Lecture #4
Temperature
(Review of Plant Physiology)

The $Q^{10}$ Effect
Managing temperature in an interiorscape or greenhouse environment is extremely important. Controlling temperature allows you to control growth, utilization of carbohydrate and amino acid resources with the plant, and to control to some extent, the rate of plant senescence or decline.

Fewer plant replacements can mean more consistent profit for the business owner. It also means longer contracts, happier customers and fewer route management headaches. To control temperature, you must also understand how it affects plant metabolism.
Plant enzymes and biochemical systems have a set temperature range in which the system performs properly. Go outside that range, and chemical processes, enzyme reactions and transport may cease.

Even photosynthesis is affected by temperature, as is shown in this graph. Each specie of plant responds differently to changes in temperature, and has it's own optimal temperature.
Temperature

Biological Activities
(Most Organisms)

Interior
Plants

Human
Comfort

32°F  77°F  100°F

58°F  86°F

72°F  82°F
Each plant has a different optimal growth temperature, and a different rate of response or tolerance to changes in temperatures outside the optimal range.
The optimal temperature for growth is not necessarily the very best temperature for an interiorscape plant. Many times we don’t want the plant to grow fast. It may require more labor, water and grow out of size specification, thus needing to be replaced.

Better to try to keep growth slow and the size near that at installation, unless directed by the client to allow it to grow.
To “hold” a plant at peak vigor, without causing uncontrolled growth, is an art and a pure science. One must learn to balance the amount of sugars and amino acids (photosynthate) used up via plant respiration during the entire 24 hour period, with the amount of photosynthate produced by the plant during daylight (12 - 18 hours) via photosynthesis. If you accomplished this, there would no longer be excess photosynthate for growth, and size would be maintained. This is much harder to accomplish than you might expect.

The secret to success is applying the Q^{10} effect!
The Q₁₀ Effect

In most chemical systems, the rate of a chemical reaction may double with every 10 °C rise in Temperature. The rate may also be reduced by half for every 10 degree drop in temperature.

The rate of increase is called the Q₁₀ effect! Most biological systems do not have a value of 2.0... but rather each system may have a unique value, such as 2.3 or 1.8.

Why is this important? Because you can control the amount of sugars used up by plants during respiration, and thus increase potential for growth and good health of your plants.
The $Q_{10}$ effect plays a role in everyday activities, from mixing epoxy to baking bread.

The $Q_{10}$ Equation

$$Q_{10} = \left( \frac{k_2}{k_1} \right)^{\frac{10}{T_2 - T_1}}$$

or

$$\log Q_{10} = \left( \frac{10}{T_2 - T_1} \right) \log \frac{k_2}{k_1}$$

where $T_1 = \text{lower temperature}$
$T_2 = \text{higher temperature}$
$k_1 = \text{rate at lower temperature}$
$k_2 = \text{rate at higher temperature}$
Respiration rates increase in summer heat. The warmer the night temperatures, the faster carbohydrates are used up in respiration. For example, many perennials do poorly in summer heat because they use up more sugars than they make. This can cost money if you are a commercial grower. A map of average summer heat allows classification of plants that may survive. Interior plants are no different, each having different tolerance to warm night temperatures.
Photosynthesis

\[ \text{CO}_2 + \text{H}_2\text{O} \xrightarrow{10/7 \text{ Light}} \text{CH}_2\text{O} + \text{O}_2 \]

Triose Sugars

Amino acids

Sucrose

Proteins, Enzymes

Cell Walls

Starch
Respiration

Sugars \( \text{CH}_2\text{O} + \text{O}_2 \overset{24/7}{\longrightarrow} \text{CO}_2 + \text{H}_2\text{O} \) (Metabolic Energy)

Sucrose

Starch
Plants in homes and offices respire (use up) sugars 24 hours a day, but only photosynthesize during short periods of time daylight, or low levels of artificial light.

Under these circumstances, there is a good chance there will not be sufficient sugars made to support growth. Most plants will slowly decline or die. There are options:

1). Raise light levels to increase photosynthesis (sugar) levels.

2). Reduce night temperature to reduce respiration rates and allow more sugars for growth.

3). Relocate the plant.
ACCLIMATIZATION:

Adaptation of a Plant to the New Environment of Your House

Favorable environment for maximum growth

High light
high nutrition
high water supply
high temperature

Interior environment

low light
low low humidity
The Two Goals of Acclimatization

Goal 1: Increase available & stored sugars by reducing night temperatures.

Goal 2: Allow plant metabolism and structure to adjust to lower light levels.
Diffusion

Materials flow from an area of high concentration, to an area of low concentration.

Temperature can affect the speed of the process, as can differences in density or the difference in concentration.

Click On The Three Video Clips
Chill Damage and Scald Damage

When a plant becomes chilled, its enzymes may slow down or cease to function, thus stopping entire biosynthetic pathways. This is what causes violets in a windowsill to wilt, or spot up after cold water is applied to it's leaves. Damage can also occur if the water is too hot, as when water from greenhouses hoses left in the sun is first applied. Know your water temperature!
On the other hand temperature control can be applied to speed up growth. A good example is using heating pads under seed or cutting flats to speed up germination or rooting. The right Temperature can take a week ro month off of rooting schedule and can take a few days to a Few weeks off of germination. Time is money.
A heated bench!
Other Factors That Can Affect Plant Enzymes

- Substrate availability
- Catalysts / Co-Enzymes
- End-product feedback
- Metabolic inhibitors
- pH (system acidity or alkalinity)
- Rate of enzyme regeneration