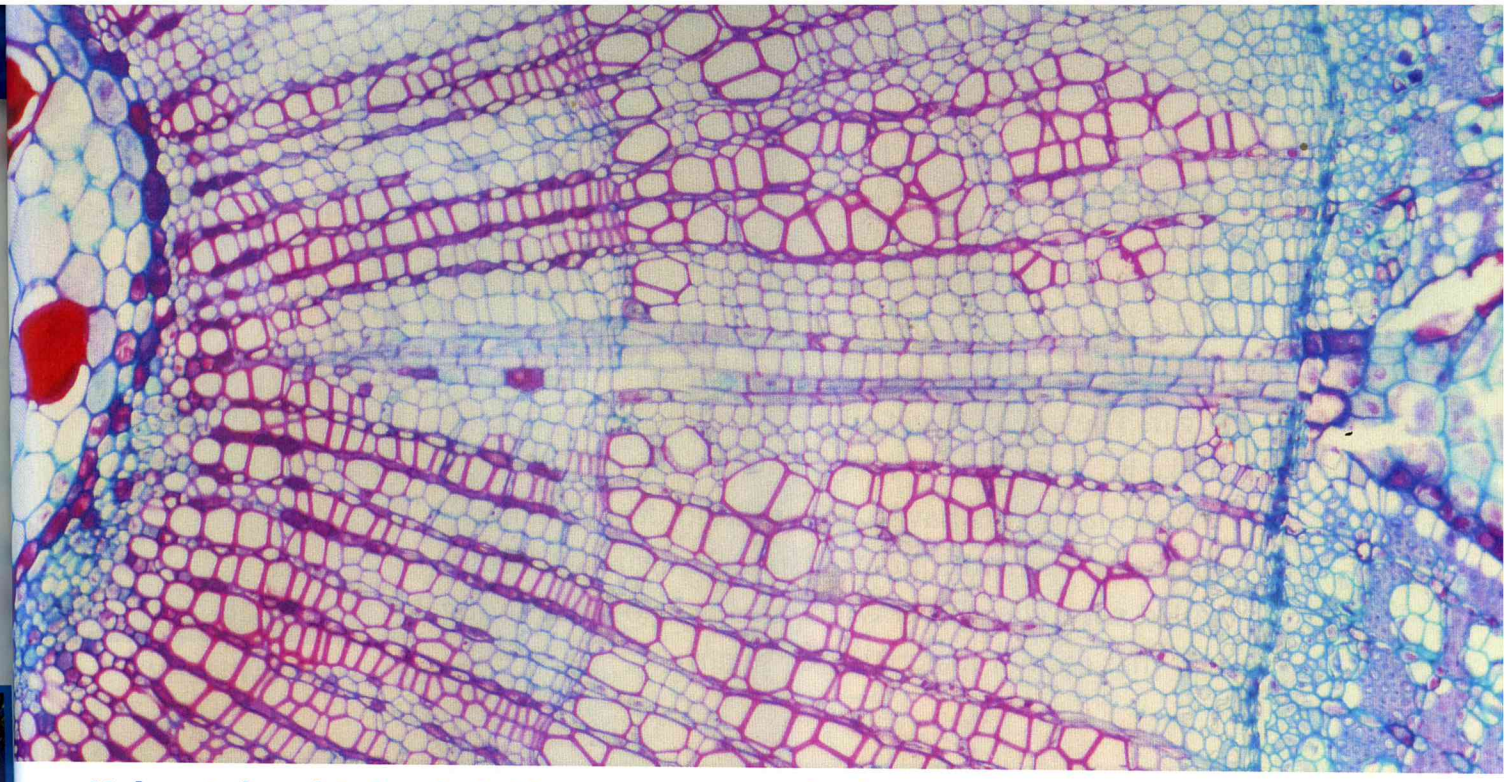
General Sherman is the biggest living organism in the world. General Sherman is the name of a giant redwood tree living in Sequoia National Park in California. This giant tree stands over 85 meters (m) tall and is 11 m wide at the base.

Like all living organisms, General Sherman is a system made of living cells. Every cell needs water, nutrients, gases, and waste removal. How do all of General Sherman's billions of cells get the resources they need to survive?

General Sherman is a vascular plant. *Vascular* means "containing vessels." You have vessels called **arteries** and **veins**. Many plants have vessels, too. Other vascular plants include wildflowers, sagebrush, cacti, orange trees, lettuce, strawberries, wheat, peas, and celery. All vascular plants have a system of tubes running through them. These **specialized structures transport** nutrients to all the cells.



**General Sherman is the world's largest living organism.**



**Xylem tubes (stained pink) carry water and minerals from the roots to the cells in the plant.**

## Xylem

Vascular plants have roots that reach deep into the soil. The roots take up water from the soil. The water enters long, hollow tubes called **xylem**. The xylem tubes start as long cells that are connected end to end. When the tubes are complete, the cells die. The resulting tubes transport water and minerals to the cells at the very top of General Sherman and to all the other living cells as well.

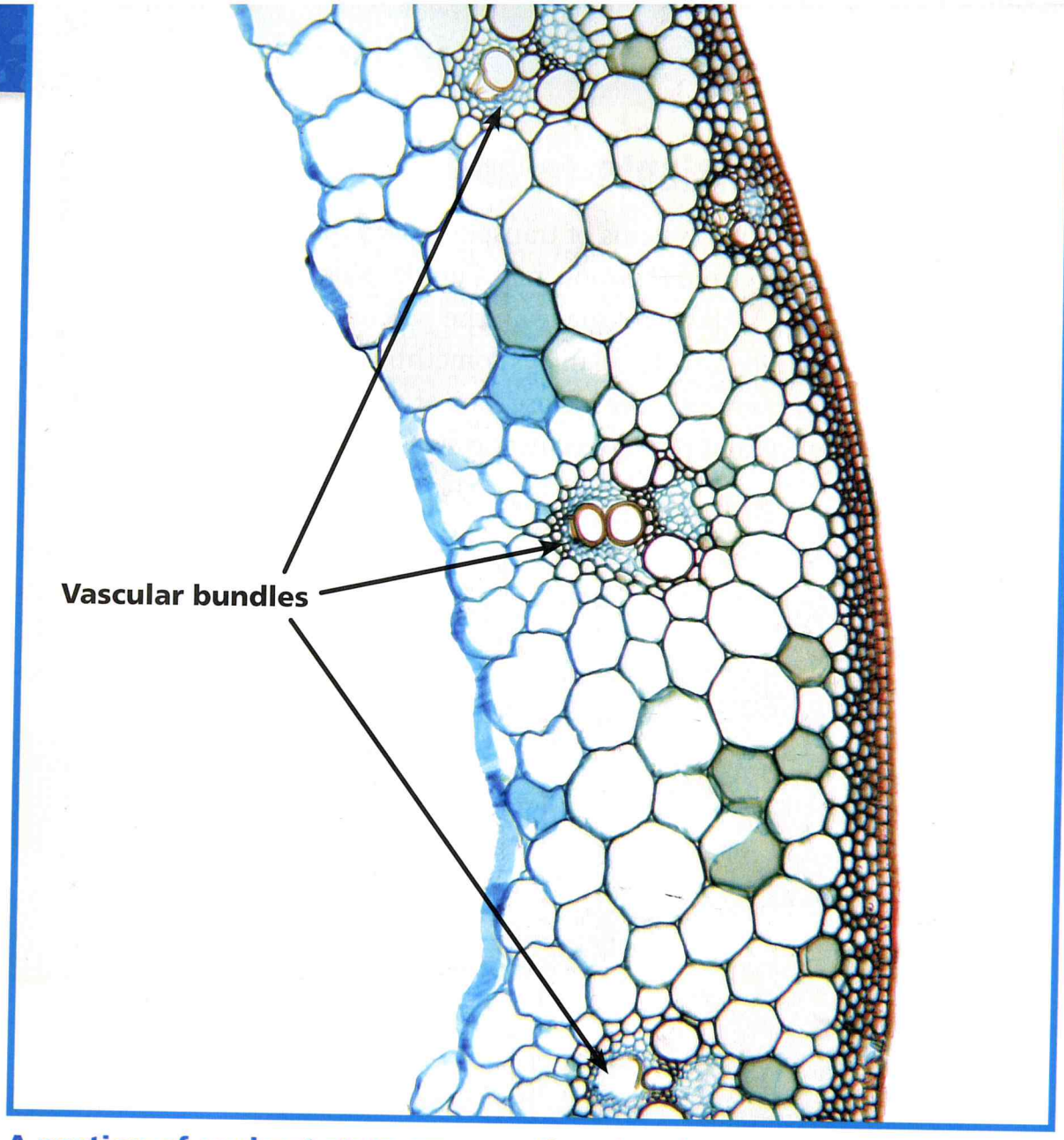
If you cut across the trunk of a tree, you can see the xylem tubes. New xylem cells grow all the time. The old xylem tubes form the main trunk of the tree. We call the old xylem cells wood.

**Old xylem cells can be seen as rings in tree trunks.**

## Phloem

The green leaves of plants produce sugar. The sugar is the food used by all the cells in the plant. Some cells, like root cells and flower cells, do not make sugar. They need to get sugar from the cells that make it.

Vascular plants have a second kind of tube called **phloem**. Phloem tubes transport a sugar-rich liquid called **sap**. The phloem delivers sugar to every living cell that cannot make its own sugar.



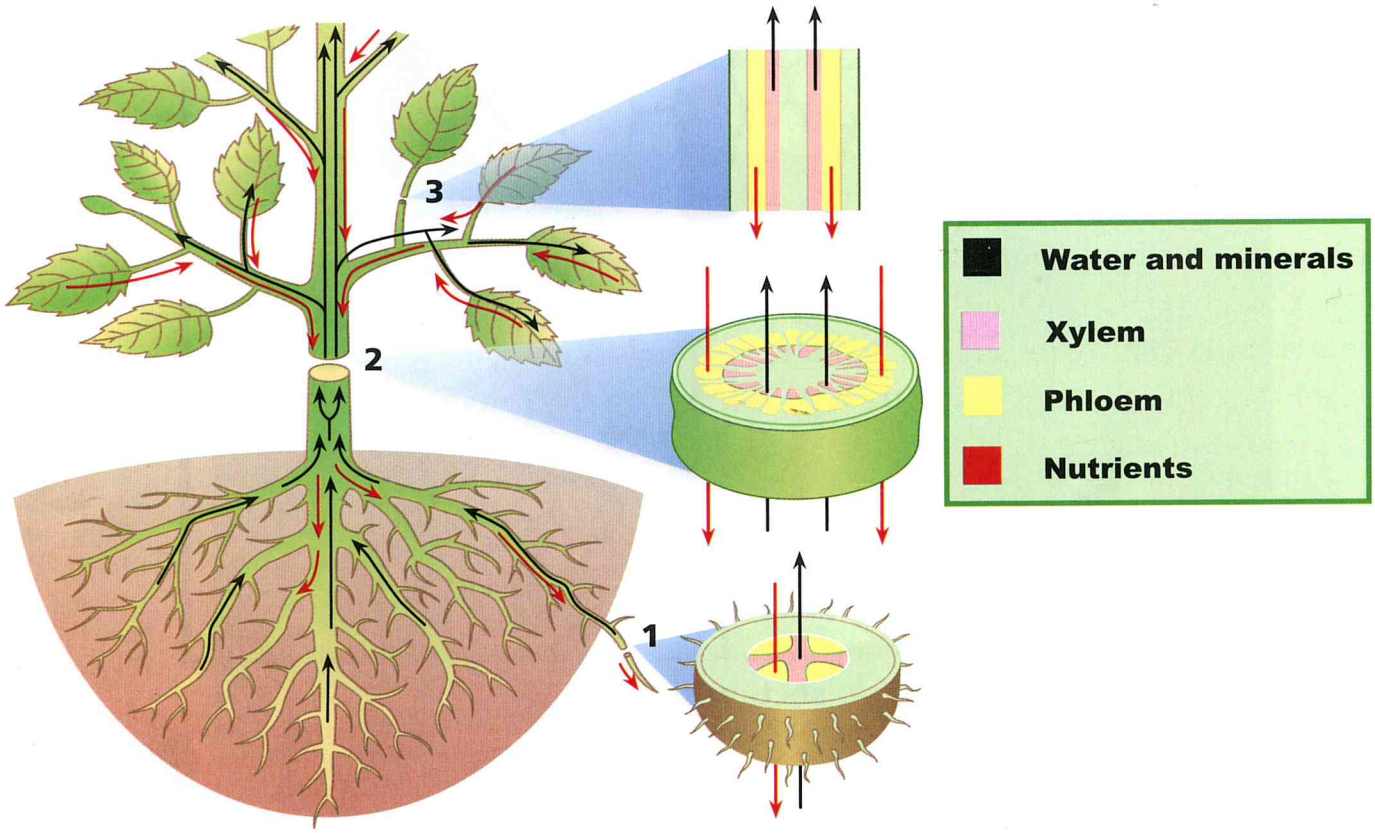

**A portion of a wheat stem cross section showing vascular bundles (100X)**

Many vascular plants have specialized structures called **vascular bundles**. A vascular bundle includes xylem tubes and phloem tubes. A celery stalk has vascular bundles you can see in cross section. With a microscope, you can see the xylem and phloem bundles in other plants, like wheat.

**The dark areas at the edge of this celery cross section are vascular bundles.**

# Transporting Nutrients to and from the Leaves

Vascular plants have two systems of transport tubes that work together. Tubes carrying water up from the roots make up the xylem system. Tubes carrying nutrients down the plant make up the phloem system. The system of xylem and phloem in vascular plants is something like the system of arteries and veins in humans. Take a close look at the illustration below. You can see how the xylem and phloem transport water, minerals, and nutrients to and from cells.




Water enters the roots underground. At number 1, a short section of root was cut. The section is shown enlarged. The pink tissue is the xylem. Water and minerals dissolved in the water flow up the root toward the stem. The black arrow shows the direction that water and minerals move through the xylem tubes.

At number 2, a section of the main stem was cut. The section has been enlarged. The xylem from all the roots passes through the stem. Often a group of xylem cells is near a group of phloem cells. They form a vascular bundle. You can see a lot of vascular bundles like spokes on a wheel around the outside of the stem.

At number 3, a section of leaf stem was cut. The section was cut again from top to bottom. In the enlarged view, you can see the xylem carrying nutrients and water to the veins in the leaves and from there to the cells in the leaves.

The xylem tubes end in spaces between the cells in the leaves. Minerals and some of the water are taken in by the cells. The rest of the water evaporates through tiny holes in the leaves and passes into the environment. This process is called **transpiration**.

## Transporting Sugar to the Cells

Some green plant cells make more sugar than they need for energy. Extra sugar passes out of the cells into the tiny phloem tubes. The sugar mixes with water to make a sweet liquid called sap. The sap flows through the phloem to all the cells that are not green. Cells that are not green can't make their own sugar.

Look at the vascular-plant illustration again. This time follow the red arrows. From the leaf, the sugar flows through the tiny leaf stem (number 3) into the branches. The phloem in all the branches comes together in the main stem (number 2). Finally, the phloem branches out into all the roots, delivering sugar to all the cells in even the tiniest root (number 1). Every cell receives sugar so it can stay alive and do its job.

**Xylem and phloem transport water and nutrients to the cells of plants.**

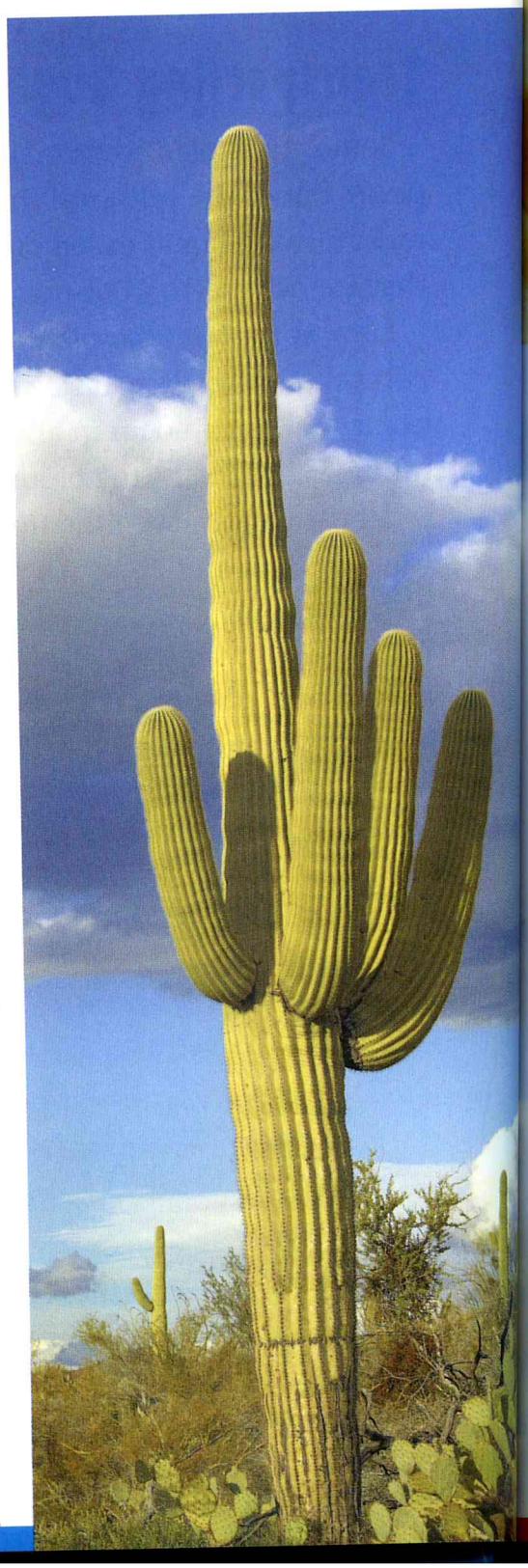
# Comparing Plants and Animals

Multicellular animals and vascular plants have specialized vascular systems to transport nutrients. In both plants and animals, nutrients flow through systems of vessels. But the systems in animals are different from the systems in plants. Animals have one system of vessels. Blood flows from the **heart** to the cells in arteries. Nutrients transfer to the cells in the capillaries. Then the blood returns to the heart in veins. Blood goes around and around, transporting everything cells need.

Plants have two systems of vessels that are not connected. Water flows from the roots through xylem tubes to all the cells. The water carries minerals as it goes. Extra water then evaporates into the air. Water passes *through* the plant. It does not **circulate** like the blood in animals.

Water and sugar (sap) come out of the green cells and flow to all the other cells in phloem tubes. The phloem carries food and water for cells.

Plants have two "one-way" systems. One system transports water and minerals up, and the other system transports nutrients down. Animals have one system that goes around and around.



**Plants like this saguaro cactus have two systems of vessels.**

**Animals like this frog have one system of vessels.**