# Table of Contents

**Acknowledgements** ........................................5

**Introduction** .........................................................6

**Chapter 1. Plant Basics** .................................8
• History of Plant Habitats ........................................8
• Plant Structure and Function .....................................10
• Fundamentals of Plant Classification and Identification ....12

**Chapter 2. Managing the Plant’s Environment** ................16
• The Foliage Environment ........................................16
• The Root Environment ..........................................17
• Plant Nutrition ..................................................19

**Chapter 3. Watering Plants** ..........................26
• Conventional Watering Techniques ...............................26
• Subirrigation Systems .............................................28

**Chapter 4. Managing Plants** ..........................32
• Pruning Trees, Shrubs, and Vines ................................32
• Grooming Interiorscape Plants ..................................34
• Foliage Plant Profiles .............................................36
• Maintaining Flowering Plant Rotations ......................85

**Chapter 5. Managing People** ..........................94
• Customer Relations .............................................94
• Safety and Health Management ................................96

**Chapter 6. Diagnosis and Control of Interior Plant Problems** ..........100
• Physiological Problems ..........................................100
• Pests ..................................................................104
• Diseases ..........................................................108
• Integrated Pest Management (IPM) .........................112

**Chapter 7. Pesticides** .................................118
• Introduction to Pesticides ..........................................118
• Safe Use of Pesticides .............................................119

**Chapter 8. Green Walls** ...............................124
• LEED Certification ................................................124
• Green Wall Design Considerations ............................126
• Infrastructure and Environmental Considerations .......127
• Case Study ..........................................................129

**Appendix A: Glossary of Terms** .................130

**Appendix B: Metric and Imperial Conversion Tables** ........134
Chapter 2. Managing the Plant’s Environment

As with all other plants, the growth of interiorscape plants is influenced by a number of interrelated environmental factors. In the interiorscape, these are light, water, temperature, and nutrition, and they affect important physiological processes such as photosynthesis, respiration, and transpiration. The foliage and roots are affected in a number of different ways by these environmental factors and physiological processes.

The Foliage Environment

In the aerial portions of interiorscape plants, light, water vapor, and temperature play important roles in the way that plants grow. Light is a major limiting factor on growth in general, even though its primary site of entry is through the foliage. It is a form of radiant energy emitted by the electromagnetic spectrum, and, as such, is perceived by the human eye as light. Light’s quality is a major factor in plant growth, as determined by the wavelength in the electromagnetic spectrum.

Wavelengths (mainly in the red and blue portions of the spectrum, and less in the spectrum’s ultraviolet and infrared portions) have been found to influence specific plant processes. For example, most of the energy for food synthesis is provided by red light. On the other hand, blue light influences phototropism, causing plant stems to grow toward the light source. Meanwhile, the roots tend to grow away from light (toward gravity). In practical terms, blue light affects foliage plants by helping produce more compact plants with shorter internodes and greener leaves. Red light causes the stems to stretch and produces paler foliage, but enhances flowering.

Phototropism usually occurs in conjunction with the action of hormones or growth regulators. Auxin, an important hormone in plant growth, is produced in the growing tips of plants. As a growth regulator, it influences the elongation of cells, favoring plant growth under certain conditions but inhibiting growth under other conditions. Plant growth is also inhibited by radiation in the ultraviolet portion of the spectrum.

Red light also influences photoperiod or the response of plants to the relative lengths of day and night. This especially applies to flowering. Thus, plants can be grouped into the following categories based on the length of the night or dark period:

- **Short-day plants** (e.g., Poinsettia; Chrysanthemum). Most of these plants require approximately 12 hours of light and 12 hours of darkness each day and normally flower in the fall unless manipulated artificially.
- **Long-day plants** (e.g., Aechmea fasciata; Hibiscus). Most of these plants require approximately 16 hours of light and 8 hours of darkness each day and normally flower in spring and summer unless manipulated artificially.
- **Day-neutral plants** (e.g., African violet, Spathiphyllum). Plants flower in a manner unaffected by the length of day or night.

Another way plants generally use light’s energy is in the basic plant process known as photosynthesis. The word “photosynthesis” can be broken down to mean “making things with light.” In this process, plants use light’s energy to produce carbohydrates from carbon dioxide and water. Subsequently, the carbohydrates are synthesized into sugars. In the reverse process of respiration, organic products (sugars in this case) in living plant tissues are oxidized or broken down to carbon dioxide and water, which releases energy.

The strength or intensity of light is an extremely important consideration in an interiorscape as this factor affects the water and nutrient uptake of plants. In low light situations, which are common in interiorscapes, plants grow more slowly and consume less water and nutrients than they would in the brighter light of a nursery or their tropical outdoor habitats.

When the intensity of the available natural light is insufficient to support plant growth, supplemental light from artificial sources can be used. Artificial light sources include fluorescent, incandescent, high-intensity discharge (HID), and mercury lamps. Such sources of illumination usually provide varying amounts of light in the blue and red ranges of the spectrum. Generally, fluorescent lamps provide energy in the blue range, while incandescent lamps provide energy in the red range. HID lamps, such as high-pressure sodium and metal halide, generally provide energy in the red and blue areas respectively, while simultaneously...
emitting high light intensity. Mercury lamps are high in the spectrum’s yellow-green portion but do provide smaller amounts of blue and red. Blended lamps and other combinations of the above also are used in various plant-growing applications.

The efficiency of any given type of lamp is measured in units known as lumens per watt, whereas the light that falls on a plant is measured in units called foot-candles, or lumens per square foot, also referred to as lux (metric). The recommended minimum light intensity required for average plant growth in the interiorscape over a 12-hour period each day is usually broken down as follows:

- **Low light**: 50 to 100 foot-candles
- **Medium light**: Between 100 and 250 foot-candles
- **High light**: Greater than 250 foot-candles

In addition to the influence of light, water in the foliage environment also affects various processes within the plant, such as water uptake, transpiration, mineral nutrition, photosynthesis, and respiration. Water interacts with temperature in many ways. Photosynthetic products and nutrients are carried respectively down and up within a plant as nourishing entities dissolved in water. Sugars, synthesized in the leaves during photosynthesis, move downward to receiving cells throughout the plant through the food-conducting phloem tissue. Meanwhile, essential nutrients absorbed by the roots move upward in the xylem conducting tissue.

Most of the water carried up within a plant is lost by evaporation through the stomata in the leaves. This produces tension, which is transmitted to the root’s water-absorbing cells. Thus, a continuous column of water moves up the plant through the xylem. This aspect of water’s movement constitutes the process known as transpiration. The transpiration rate increases roughly in proportion to increases in temperature. The transpiration rate also is higher in plants with more foliage surface area, such as plants with many small delicate leaves.

However, the presence of the water vapor around the foliage helps prevent plants from overheating, particularly in direct sunlight, by means of evaporative cooling. Plus, the quantity of water vapor and the temperature have a direct bearing on relative humidity. Higher temperatures tend to favor lower levels of relative humidity. This sets up a potential situation where plants may lose water faster through the tiny stomata in their leaves than they can replace it through their roots. This in turn affects the absorption of mineral nutrients from the soil. As a result, leaves develop tip burn and yellow margins. Wilting, shriveling, and bud-drop may occur as well. In the less common situation of high relative humidity, plants become susceptible to rot, mold, and mildew. In this case, an increase in air circulation would help control the elevated level of moisture. Wilting also will occur if plants are under moisture stress (an insufficient or excessive supply of water).

The quality of the air around the foliage is another important factor. It is true that during photosynthesis a plant’s green leaves manufacture oxygen (used in respiration), while carbon dioxide, as a by-product of respiration, is used in photosynthesis. This allows plants to manufacture their own air, making it possible for several species to grow quite satisfactorily in sealed transparent containers. However, many plants still need fresh air for adequate growth. Good air circulation not only lowers high humidity and high temperatures, but also helps reduce or remove traces of toxic vapors, which could otherwise enter plants through the stomata.

When considering air quality, it’s also important to remember that ethylene gas from ripe fruits such as apples and bananas can cause premature senescence in foliage plants. In addition, while air circulation generally is beneficial, it’s important to avoid exposing interiorscape plants to hot or cold drafts that impart air currents moving rapidly and directly across the foliage. This could result in tip burn, curled or yellow leaves, and eventually leaf drop. Oddly, and in spite of our concern for providing plants with good air quality, NASA studies have shown that many common interiorscape plants actually are quite effective in removing harmful chemical vapors from indoor air.

**The Root Environment**

Roots normally require some form of medium—solid or liquid—in which to grow. Growing mediums are used to act as reservoirs for water, air, and minerals needed for plant growth, and to provide mechanical support for plant roots. Often, in hydroponic systems, a liquid growing medium is supplemented by an inert solid medium called aggregate, which provides the necessary mechanical support for the roots. Most commercially prepared growing media generally consist of soil or “soilless” ingredients, or a combination of these. In fact, soil is a naturally occurring mixture of weathered minerals—sand, silt, and clay—and decayed organic materials. Nevertheless, most growing media still are loosely referred to as soil mixes, whether they do or don’t contain real soil, while compost from organic waste is most often classified as a form of soilless media.

Interior plantscapers generally favor the use of soilless media over soil-based mixes. There are several reasons, foremost among them is the soil’s variable quality. In soilless media, superior
physical properties can be achieved through manipulation of the ingredients. The ingredients are usually pest- and disease-free as well as weed-free. When conventional soil is used in a container, the soil’s relatively small particles and pore spaces make it more difficult for gravity to overcome water’s movement by capillary force as opposed to the deeper profile of soil in a planting bed. This keeps the medium too wet for too long after watering and deprives the root system of necessary oxygen, which can lead to root diseases. By contrast, most soilless ingredients have larger particles and pore spaces, allowing for greater drainage and aeration but less capacity to hold water. A mix of different particle sizes is best for good plant growth.

Thus, providing adequate aeration in the growing medium is just as important as providing sufficient water for plant growth. Affording a balance between these two factors depends on the size and shape of the particles in the medium or, more specifically, the air spaces between the solid particles. The air spaces need to be filled with oxygen while carbon dioxide is expelled during respiration. Large particles result in large air spaces and small particles in small air spaces.

Particle shape also can determine the availability of more or less water. In addition, after a plant is watered and the water is allowed to drain away, the particles retain a thin film of water around them. The extent of water retained depends on the particle type (see Table 2.1 on page 19). The tiny root hairs penetrate into the spaces between the solid particles to absorb water retained by the particles along with water that has risen from below by capillary action. Nutrients dissolved in the water also enter plants by this means. Figure 2.1 illustrates the relationship between the “soil” particles, water, and air in the root environment.

Since most interiorscape plants are grown in containers, it’s important to note that a container’s height and width will affect the air space and water available to a plant. The medium in a tall container will be drier in the top layers than the medium in a wider, shallower container of the same volume.

In summary, the success or failure in achieving satisfactory plant growth in any given medium depends on the medium’s physical