CHAPTER 2.

PLANT STRUCTURE AND FUNCTION

Alex Shigo described trees as “highly compartmented, woody, perennial, shedding plants,” and noted that, “They are often long-lived and massive.” In order to withstand the extremes of climate as well as the large size that results from their perennial nature, trees have evolved a variety of structural features, each of which has a variety of functions. Central to the structure–function relationship of the tree’s organs are the basic physiological processes characteristic of higher plants: photosynthesis, respiration and transpiration.

The tree is comprised of the foliage, branches, roots and the trunk. Leaves vary widely in structure but function as the primary photosynthetic organ of the tree. Xylem tissue derived from the meristematic activity of the cambium, is the primary path of movement of water and mineral elements from roots to the other organs. Wood and cambium-produced xylem are synonymous. Wood supports the weight of the tree. The phloem, which stores and transports organic substances such as sugars, is also derived from cell divisions in the cambium. Arborescent monocots, such as palms, may produce secondary tissues but do not develop “wood” in the traditional sense.

Fungi may degrade wood structure, leading to the formation of decay. The tree responds to wounds to its woody parts through the process of compartmentalization, development of physical and chemical barriers that resist the spread of decay.

The form of the crown, the main system of branches and foliage, is determined by the differential elongation of shoots over many years. For most trees, the key element of form is the permanence of the main stem (central leader). In contrast, the form of the root system is more dependent upon the differential proliferation of roots in the soil. No matter the ultimate spatial distribution of roots, they exist in association with a variety of microorganisms, most prominently fungi and bacteria.

The pattern of growth and development for an individual tree is determined by the interaction of its genotype with the environment. General anatomy, pest and environmental tolerance, life history, potential life span and compartmentalization response are genetically controlled. The expression of the genetic material changes as trees age, particularly in their capacity to form reproductive structures and response to stress. Environmental factors such as light, temperature, wind and precipitation influence the expression of these genetic characters. A number of plant growth substances provide the chemical means by which genetic and environmental factors are translated into growth responses. Most prominent among these are auxin, gibberellin, abscisic acid, cytokinin and ethylene.
The principles underlying the **mechanical design of trees** have been revealed by Claus Mattheck and his colleagues. As structures that must bear great weight, trees add support tissue (wood) to evenly distribute mechanical stress, thereby adhering to the constant strain hypothesis. The pattern of tree growth therefore reveals the pattern of mechanical stress.

**Important terminology to define and understand**

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<thead>
<tr>
<th>Term</th>
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<tbody>
<tr>
<td>Abscisic acid</td>
<td>Buds</td>
<td>Gibberellin</td>
<td>Photosynthesis</td>
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<td>Aging</td>
<td>Cambium</td>
<td>Girdling roots</td>
<td>Reaction wood</td>
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<td>Apical control</td>
<td>Chlorophyll</td>
<td>Included bark</td>
<td>Respiration</td>
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<td>Apical dominance</td>
<td>Compartmentalization</td>
<td>Juvenility</td>
<td>Shoots</td>
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<td>Auxin</td>
<td>Crown</td>
<td>Leaf</td>
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<td>Bark</td>
<td>Cytokinin</td>
<td>Mechanical design</td>
<td>Transpiration</td>
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<td>Branch attachment</td>
<td>Ethylene</td>
<td>Phloem</td>
<td>Xylem</td>
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**Discussion topics or questions**

1. Discuss the contrast between biological health (growth, vigor, resistance to pests) and mechanical stability. Can a tree have one without the other? What are the important implications for tree management?

2. Review the process of compartmentalization and the impact this process has on tree care practices such as pruning.

3. Discuss how and why patterns of growth processes such as flowering, apical control and growth rate may change over time.

4. Is a tree’s root:shoot ratio determined by genetics or the environment? Can it change over time? How?

**Example true and false questions (Correct false statements)**

1. The cambium is the meristem that produces xylem and phloem.  
2. Trees with strong apical control usually have a decurrent form. (Pg 20 - 22)  
3. The form of the crown is a general indication of the form of the root system. (Pg 26 - 28)  
4. The relative strength of the attachment of branch to stem can be gauged by the angle between them. (Pg 36 - 38)  
5. Trees tightly tied to stakes develop taper more quickly than those loosely tied. (Pg 31 - 33)  
6. In reacting to wounds, trees form barriers to the spread of decay through a process known as compartmentalization.
7. Trees react to the mechanical stresses of weight and wind by distributing new wood evenly throughout the crown. (Pg 14)

8. In gymnosperms, reaction wood takes the form of compression wood, seen on the underside of branches and trunks.

9. A flush of new shoot growth represents the elongation and expansion of tissues contained in a dormant bud.

10. A field method to determine if endomycorrhizae are present in a landscape is to excavate in the root area and examine roots. Affected roots appear shortened, swollen and highly branched.