16.11: CONJUGATION, COLOR, AND THE CHEMISTRY OF 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 the eye and stimulates its photoreceptors.

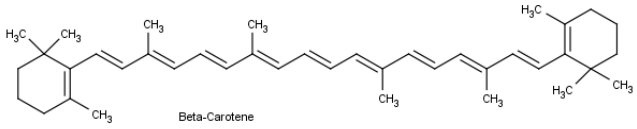
PHYSICAL CHARACTERISTICS OF LIGHT

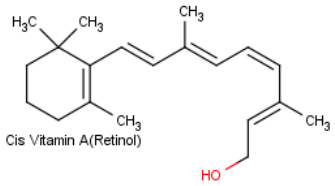
File:EM spectrum.svg[1]

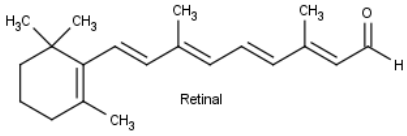
The energy of light can be determined from its wavelength. The energy of light increases from long wavelength to short wavelength. The visible spectrum ranges from 400 nm to 700 nm.

ENERGY CONVERTING CHEMICALS

Light energy can convert chemical 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 convert 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.

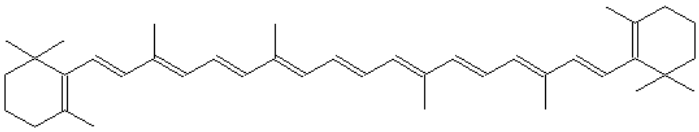




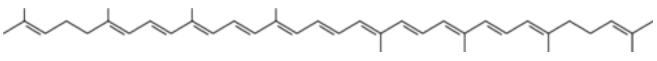


COLORED MOLECULES

The conjugated double bonds in beta-carotene produce the orange color in carrots. The conjugated double bonds in lycopene produce the red color in tomatoes.



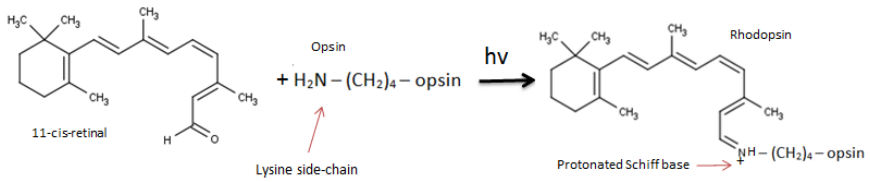
ß carotene



lycopene

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]

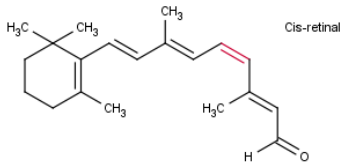


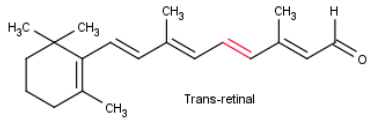
The reaction above shows Lysine side-chain from the opsin react with 11-cis-retinal when stimulated. By removing the oxygen atom form the retinal and two hydrogen atom form the free amino group of the lysine, the linkage show on the picture above is formed, and it is called Schiff base.

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 describe the ways cells react and response 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.

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)