## LIMITED WARRANTY

Meter is warranted free from defects for one year from date of purchase. During this period the meter may be returned to Luster Leaf Products Inc., together with proof of purchase and $3.00 to cover postage and handling, and it will be repaired or replaced. During the Initial 90 days of this warranty period the selling dealer is also authorized to replace a defective meter.

This warranty does not cover abuse, as accidental damage, repair by anyone other than Luster Leaf Products Inc., or consequential loss or inconvenience resulting from use of the meter.

This warranty gives you certain specific legal rights and you may also have other rights which vary from State to State.

## SERVICE

If adjustment or repair becomes necessary after the warranty expires, return the meter to Luster Leaf Products Inc. together with $7.50 to cover postage, handling and service. Service includes labor and parts as required, except for replacement of externally damaged or lost components.

For service, or information regarding other Luster Leaf products, please address:

Luster Leaf Products Inc.
2220 Techcourt
Woodstock IL 60098

## INTRODUCTION

The **Light Intensity Meter** is a pocket-size, portable, light-sensitive instrument capable of reading illuminance, luminance, reflectance and transmittance up to 10,000 footcandles (lumens per square foot).

The logarithmic response of the meter provides the operator with accurate meter deflections and easy reading at all light intensities.

The Universal Light Sensor Probe, specifically designed to be maneuverable to any lighting angle or condition, can be extended to a distance of up to 2½ feet, giving the operator a much greater degree of flexibility than a self contained instrument could do.

A clear epoxy dome is affixed over the photo cell as a permanent protective feature to assure maximum durability.

The "Table of Light Requirements" was compiled from materials supplied by the Dept. of Agriculture and other authoritative sources. We suggest you contact the USDA in your state for recommended light intensities of plants not listed here, or for additional specific information on a particular plant.

## LIGHT INTENSITY METER

The **Light Intensity Meter** is designed specifically for the measurement of radiant light energy that directly affects plant growth, development and seed germination.

The meter is not color corrected. With this feature, we can assure maximum accuracy in measuring the intensity of the light emitted from the sun and can compare the light intensity of artificial light sources to the proper radiant color of the sun because the sun is the standard light color that affords plants maximum growth and development.

The meter incorporates a silicon photovoltaic cell that converts radiant light energy into electrical energy alleviating the need for a battery. The photovoltaic cell exhibits a very fast reading and has a stable, linear and reproduceable output per light intensity. The cell displays no fatigue and has unlimited life expectancy. It has versatility and assures freedom from personal operator error factors.



Although the results will depend upon the visual acuity of the operator, the instrument is sensitive to fractions of a footcandle provided the spectral content of the artificial light and the standard (sunlight; used in our calibration) are identical.

The meter is capable of reading up to 10,000 footcandles, can be used to determine brightness, reflectance, transmittance and the most important measurement, illuminance.

## LIGHT

Light as will be discussed and measured by the **Light Intensity Meter** is the radiant energy emitted by the sun, fluorescent and incandescent lamps.

The readings are made expressly for the purpose of properly growing plants and seeds, and the "Table of Light Requirements" listed in this book is based upon this fact.

## PHOTOSYNTHESIS AND THE LEAF

Photosynthesis is the manufacture of carbohydrates from carbon dioxide and water in the presence of chlorophyll (the green color). Photo-light and synthesis-putting together is apt. The basic formula is carbon dioxide + water + radiant energy yields carbohydrates + oxygen.

Since the leaf is the primary place of the photosynthetic process and chlorophyll is the energy absorber, it is fundamental to understand the leaf.

## LEAF COMPOSITION

**Epidermis:** The "skin" covering the complete leaf. It is covered by a cuticle, which is a waxy layer that retards the movement of water into and out of the leaf. The epidermis is perforated by numerous openings called stomates.

**Mesophyll:** The layer in which photosynthesis is localized. It comprises all the cells inside the epidermis. All mesophyll cells contain chlorophyll.

**Vascular Bundle:** Strands of tissue that function as support and conductors for the leaf.

**Chlorophyll:** Consists of two pigments; blue-green and yellow-green.

A percentage of the light that strikes a leaf is absorbed, a percentage is transmitted through the leaf, and a percentage is reflected. The quantity absorbed by the pigments depends upon structure and may be as high as 90% of the spectrum.



## COLOR SPECTRUM

The Color-Spectrum is that portion of radiant light energy within the visible range that consists of the following colors: Violet, Blue, Green, Yellow, Orange, and Red.

**Natural Light:** The radiant light from the sun consists of a small percentage of ultraviolet, about half in the visible range and the balance in infrared.

Green leaves absorb little or none of the ultraviolet and infrared* and these wavelengths are of little importance in photosynthesis.

The visible spectrum can be separated by a spectroscope into these colors: Violet, Blue, Green, Yellow, Orange and Red.

*Infrared under Light and Plant Growth

**Artificial Light:** Fluorescent tubes emit the visible spectrum and ultraviolet but no infrared.

Incandescent lamps emit the full color spectrum (visible) and infrared but no ultraviolet.

Therefore, they must be used in combination or lamps must be chosen that emit both visible and infrared. Cool white and warm white tubes in combination provide this spectrum with little heat effect.

## LIGHT INTENSITY

Of all the limiting factors in photosynthesis, light intensity is the most important. The light intensity of a full sun on a clear day is approximately 10,000 footcandles. *(A footcandle is the amount of light cast by one candle at a distance of one foot).*

## PHOTOPERIODISM

Is the length of time a plant is exposed to light. Plants of our temperate zone can be categorized into short-day, neutral and long-day plants.The dividing line between day lengths favorable to vegetative growth and those tending to cause seed and flower formation is called the **Critical Light Period**. For most species the critical light period is between 14 and 16 hours.



The intensity of the light and the duration of exposure combine to let us know the quantity of light received by the plant. The divisions on the scale of the meter indicate the maximum amount of light that a species can be exposed to for a 14 hour day (As listed in the Table of Light Requirements)

**Plants Grown Under Artificial Light:** If an artificial light is purchased, be sure that it emits the full spectrum of light when compared to sunlight. With artificial light emitting the full spectrum, plants can be grown successfully. The proper maturity will occur if a plant is exposed to a maximum light intensity for a specific time period. (Intensity of at least 1000 footcandles is minimum). The minimum quantity of light is 15,000 footcandles which is the light intensity reading multiplied by the duration of exposure in hours.

**Plants Grown In Natural Sunlight:** Plants grown in natural sunlight should be positioned so that the recommended light intensity is measured according to the "Table of Light Requirements". The normal sunrise to sunset, depending upon your latitude, will be the sole controlling factor for time of exposure. With this fact in mind, supplement with artificial light only on overcast, cloudy or dark days and be sure the supplement is during the 14 hour exposure period. Plants must have rest periods, so don't expose them longer than 14 hours.

In the home and in greenhouses, plants are behind windows that absorb the ultraviolet light, but can be grown successfully because the visible and infrared spectrum is not absorbed.

## LIGHT AND PLANT GROWTH

Vegetative growth of plants is, to a large degree, controlled by light. Plants grown in total darkness have very long internodes, small leaves, and are yellow in color because no chlorophyll is formed. If the dark-grown plants are exposed to weak light for a minute or two each day, the plants have shorter internodes and normal-size leaves, although they may still be yellow and without visible chlorophyll. Daily exposures of the plants to light of higher intensities or for a longer duration may not change the size of the leaves or internodes of the plants from that obtained with brief exposures to light of low intensity, but the plants turn green as chlorophyll is formed.



The formative effects of light, but not chlorophyll formation, result from the some red, *far-red reversible photoreaction that also controls flowering of photoperiodically sensitive plants, germination of light sensitive seeds, and many other plant responses. Red is the most efficient portion of the spectrum in inhibiting stem elongation and promoting leaf expansion. A far-red irradiation immediately following the red reverses the potential effect of the red irradiation and the stems become long. Far-red at the close of each light period causes stems of light-grown plants to elongate. If the far-red is followed by a brief exposure to red, the effect of the far-red is reversed and the stems remain short.

If light is directed at either light grown or dark-grown plants from one side, the leaves tend to bend and the leaf petioles twist until the plane of the leaf blade is perpendicular to the light.

* Far-red is infrared.

The stems tend to curve in such a way that the tip of the stem is directed toward the light source. This phenomenon is called phototropism and is caused by a different photoreaction than the red, far-red one. Blue light is the most effective kind of light to promote the phototropic response.

Experiments show several ways in which light influences plant growth and development. These demonstrations tell us the following facts:

- **Light inhibits stem growth and promotes leaf expansion.**
- **Plants bend toward the light.**
- **Chlorophyll formation requires light and the light must be of higher intensity than that which controls stem length.**
- **The red, far-red reversible photoreaction that controls seed germination also controls stem length and leaf size.**

Additional experiments can be designed to answer many other questions relating to the manner by which light controls plant growth. Examples of such questions are as follows: Are bending (phototropism) and growth of internodes controlled by the same photoreaction? This question can be answered by using different regions of the spectrum (colors of light) and testing to see if bending and growth are controlled by the same colors.



Does the duration of darkness following the far-red irradiation of light-grown plants affect the ultimate length of the internodes: What is the optimum period of darkness and why is it optimums?

How concentrated is the pigment that controls growth? How do we know it is not chlorophyll? These questions can be answered by comparing the growth responses of albino and green corn or barley seedlings.

## LIGHT AND PLANT PIGMENTS

The autumn coloration of leaves and stems of woody plants is in part caused by the formation of a red pigment called anthocyanin. The formation of anthocyanin is also responsible for the red color of apple fruits and for the red to purple color of mile, turnip, and cabbage seedlings.

A common observation is that apples often do not turn red uniformly, but that one side of the fruit is green or at least a lighter shade of red than the other side. The reddest side of the apple is usually facing outward from the tree The formation of the red color (anthocyanin) in apple fruits is controlled by light. Detailed studies have shown that anthocyanin formation in milo, turnip, and cabbage seedlings and in leaves of red maple and other trees is also regulated by light.

Unlike many other light-controlled plant responses, anthocyanin formation requires high-intensity light for a relatively long time. However, at the close of the high-intensity light period the low-intensity-red, far-red photoreaction may exert final control on anthocyanin synthesis. Thus, if the plant material is irradiated for a few minutes with far-red at the close of the high-intensity light period, the potential anthocyanin synthesis is inhibited and very little is formed. If a brief irradiation with red follows the far-red, then anthocyanin is formed in an amount equal to that produced by the high intensity light alone.

An example of a low-intensity light-controlled coloration is the yellow color of the skin of the tomato fruit. Plant breeders recognize differences in the color of the skins of fruits of certain tomato varieties and have classified the skins as yellow or clear. The red flesh and a transparent or white skin give the fruit a translucent pink color, whereas the red flesh and a yellow skin give the fruit an orange-red appearance. In many tomato varieties the formation of this yellow pigment is controlled by light. Moreover, the same reversible red, far-red photo reaction that controls flowering of photoperiodically sensitive plants, germination of light-sensitive seeds, and many other plant responses also controls the formation of the yellow pigment in the skins of tomato fruit.



**From experiments we know:**

- That light is required for the formation of the red (anthocyanin) of certain seedlings and apple fruits.
- Light is required for the formation of a yellow pigment in the skin of tomato fruit.
- The coloration occurs only in the areas that received light—there is no translocation of the stimulus.

Additional experiments can be designed to learn more about the light reaction and about the chemical processes that result in pigment formation. Questions that one might ask are: How much energy is required to induce the formation of anthocyanin? As light energy is increased, does the amount of anthocyanin increase proportionately? Once the light requirement is fulfilled, what is the rate of anthocyanin formation? What is the role of temperature? What is the role of sugar? Does the red, far-red reversible photoreaction operate in the control of coloration? Observations of apples under differing temperatures, and lighting conditions will answer these questions.

## COMPETITION

As long as plants live as individuals, growth is only influenced by climate and soil. But when plants live in groups, they compete with one another at all stages of growth from seedling to maturity.

The competition is primarily for water, nutrients and light. When plants grow together, the foliage of one plant tends to shade another. As a result, some grow larger than others and the more vigorous and better adapted plants become dominant.
Other less vigorous plants become suppressed or eliminated.

It is therefore beneficial to eliminate weeds as competitors because most cultivated plants cannot compete. Under cultivation, proper spacing of seeds and seedlings are under man's control.

When repotting or positioning a plant, light intensities must be observed to properly afford each individual its optimum light requirements.

Measurements with your **Light Intensity Meter** should be taken at all locations and after positioning a plant from all sides. Since plants will bend towards the sun, they must be rotated on some regular schedule.

## GROWING PLANTS IN DIM LIGHT

If house plants have the proper amount of water and heat for good growth but do not have enough light, they tend to grow long and spindling. Often, planters are used as decorating accessories in locations that are not lighted well enough for good growth of plants. However, foliage plants can be acclimated to low light intensities.

To grow house plants successfully where they get little or no daylight:

- **Water the plants only often enough to prevent wilting.***
- **Reduce the amount of fertilizer that you apply to the plants.**
- **Keep the air temperature as cool as you can tolerate.**
- **Provide supplementary lighting with fluorescent tubes.**

*Do not let plant wilt at any time.

Double pot plants that are to be grown under artificial light. This makes soil moisture control easier than leaving the pot exposed to the air.

Begin watering as frequently as you would if the plant had sufficient light. Then gradually lengthen the intervals between waterings.

A few of the oldest leaves may die while you are adopting the plant to dry-soil conditions, this is part of the readjustment to the new environment.

Fertilize the plants more sparingly than normal. Use only about one-third as much fertilizer as is recommended for plants growing vigorously. Continue to fertilize frequently.

Maintain an air temperature that is as low as human occupants can comfortably tolerate. Most plants thrive at temperatures of 60° to 75°. In general, weakly lighted plants do best in the lower limits of this range, while brightly lighted plants do best in the upper limits.

If you can add moisture to the air, do so. Plants will grow under conditions of low humidity, but they need more attention to watering than they do under moderate humidity.

Fluorescent tubes are best for supplying supplementary lighting. Regular incandescent lights or reflector floods can be used for spot lighting, but they are too hot when used in numbers large enough to provide the relatively high lighting intensities required by the plants.

The required lighting intensity for a plant varies according to the time the plant is lighted; the dimmer the light, the longer the plant must be lighted.

If you use a fixture containing two 40-watt fluorescent tubes and light the plants for 16 hours a day, the minimum lighting intensity for growing foliage can be supplied by placing the fixture the following height above the plants:

| **36 to 54 inches:** | **Closer than 36 inches:** |
|---|---|
| *Anthurium hybrids* | *Fatshedera lizei* |
| *Bromeliads* | *Ficus pandurata* |
| *Peperomia obtusifolia* | *Hedera helix* |
| *Scindapsus aureus* | *Ciccus rhombifolia* |

The maximum distances for satisfactory plant growth is 66" All the plants grow best if they are no farther than 36 inches from the lighting fixture.

## SPECIAL LIGHTING FIXTURES:

The use of H.I.D.* lighting fixtures, such as Metal Halide and High Pressure Sodium for indoor plants requiring higher intensities than can be supplied by fluorescent fixtures, have proven to be the best source of light for optimum plant growth that the serious gardener can utilize.

These innovative systems approximate the intensity and spectral colors of the sun. Under discriminating spectral analysis, they are almost identical and for all practical purposes, they are identical.

## METER SPECIFICATIONS

- Power Source . . . . . . . . . . . . . . . . . . Lifetime Photovoltaic Cell
- Footcandle Scales . . . . . . . . . . . . . . . 0 to 10,000 for Sun.
  . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0 to 1,000 for Fluorescent
- Multiplier . . . . . . . . . . . . . . . . . . . . 10x on both scales
- Accuracy. . . . . . . . . . . . . . . . . . . . . . -2%
- Footcandle Categories . . . . . . . . . . . . 4
- Universal Sensor Probe . . . . . . . . . . . . Length.....3 inches
  . . . . . . . . . . . . . . . . . . . . . . . . . . . . Diameter.....1 inch
  . . . . . . . . . . . . . . . . . . . . . . . . . . . . Lens .....¼ inch
- Sensor . . . . . . . . . . . . . . . . . . . . . . . 2½ ft. calibrated two
  . . . . . . . . . . . . . . . . . . . . . . . . . . . . conductor with epaxy incap-
  . . . . . . . . . . . . . . . . . . . . . . . . . . . . sulated photovoltaic cell
- Dimensions . . . . . . . . . . . . . . . . . . . Height: 4 ½ inches
  . . . . . . . . . . . . . . . . . . . . . . . . . . . . Width: 2 ½ inches
  . . . . . . . . . . . . . . . . . . . . . . . . . . . . Depth: 1 ½ inches

## OPERATING INSTRUCTIONS

**To Measure Illuminance:** To determine the level of illuminance on the surface of a leaf, point the universal sensor probe directly at the radiant light source while holding the probe in the same plane that the leaf occupies (Hold at leaf level). Avoid positioning your hand or body in such a way as to inhibit or reflect light.

**To Measure Luminance:** On transmitting surfaces, hold sensor probe directly on the surface. On reflecting surfaces, hold the sensor probe approximately two inches above the surface.

**To Measure Reflectance:** Make an illuminance reading, then make a luminance reading as described for reflecting surfaces. The ratio of reflected footcandles to illuminance footcandles is the reflectance.

**To Measure Transmittance:** Place the tip of the sensor probe directly under and "flush" with the leaf surface, making sure that light source is on top of leaf. Take reading and note. Now take an illummance reading at leaf level. Note or jot down. The rate of the first reading to the second reading is transmittance or translucency of the leaf.

With the transmittance measurement you can closely predict how much light a leaf absorbs, how much is reflected and how much goes directly through the leaf (Transmittance). The efficiency of photosynthesis for your plant can now be evaluated.

Take illuminance readings in the early morning, at noon and again in late afternoon to determine the average footcandles your plants are receiving. The average footcandle multiplied by the time of exposure will yield the footcandle hours. Consulting the Table of Light requirements will tell you if this amount of light is for your species.

## CLARIFICATION OF READINGS

| | |
|---|---|
| **Sun & H.I.D.:** | Slide switch up. Read top scale ONLY<br>Multiply all readings by 10. |
| **Fluorescence:** | Slide switch down. Read bottom scale ONLY<br>Multiply all readings by 10. |
| **Recommendation:** | When not in use, leave switch in up position. |

**Footcandle Hours (Fc. Hrs.)** as listed under the Table of Light Requirements are readings of footcandles times the exposure time in hours and based on a 14 hour day.

## READINGS

**For Plants Already in Position**

1. Measure the light intensity at leaf level.
2. Consult the Table of Light Requirements
3. If too much light: Reposition plant
   Shield plant
   Screen or curtain light
4. If too little light: Reposition closer to light
   Reposition to another location.
   Supplement artificially

**For New Plants**

1. Take readings at all possible locations and at different times of the day.
2. Take readings at several distances from a light source.
3. Jot down readings of each location and distance
4. Consult and Table of Light Requirements

**Example:** Agapanthus — Max 50,000 footcandle hours
Min 25,000 footcandle hours

| Time | Hours | | Footcandles | Footcandle Hours |
|---|---|---|---|---|
| 7:00 a.m. to Noon | 5 | Times | 2000 average equals | 10,000 |
| Noon to 4:00 p.m. | 4 | Times | 1000 average equals | 4,000 |
| 4:00 p.m. to 9:00 p.m. | 5 | Times | 500 average equals | 2,500 |
| **Totals** | **14** | | **equals** | **16,500** |

**Interpretation:** Insufficient Light Intensity
**What to do:** Move Closer To Light Source
Reposition To Better Location
Supplement Artificially

**Caution:** When supplementing light artificially, do so during the normal light exposure times, preferable late afternoon till 9 p.m. Do not increase exposure time because plants need dark periods for rest.



**Maximum Foot-candle hours: 50,000**
**Minimum Foot-candle hours: 25,000**

*This category of plants will thrive in full sunlight for medium short periods. East and South exposures are preferred.*

| | | | |
|---|---|---|---|
| **Bulbs:** | Agapanthus | Amaryllis | Anemone |
| Calla Lily | Freesia | Haemanthus | Ixia |
| Montbretia | Oxalis | Ranunculus | Tulbaghia |
| **Flowering Plants:** | Bird of Paradise | Chrysanthemum | Geranium |
| Gerbera | Gloriosa | King's Crown | Lilies |
| Miniature Rose | Passion Flower | Poinsettia | Shrimp Plant |
| **Foliage Plants:** | Agave | Aloe | Aporacactus |
| Astorphytum | Bamboo | Caphalocereus | Echeveria |
| Enchinocactus | Echinocereus | Echinopsis | Eucalyptus |
| Gymnocalycium | Gynura | Herbs | Iresine |
| Jerusalem Cherry | Kalanchoe | Lobiva | Mamillaria |
| Notocactus | Opuntia | Pereskia | Polyscias |
| Rebutia | Sedum | Stapelia | |
| **Shrubs:** | Acalypha | Allamanda | Azalea |
| Bouganvilleo | Citrus | Coccolobo | Croton |
| Flowering Maple | Hibiscus | Hydrangea | Ixora |
| Myrtle | Oleander | Privet | Pyracantha |
| Rhododendron | Stephanotis | | |

**Maximum Foot-candle hours: 37,500**
**Minimum Foot-candle hours: 20,000**

*This category requires bright light with little direct sunlight. East and West exposures are preferred.*

| | | | |
|---|---|---|---|
| **Bulbs:** | Clivia | Daffodil | Hyacinth |
| Narcissus | Tulip | | |
| **Flowering Plants:** | | Cineraria | Crossandra |
| Cyclamen | Flame Violet | Gloxinia | King's Crown |
| Lipstick Vine | Shrimp Plant | | |
| **Foliage Plants:** | Beaucornea | Coleus | Columnea |
| Crassula | Dizygotheca | Euphorbia | Fatsia |
| Fittonia | Gynura | Haworthia | Hypoestes |
| Joseph's Coat | Pleamele | Rhipsalas | Rhoeo |
| Saxifraga | String-Of-Pearls | Swedish Ivy | Tomieo |
| Tradescantia | Wax Plant | Zebra Plant | Zebrina |
| **Shrubs:** | Ardisia | Aucuba | Camellia |
| Clerodendrum | Coffea | Dipladenia | Eleagnus |
| Eunonymus | Fuchsia | Gardenia | Nandina |
| Silk Oak | | | |

**Maximum Foot-candle hours: 27,500**
**Minimum Foot-candle hours: 15,000**

*Plants in this category thrive on bright indirect light with no direct sun light. North exposures are preferred. Subdued light by screening or a lightweight curtain will be adequate at East, South, or West exposures.*

| | | | |
|---|---|---|---|
| **Bulbs:** | Caladium | | |
| Flowering Plants: | Achimenes | African Violet | Begonia |
| Christmas Cactus | Flowering Tobacco | Impatiens | Orchids |
| **Foliage Plants:** | Acorus | Anthurium | Brassia |
| Bromeliads | Cissus | Helxine | Hypoestes |
| Norfolk Island Pine | Pandanus | Pellionia | Peperomia |
| Pileo | Prayer Plant | | |

**Maximum Foot-candle hours: 15,500**
**Minimum Foot-candle hours: 7,500**

*The plants in this category are best suited to dim light. Light intensities within the interior of a room away from windows are preferred.*

| | | | |
|---|---|---|---|
| **Foliage Plants:** | Asparagus | Aspidistra | Chlorophytum |
| Chineoe Evergreen | Cyperus | Dieffenbachia | Dracena |
| English Ivy | Ferns | Ficus | Liriope |
| Palms | Philodendron | Pothos | Selaginella |
| Snake Plant | Spathiphyllum | Syngonium | |
| **Shrubs:** | Pittsoporum | Podocarpus | |