Conversion of Vitamin A into Cis-Retinal

Vitamin A, trans-retinol, is carried to the rods in the eyes from storage in the liver. First it is converted to cis-retinol by a process of isomerization, which means that the trans isomer is converted to a cis isomer. The molecule must break the pi bond, rotate on the single bond, and reform the pi bond. The cis-retinol, an alcohol, is then oxidized to cis-retinal, an aldehyde.

Isomerization of Retinal

Photochemical events in vision involve the protein opsin and the cis/trans isomers of retinal. The cis-retinal fits into a receptor site of opsin. Upon absorption of a photon of light in the visible range, cis-retinal can isomerize to all-trans-retinal. In the cis-retinal, the hydrogens (light gray in the molecular model on the left) are on the same side of the double bond (yellow in the molecular model).

In the trans-retinal, the hydrogens are on opposite sides of the double bond. In fact, all of the double bonds are in the trans-configuration in this isomer: the hydrogens, or hydrogen and -CH3, are always on opposite sides of the double bonds (hence, the name “all-trans-retinal”).

Note how the shape of the molecule changes as a result of this isomerization. The molecule changes from an overall bent structure to one that is more or less linear. All of this is the result of trigonal planar bonding (120° bond angles) about the double bonds.
This photochemical reaction is best understood in terms of molecular orbitals, orbital energy, and electron excitation. In cis-retinal, absorption of a photon promotes a p electron in the pi bond to a higher-energy orbital. This excitation "breaks" the pi component of the double bond and is temporarily converted into a single bond. This means the molecule can now rotate around this single bond, which it does by swiveling through 180°.

The double bond then reforms and locks the molecule back into position in a trans configuration of the all-trans-retinal. This isomerization occurs in a few picoseconds (10-12 s) or less. Energy from light is crucial for this isomerization process: absorption of a photon leads to breaking the double bond and consequent isomerization about half the time (in the dark is almost never happens).

Contributors

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