

Why are many leaves green?

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Many leaves look green in daylight because the light reaching our eyes from them contains a relatively strong green contribution. Pigments and the leaf's structure absorb, scatter and transmit different wavelengths differently. Chlorophyll is important to that pattern, but "the leaf reflects green" is incomplete if it is taken to mean that green light cannot be absorbed or used in photosynthesis.

The title also contains two questions that should be kept apart. What optical processes make a present leaf appear green? And why did evolution produce the pigments and structures found in present plants? The first can be investigated directly in an existing leaf. The second is a historical question that cannot be settled by inventing a purpose for the colour.

1. Colour concerns the light that reaches an observer

A leaf's appearance depends on illumination as well as on the leaf. Under ordinary broad-spectrum light, the balance of reflected wavelengths contributes to its colour. Change the illumination and the available reflected spectrum changes, even if the leaf's pigments are unchanged. A green appearance is therefore not a substance that the leaf sends out independently of incoming light.

Chlorophyll absorbs green light relatively weakly, a property explicitly discussed by Terashima and colleagues. [2] "Weakly" must not be replaced by "not at all," especially when moving from isolated pigments to an entire leaf. Plants also contain other pigments with different spectral patterns; OpenStax describes the pigment classes and the measurement of their absorption spectra. [1]

A leaf also has internal structure. Light can be scattered and encounter absorbing material along different paths. Its optical behaviour is not identical to that of a dilute pigment solution. The colour of the whole leaf therefore cannot be deduced merely by treating every photon as if it passed a single isolated chlorophyll molecule once.

2. Relative reflection is not total rejection

A numerical illustration can expose the common mistake. Imagine equal incoming counts of photons at one green wavelength and one red wavelength. Of 100 green photons, suppose 15 are reflected, 10 transmitted and 75 absorbed. Of 100 red photons, suppose 5 are reflected, 5 transmitted and 90 absorbed. These are invented optical budgets, not measured values for a particular species.

The reflected green count is three times the reflected red count, even though three-quarters of the incident green photons are absorbed. A relative excess in the outgoing light is entirely compatible with substantial absorption of the same colour.

For each wavelength, these simplified budgets satisfy $R + T + A = 1$, where R , T and A are fractions reflected, transmitted and absorbed. The calculation neglects conversion into emitted light at a different wavelength and uses a clearly defined incoming beam. It is bookkeeping, not a complete model of human colour perception.

The example does not establish that the leaf will have one exact perceived shade. Other wavelengths and the observer's visual response matter too. It establishes the narrower

logical point: a green-looking object need not reject all, or even most, of the green light falling on it.

3. Absorption and photosynthesis require different measurements

An absorption spectrum asks how interaction with a sample varies with wavelength. A photosynthetic response asks how the biological process changes under specified illumination. The two are related, but they are not identical measurements.

Pigment extraction and spectrophotometry can help identify absorption patterns; OpenStax describes those methods. [1] An intact-leaf experiment adds questions about where light is absorbed and how the photosynthetic machinery responds. Absorbing a photon does not guarantee that all its energy becomes stored chemical energy: the state of the biological system matters.

This is why “which colour is best?” is incomplete without conditions. Best per incident photon or per absorbed photon? Added to darkness or added to already bright illumination? Measured in a pigment solution or an intact leaf? Changing those choices changes the comparison.

4. Green light can drive photosynthesis

Terashima and colleagues tested the response to added monochromatic light in sunflower leaves under white illumination. They found that, under moderate to strong white light in their experiments, additional green light could drive photosynthesis more effectively than additional red light. Their interpretation concerned the penetration of light into the leaf and the distribution of photosynthetic capacity among chloroplasts. [2]

The scope is essential. This is not a claim that green light always produces the greatest photosynthetic response, nor that red light is ineffective. The comparison involves extra light added to an existing illumination regime. Conditions near the illuminated surface can differ from conditions deeper inside the leaf.

A useful way to read the result is that photons of different wavelengths need not reach the same biological machinery in the same proportions. The whole-leaf response depends on that spatial distribution as well as on pigment absorption. The result directly contradicts the blanket claim that green light is useless to a green leaf. [2]

5. Greenness is not a complete carbon meter

A visible colour measurement is not a direct measurement of the rate at which a leaf fixes carbon. It records an optical response under particular illumination and observation conditions. To infer physiology from it requires an additional relationship that can be tested, and that relationship may depend on other conditions.

NASA's account of vegetation remote sensing describes using contrasts between visible and near-infrared reflection to estimate vegetation properties. It also distinguishes the contribution of pigments from that of leaf structure. [3] The inference uses a measured spectral pattern, not the assumption that everything appearing greener must always photosynthesize faster.

The same caution applies when looking at a photograph. Changes in illumination, viewing geometry or leaf coverage can alter an image. Inferring a biological change requires separating those possibilities from a change in the plant itself. A colour observation can be useful without being a complete diagnosis.

6. Why this is not an evolutionary purpose story

The optical mechanism explains how present pigments and tissues produce a spectral response. It does not demonstrate that a lineage acquired those features in order to look green, hide among other leaves or reject the most available sunlight. Each historical explanation would need its own evidence.

Similarly, demonstrating a useful present consequence does not establish that this consequence was the original reason a trait evolved. An evolutionary account would compare alternatives, constraints and inherited features across lineages. The experiments on sunflower leaves answer a narrower physiological question and should not be made to certify that larger history.

This separation leaves room for an honest uncertainty. We can measure absorption and photosynthetic responses under chosen conditions more directly than we can reconstruct every selective step behind the pigment systems now present. A secure proximate explanation and an incomplete historical explanation can coexist.

7. The answer with the shortcut removed

Many leaves appear green because their wavelength-dependent optical properties leave a relatively green-rich visible signal under ordinary illumination. Chlorophyll contributes strongly, while other pigments, tissue structure and illumination affect the result. That appearance is compatible with the absorption and productive use of substantial green light.

The common mistake is to turn a relative difference into an absolute prohibition: green is reflected, therefore green is not absorbed, therefore green cannot drive photosynthesis. Each “therefore” adds a claim that the colour alone does not establish. Measurements of intact leaves show why the shortcut fails.

Related reading

Article 022, “Why can losing one species change an ecosystem?”, examines how biological effects depend on interactions and context at a larger scale. The link is associative; neither article is a prerequisite for the other.

References

- [1] OpenStax. Biology 2e, section 8.2: The Light-Dependent Reactions of Photosynthesis. <https://openstax.org/books/biology-2e/pages/8-2-the-light-dependent-reactions-of-photosynthesis>
- [2] I. Terashima, T. Fujita, T. Inoue, W. S. Chow and R. Oguchi. Green light drives leaf photosynthesis more efficiently than red light in strong white light: Revisiting the enigmatic question of why leaves are green. *Plant and Cell Physiology* 50(4), 684–697 (2009). <https://doi.org/10.1093/pcp/pcp034>
- [3] NASA Earth Observatory. Seeing Leaves in a New Light. <https://science.nasa.gov/earth/earth-observatory/seeing-leaves-in-a-new-light/>