3.7: Conjugation and the Absorption of Light in the Real World

Objectives

- explain why some organic compounds have different colours based on compound structure and our perception of light.
- state the relationship between frequency of light absorbed and the extent of conjugation in an extended pi electron system.

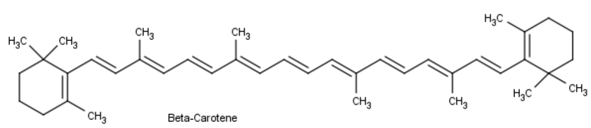
Eyes receive light energy then transfer and passing the energy into neural impulses to brain. This page will show the role of light plays in vision.

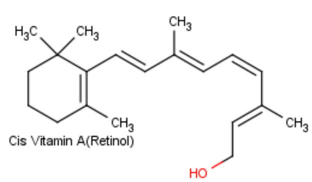
Introduction

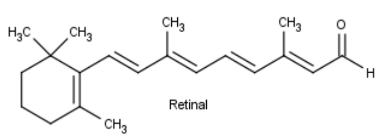
Light is one of the most important resources for civilization, it provides energy as it pass along by the sun. Light influence our everyday live. Living organisms sense light from the environment by photoreceptors. Light, as waves carry energy, contains energy by different wavelength. In vision, light is the stimulus input. Light energy goes into eyes stimulate photoreceptor in eyes. However, as an energy wave, energy is passed on through light at different wavelength. For example, "white" light from a lamp consists of all the wavelengths in the visible region. When this white light hits beta-carotene, the wavelengths from 400 to 500 nm are absorbed and all the other wavelengths are transmitted to our eyes. The carrot looks orange because the wavelengths of 400 to 500 nm that were absorbed occur in the blue range, when blue is removed our eyes see an orange color for beta-carotene.

Energy converting chemicals

Light energy can convert chemicals to other forms. Vitamin A, also known as retinol, anti-dry eye vitamins, is a required nutrition for human health. The predecessor of vitamin A is present in the variety of plant carotene. Vitamin A is critical for vision because it is needed by the retina of eye. Retinol can be converted to retinal, and retinal is a chemical necessary for rhodopsin. As light enters the eye, the 11-*cis*-retinal is isomerized to the all-"trans" form.

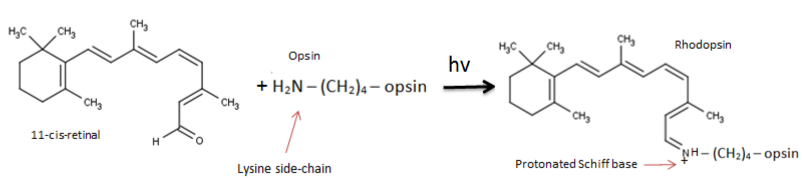






Mechanism of Vision

We now know in rhodopsin, there is protein and retinal. The large protein is called opsin. Opsin does not absorb visible light, but when it bonded with 11-cis-retinal by its lysine side-chain to from rhodopsin, the new molecule has a very broad absorption band in the visible region of the spectrum.[2][3]

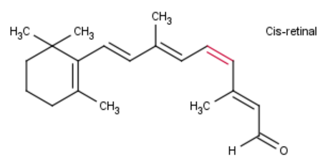


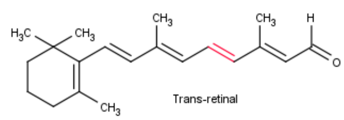
The reaction above shows Lysine side-chain from the opsin react with 11-cis-retinal when stimulated. By removing the oxygen atom form the retinal and two hydrogen atom form the free amino group of the lysine, the linkage show on the picture above is formed, and it is called Schiff base.

Signal transduction pathway

In human eyes, rod and cones react to light stimulation, and a series of chemical reactions happen in cells. These cells receive light, and pass on signals to other receiver cells. This chain of process is class signal transduction pathway. Signal transduction pathway is a mechanism that describes the ways cells react and respond to stimulation.

The molecule cis-retinal can absorb light at a specific wavelength. When visible light hits the cis-retinal, the cis-retinal undergoes an isomerization, or change in molecular arrangement, to all-trans-retinal. The new form of trans-retinal does not fit as well into the protein, and so a series of geometry changes in the protein begins. The resulting complex is referred to a bathrhodopsin (there are other intermediates in this process, but we'll ignore them for now).





As the protein changes its geometry, it initiates a cascade of biochemical reactions that results in changes in charge so that a large potential difference builds up across the plasma membrane. This potential difference is passed along to an adjoining nerve cell as an electrical impulse. The nerve cell carries this impulse to the brain, where the visual information is interpreted.

? Exercise 3.7.1

Indigo is an organic dye with a distinctive blue color. What wavelength does indigo absorb? What color is absorbed for our eyes to perceive blue?

Answer

Indigo absorbs orange light, which is a wavelength of 375-475 nm.

References

1. Biochemistry, L. Stryer (W.H. Freeman and Co, San Francisco, 1975).
2. *The Cambridge Guide to the Material World*, Rodney Cotterill (Cambridge University Press, Cambridge, 1985)
