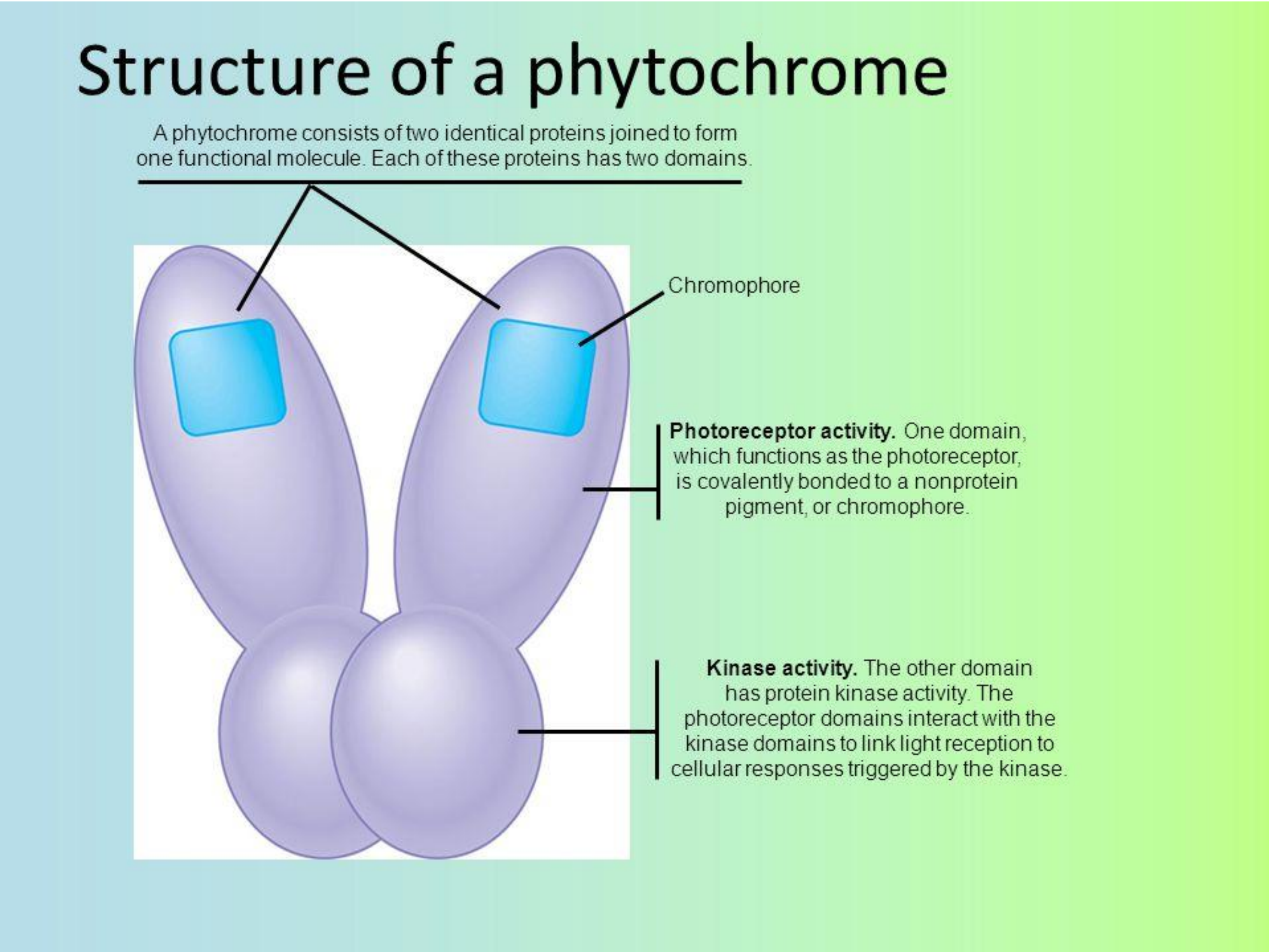
Phytochrome

Phytochrome is a photoreceptor in plants that regulates a variety of photomorphogenic processes. Plants, fungi, and different microorganisms such as bacteria, cyanobacteria, and proteobacteria have photoreceptors called phytochromes. Phytochrome is a photo morphogenetic chromoprotein that induces photomorphogenesis by strongly absorbing red and far-red light.

The structure of phytochrome was elucidated in the 1980s by several research groups using X-ray crystallography and other techniques. Phytochrome is a dimeric protein, meaning it consists of two identical subunits. Each subunit contains a chromophore, which is the part of the protein that absorbs light. The chromophore is a linear tetrapyrrole molecule called phytochromobilin (PCB) that is covalently bound to the protein. The chromophore is responsible for the reversible conversion between the Pr and Pfr forms of phytochrome.



Phytochrome Discovery

In the early 1950s, Harry A. Borthwick, Stirling B. Hendricks, and coworkers at the US Department of Agriculture proposed the presence of phytochrome. According to their studies, many plant responses were most successfully induced by red light, and this induction may be cancelled by brief exposure to far-red light. Following these findings, a pigment with two interconvertible forms was suggested – a red light-absorbing form and a far-red light-absorbing form. Using sensitive dual-wavelength spectrophotometry, a pigment with this photochromic characteristic was discovered for the first time in 1959. This spectrophotometric technique was then used to purify phytochrome.

Types of Phytochrome

Phytochrome comes in two photo reversible varieties or forms. Pr and Pfr are their types. The absorption peak of these two pigments is different.
1. Phytochrome red (Pr) or Red light absorbing form: This pigment absorbs the maximum light in the red region. It has a 660 nm wavelength. Pr is the inactive form that does not initiate biological responses.
2. Phytochrome far-red (Pfr) or Far-red light absorbing form: Its absorption peak is at 730nm in the far-red region. Physiologically, only Pfr phytochrome is an active form that initiates biological responses.
Red light (R) converts the Pr form of pigment to the Pfr form, while far-red light (PR) converts the Pfr form of pigment to Pr.

Difference Between Pr and Pfr Forms of Phytochrome

Pr form	Pfr form
1. It's an inactive type of phytochrome that's blue-green in colour and doesn't respond to phytochrome-mediated stimuli.	1. It is a light green active form of phytochrome that exhibits phytochrome-mediated responses.
2. It absorbs the most in the red region (about 660nm).	2. It absorbs the most in the far-red region (about 730nm).
3. The pyrrole rings in the Pr form have a lot of double bonds.	3. All pyrrole rings in the Pfr form have rearranged double bonds.
4. It's widely distributed throughout the cytosol.	4. It can be found in discrete cytosolic areas.

Phytochrome Functions

Some of the functions of phytochromes are given below:

1. Photomorphogenesis, photoperiodism, and cleistogamy are all developmental processes in which phytochrome plays a role.
2. It is involved in seed dormancy, leaf abscission, and the production of gibberellins, anthocyanins, and carotenoids.
3. Plant growth and development are regulated in different ways by phytochromes A and B.
4. PhyB is more sensitive to red and far-red light.
5. Some seeds require phytochrome for germination.
6. It promotes leaf production as well as regulates leaf size, quantity, and shape.

PHYTOCHROME: MODE OF ACTION

Phytochromes are photoreceptor proteins found in plants that play a crucial role in mediating various light-related processes, including germination, growth, flowering, and shade avoidance. These proteins are sensitive to red and far-red light, allowing plants to perceive changes in light quality and quantity. The mode of action of phytochromes involves several key steps:

Light Absorption: Phytochromes exist in two interconvertible forms: Pr (red-light absorbing) and Pfr (far-red-light absorbing). Pr absorbs red light (approximately 660 nm), converting it to the Pfr form. Pfr absorbs far-red light (approximately 730 nm), converting it back to the Pr form.

Conformational Change: When Pr absorbs red light, it undergoes a conformational change to become Pfr. This change triggers a cascade of downstream events in the plant cell.

Signal Transduction: The Pfr form of phytochrome acts as the active form, initiating a signal transduction pathway that involves various cellular processes. It primarily involves interactions with other proteins, especially the PIF (Phytochrome Interacting Factors) family.

PIF Interaction: PIFs are transcription factors that regulate the expression of various genes involved in plant growth and development. When phytochrome is in its active Pfr form, it can bind to PIFs and promote their degradation. This degradation releases their inhibition on downstream genes.

Gene Expression: With the inhibition of PIFs lifted, certain genes responsible for various growth responses can be transcribed and translated. These responses may include elongation of stems, suppression of branching, changes in leaf development, and the promotion of flowering.

Reversion to Pr: Pfr can revert back to Pr over time, even in the absence of light. This reversion ensures that the plant can adjust its growth patterns based on the duration of exposure to light.

Physiological Responses: The altered gene expression leads to physiological responses that enable the plant to adapt to changing light conditions. For instance, if a plant is shaded by neighboring vegetation, a decrease in the ratio of red to far-red light will lead to the conversion of Pfr to Pr, activating PIFs and promoting elongation of stems to reach for more light.

In summary, phytochrome's mode of action involves light absorption, conformational changes, interaction with transcription factors (PIFs), gene expression modulation, and subsequent physiological responses that allow plants to adapt and optimize their growth patterns in response to changing light conditions.