What is a leaf?

To a plant, leaves are food producing organs. Leaves "absorb" some of the energy in the sunlight that strikes their surfaces and also take in carbon dioxide from the surrounding air in order to run the metabolic process of photosynthesis. The green color of leaves, in fact, is caused by an abundance of the pigment "chlorophyl" which is the specific chemical agent that acts to capture the sunlight energy needed for photosynthesis. The products of photosynthesis are sugars and polysaccharides. An important "waste product" of photosynthesis is oxygen. To an animal, a leaf may be a food source or a place to live on or under (i.e. a "habitat").

What kinds of leaves do we see on the trees found on the Nature Trail?

The leaves found on the trees of the Nature Trail are either broad and flat (like oak leaves) or needle-shaped (like red pine needles). Both kinds of leaves are photosynthetic organs and both kinds of leaves can serve as food or as habitat for a great variety of other organisms.

Why do tree leaves have different shapes?

The shape of a tree's leaves are a response to the tree species' long term ecological and evolutionary histories. An ecosystem's limiting factors may also modify the finished form and shape of a tree's leaves. Understanding of the "logic" behind the varied forms of leaves is facilitated by a firm grasp of the precise functions a leaf must accomplish.
1. A leaf must "capture" sunlight for photosynthesis (and as it does this it may also absorb a great deal of heat!)
2. A leaf must take in carbon dioxide from the surrounding air via pores (called "stomatae"). This carbon dioxide is also needed for photosynthesis. When these leaf stomatae are open to allow the uptake of carbon dioxide, water from inside the leaf is lost to the atmosphere. The leaf, then, is affected by these balancing acts: enough sunlight and carbon dioxide to run photosynthesis, but not too much associated heat absorption or water loss.

How does this "balancing act" influence the ultimate expression of a leaf's shape?

Leaves high in the tree canopy receive a great deal of sunlight. These leaves tend to be smaller in size (and, therefore, have reduced light absorptive surface area) and tend also to have complex edges and lobes (which enables them to disperse absorbed heat very rapidly). Leaves in the lower tree canopy are more shaded. These lower canopy leaves tend to be larger (more light absorptive surface area) and tend to have reduced expressions of lobes and edges. These trends may be observed in comparing the leaves of high canopy trees (like oaks) to the leaves of low canopy trees (like dogwoods), or they can also be observed in an individual tree that has leaves in both the upper and lower canopies (the white oak, for example). In the white oak the smaller upper canopy leaves are also noted to allow
significant amounts of light to pass through the upper canopy in order to keep the lower leaves supplied with sufficient light to allow their continued photosynthesis.

Needle-shaped leaves have a very low light absorptive surface area. Each needle, then, is not able to capture very much sunlight energy for photosynthesis. Needles also have a very thick, outer cuticle coating and special "pit-like" stomatae designed to prevent excessive water loss. Trees with needle-shaped leaves are especially well suited to sites that have drier soils and to climates in which the careful conservation of water is an important survival strategy. Needle-shaped leaves also differ from broad leaves (in our climate zone anyway) in that needles last for three or four years while broad leaves only "live" for a single growing season. These 'evergreen" needle trees, then, have a great advantage over the "deciduous" broad leafed trees in that the metabolic cost of the leaf's synthesis can be recovered via photosynthesis over several growing seasons. Also, the continuous presence of the needles means that whenever environmental conditions are sufficiently moderate (even in the middle of winter!) the needles can photosynthesize and thus gather energy for the tree! A study in Germany compared energy production in beech trees (which have broad, flat leaves) and Norway spruce trees (which have needles). It was found that the beech trees photosynthesize for 176 days in a year while the Norway spruce photosynthesize 260 days in a year! The bottom energy line was that with this increased time base for photosynthesis, the smaller leafed surface area of the Norway spruce was actually 58% more productive than the beech!

Are the arrangements of leaves on a tree always the same?

There are two basic arrangement patterns of leaves on a tree: "mono-layer" and "multi-layer". In a mono-layer arrangement the leaves are arrayed so that no leaf is above and, therefore, shading any other leaves of the tree. This is the leaf pattern seen in the shade dwelling under story trees like the dogwood. In a multi-layer arrangement there are leaves above and below other leaves on the tree. This is the pattern seen in trees which extend u into the upper stories of a forest canopy. The light-rich upper leaves (as previously mentioned) tend to be smaller and more lobed than the lower. This leaf shape facilitates heat loss and prevents extreme self-shading.