Carotenes: From orange to pink to blue

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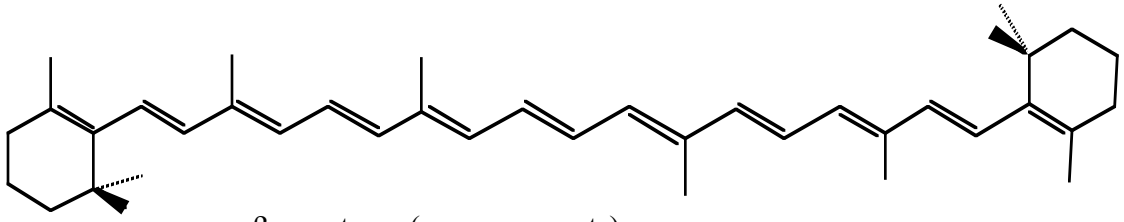
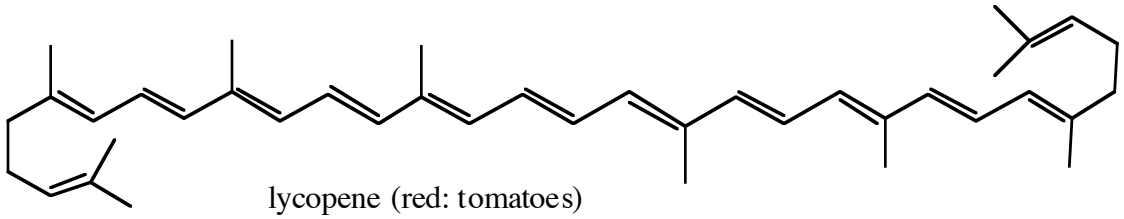
Carotene and related compounds form one of a very few classes of organic compounds that produce color in nature.[1] Everyone has heard of β-carotene, the compound that gives the distinctive orange color to carrots, butternut squash, and cantalope melons. Spinach and broccoli contain lots of β-carotene as well, but the orange color is masked by chlorophyll, which is, of course, green.

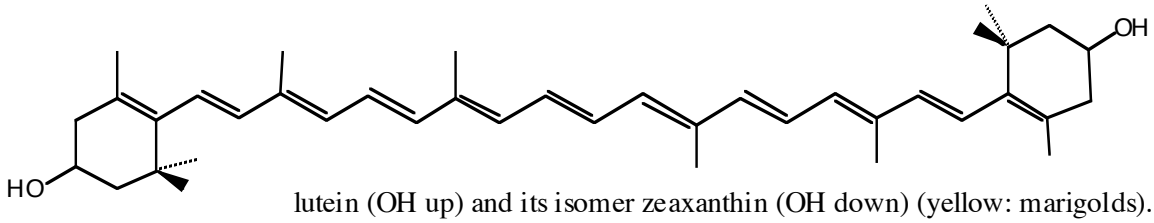


β–carotene (orange: carrots)

Slight variations in the molecular structure at the ends of carotene gives rise to other compounds. Lycopene, for example, provides the red color in tomatoes;[2] lutein and its isomer zeaxanthin, the orange in marigolds; and canthaxanthan, the pink color in flamingo feathers. Crustacyanin, a blue pigment formed when a molecule of astaxanthan binds to a protein, is found in the rare (1 in ~3 million) blue lobster.[3]



lycopene (red: tomatoes)



lutein (OH up) and its isomer zeaxanthin (OH down) (yellow: marigolds).

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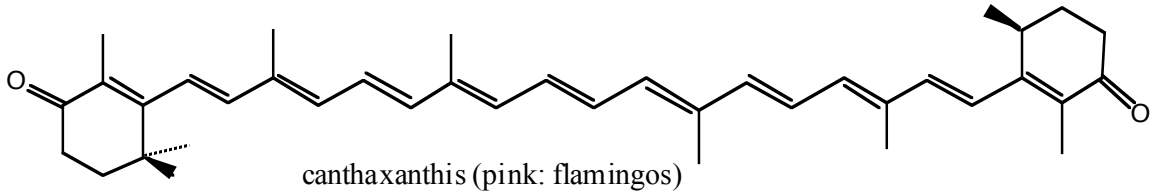
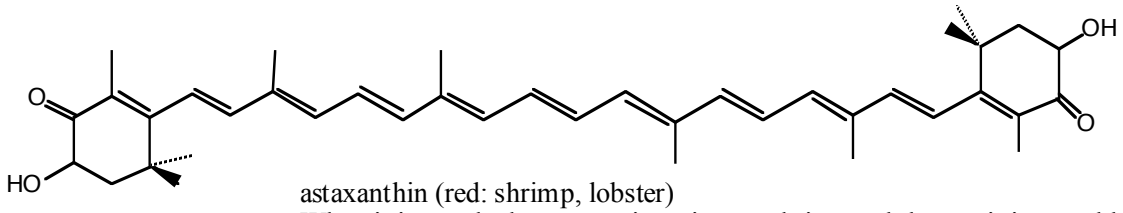
[1] For example: carotenes – read on; anthocyanins (yellow, orange and red in fall leaves, red in roses, blue in cornflowers); porphorins (red and green in blood and leaves); and tannins (browns, as in tea).

[2] See January 2005 Molecule for the Month.

[3] The blue disappears when the lobster is cooked because the protein is destroyed by heat. Therefore, all cooked lobsters look alike – red – due to astaxanthan.

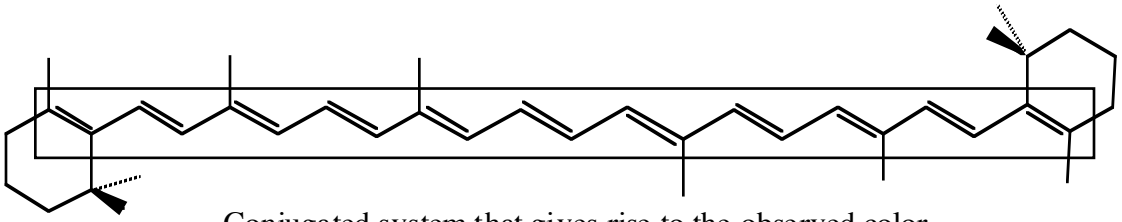


canthaxanthis (pink: flamingos)



astaxanthin (red: shrimp, lobster)
When it is attached to a protein as in raw shrimp or lobsters, it is gray-blue.

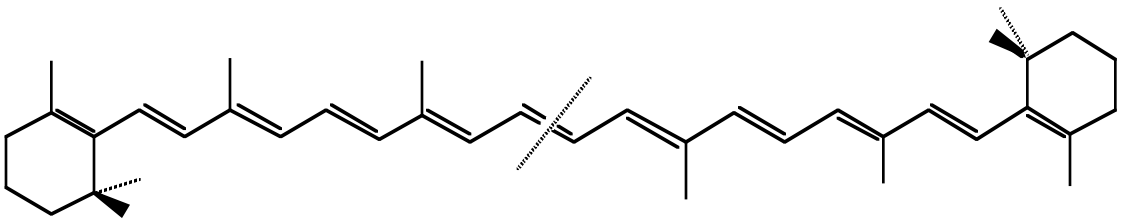
The color is generated by the interaction of light with the long conjugated system in the carotenes; the seemingly slight molecular changes at the ends lead to the different colors.

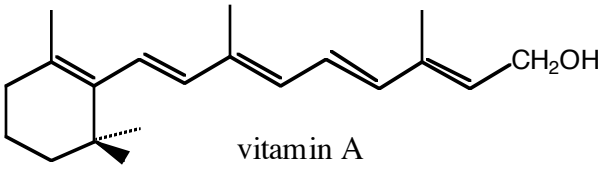


Conjugated system that gives rise to the observed color.

If an animal is colored by a carotene, it must have obtained it in its diet, as algae, plankton, or other plants (or plant/algae eating animals such as crustaceans) are the sole source of these compounds; animals do not make them. Therefore, flamingos or salmon bred in captivity or farmed will be off-white, so a caroteneoid dye is added to their food to provide the expected pink or salmon color.

Notice that vitamin A has a structure that is half of the β-carotene compound. We eat food that provides a direct source of vitamin A, but β-carotene may be cleaved in the body to form vitamin A.





vitamin A

These examples represent only a few of the many carotenoid compounds found in nature.

References:

Plug into any search engine the name of any carotenoid compound or a fruit or vegetable and its color and you will find a wealth of references. Always be careful of references that end in ".com."

A nice animated version of a "generic carotenoid"
http://www-ocean.tamu.edu/~pinckney/carot.htm

Blue lobsters

http://www.mysticaquarium.org/animals/facts/animalfacts.asp?otheranimals=&animal=28&Submit=Go

http://www.nytimes.com/2005/03/15/science/15blue.html?ex=1111899600&en=4c3e4eb1637840c5&ei=5070

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