The DIRT Society

Plants and Light

Humankind is agricultural, requiring light to sustain the plants we harvest. Not only do we need light to see the difference between a ripe, red tomato and an unripe, green youngster on the same stem; we need it to feed our plants.

Yes, plants are feeding on light. *But how?*

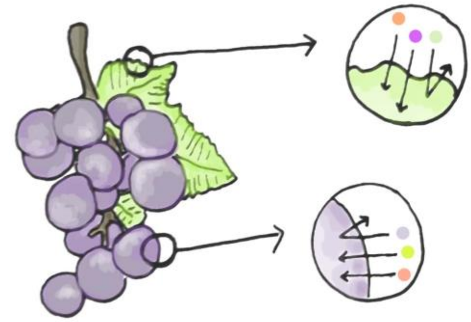
Our first mental image of "light" is likely a very narrow one. Maybe you think of a bright white glare, a bulb or the sun. But light is, more accurately, everything you can see around you. All that you perceive visually is the work of photons (energy) traveling in wavelengths between 380 and 750 nanometers. Those are the colors of the rainbow; violet begins at 380 nm and by 750 nm you've reached red. Each color is its own wavelength of photons, and acts in its own distinct way.

These photons can be manipulated, of course. Microscopes, telescopes, filters, reading glasses, mirrors and electric lights are all making use of photons. While we may diminish the clarity or behavior of the light in manipulation, a photon remains a photon. Thus plants, which rely on light to grow, can survive beneath artificial lights or flourish thanks to a well-placed panel of reflective aluminum.

So why are there so few basement gardens? Couldn't we simply grow gardens indoors beneath lamps? Light from a bulb and light from the sun are both photon energy. Plants can use either type of light to grow. However, artificial lights are far more limited in scope than sunlight, and it would take a mixture of lights (blue, red, fluorescent, incandescent, etc.) to create a suitable environment for a plant. Plants require certain photons in certain quantities, and developing an artificial light regime for each crop would be intense and costly work. Thus, we find more gardens on balconies than we do in basements. Outdoor plants are free to pluck the photons they need from sunlight, and they do that using *pigments*.

The last feature of light that will serve as a foundation for understanding plant life is this: When an object appears to be a certain color, it could be due either to the light source or the object's pigmentation. As an example, a red light could make a whole room appear red. But a ripe strawberry will look red under many different lights. While pigments are used in paints and dyes to evoke different colors, they are used in plants for survival.

Pigments are particles that absorb photons of particular wavelengths. If a photon can't be absorbed by a pigment, it is either reflected or it passes through; giving the surface visible color.



Imagine that pigments are like keyholes. A keyhole that we perceive to be purple is one that all the *other* colors pass through. Purple doesn't fit, so it stays outside. When we look at the keyhole, it appears to be purple but, on the inside, every other wavelength of light has been absorbed. A purple grape is covered with these keyholes. Its green leaves, however, are reflecting back green light. The photons that appear to be green are, therefore, not fitting the leaves' pigment keyholes.

Chlorophylls *a* and *b* are the primary and accessory pigments in plants. Chlorophyll *a* reflects and transmits green wavelengths, meaning two things; most plants appear green and cannot use a green light to grow. The parts of a plant that are red, orange, yellow, pink, violet, blue, brown, etc. are likely using pigments such as carotenoids, xanthophylls, phycobilins or anthocyanin. (This is not only true in blossoms, fruit, and atypical foliage; it is also true of the deciduous leaves of autumn. These leaves change color because the light available to them is changing. As seasonal light alters, the plant will too. Once it adjusts, we see reds, oranges and yellows. After the tree has determined that the light it needs to grow has diminished for the season, it loses its leaves entirely; allowing itself to power down until more food can be produced in the spring.)

Armed with this understanding of light and pigment, we can now explore how it all relates to our garden.

Plants can do two things with sunlight that most animals cannot; they can create food and they can keep themselves from cooking. **We eat plants because we lack their ability to utilize light's energy in making digestible carbohydrates, which we need in order to live.** We also survive by protecting our bodies from the sun using hydration, clothing, shelter, mud or screens. If you consider that most of our shelters, pigments and fabrics are made from plants, it is easy to understand why we desperately need them to thrive if we are going to exist in this light-filled world.

The plant does both; creates food and keeps itself thermo-regulated; using an impressively effective system called *photosynthesis*. With this circular process a plant can use its supply of water, carbon dioxide and a few enzymes, add sunlight, and create the air we breathe, the carbohydrates we eat, and enough water to cool itself off.

The products of photosynthesis:

Air, or oxygen, is the plant's waste; similar to the carbon dioxide we exhale when we breathe.

The carbohydrate is its energy. Plants use this in the same way we do; as nourishment. Animals and plants both require these compounds in some form. Without them, we cannot grow or reproduce. As animals, humans either eat the plant and use its carbohydrates, or eat other animals that have, somewhere down the chain, eaten plants.

Water created by plants can cool our environment but, more importantly, it keeps the plant alive while it toils under the sun. A plant releasing water is doing something between breathing and sweating; an exhalation and a cooling of the body. In extreme temperatures, plants will regulate how much water they can afford to lose. They will release much more in the heat (and require more as a result) or preserve it when cooler temperatures allow. Another benefit of this exhalation is that, like a hose, if water is pulled from one end, it is drawing up from another. By cooling itself, the plant is taking water up by its own roots. Thus, in the warm seasons, its increased output of water is linked to its increased intake. This is why gardens in which the water table is low (container gardens in particular) can so easily dry out in the sun.

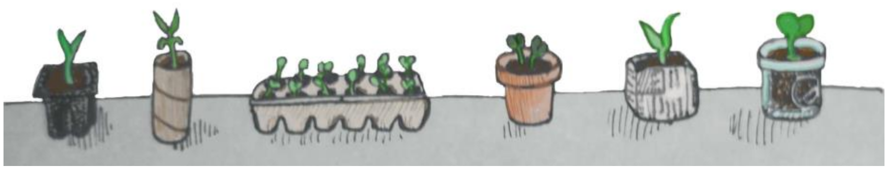
Photosynthesis occurs in different microscopic regions of the plant, and unfolds in two distinct phases. The exact input and output of a photosynthetic cycle varies by plant, region and carbohydrate produced, but the whole process is typically summed up as:

$$CO_2 + H_2O + \text{Photons} = H_2O + O_2 + \text{Carbohydrates}$$

That is, when plants combine carbon dioxide and water as fuel, then ignite a reaction with light energy, they create the three products we discussed above; water, oxygen and carbohydrates. In a way, photosynthesis is similar to gardening. Plants have a few basic resources that they nurture and feed. With the help of a little light, carbon and water, they grow food for themselves.

A plant's survival, then, is dependent upon its ability to absorb light. Almost all photosynthesis occurs on a plant's leaves (or the equivalent structure.) Thus, if the leaves are stripped from a plant, it will likely die. Because of this, we cannot harvest all of the basil, lettuce, or spinach from a stem without greatly hindering growth or killing the entire plant. A few leaves must always left behind if we want the plant to continue living.

Light is, understandably, an essential ingredient in successful farming. When planning your garden, check to see if the desired location receives approximately **six hours of light per day** during the growing season. Some crops will require more or less light, but a semi-flexible six hour stretch is the industry standard.



If you want to grow crops that require more light than you can provide, you are not without options. There are many ways to assist plants in their photon uptake. A gardener or farmer may wish to clear objects creating shade, though this must be exercised with care. (The loss of a single tree could have a dramatic effect on soil runoff, physical wind damage or biodiversity loss.) Other options include planting suitable crops in moveable containers or installing some inexpensive reflective surfaces in the vicinity. Around the world, many farmers have rigged ingenious systems of light reflection to grow crops in deep, shaded valleys.

With adequate sun, plants will be determined to perform well; creating food to eat, oxygen to breathe, and water to cool. Humanity could not exist without their industrious work.