

Dr. Iverson,

I took your Organic II class a few years ago, and I loved it enough to switch my major to chemistry. I am now a second year chemistry PhD student at The Scripps Research Institute. I'm contacting you, however, regarding another passion of yours: running and fitness. When I took your course, I was quite frankly annoyed at your frequent suggestions that your students exercise. Who was this guy to tell ME what to do with MY body? I'm sure you won't be surprised to know that I didn't participate in the class 5K, and I lived a very sedentary and unhealthy lifestyle. It finally caught up with me recently. In October, I went to a doctor for a routine exam. I was overweight, my cholesterol was through the roof, and I even had fatty deposits on my liver. High cholesterol? I'm only 25 years old! I never thought I would hear the word "Lipitor" in my twenties! I quickly changed my diet, including the addition of many more fruits and vegetables and the reduction of fried greasy foods. Perhaps more importantly, I started running. Slowly at first - I couldn't jog 100 yards without losing my breath. Within a week I was feeling much better. Within a month I was even enjoying running. Four months after my health scare, I have lost 25 pounds. My cholesterol has decreased dramatically (well within normal/healthy limits), and I've never felt better in my life! I now run 15-20 miles a week. It takes so little time that I have no excuse not to. I am so glad I heeded your advice, even if it was a few years late. I am telling you all this hoping it might encourage your students to begin getting in shape before their health is affected like mine was.

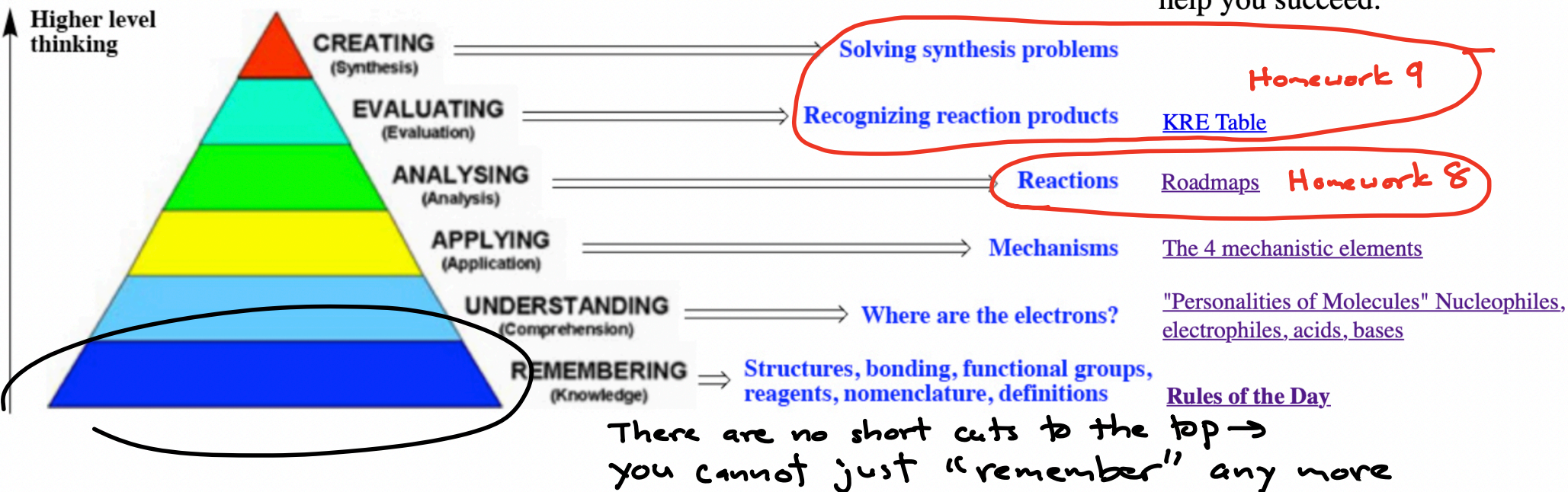
Cheers and Happy Running,



Bloom's Taxonomy of Learning

Organic Chemistry Analog

Tools we created to help you succeed:



Organic chemistry is difficult because it requires higher order thinking. According to Bloom's taxonomy of learning, the lowest level of learning involves pure memorization ("Remembering"). As one moves up the pyramid to higher learning, understanding, applying, analysing, evaluating and creating are reached. I believe there are Organic chemistry analogs of all of these, culminating in synthesis which involves creativity along with all of the other levels of thinking. It is likely that many of you have never been challenged all the way to the top of the Bloom's taxonomy of learning pyramid before, explaining why this feels different and disorienting. DO NOT GIVE UP. As shown on the right, we have created tools to help you master each step up the ladder. On the above diagram you can click on the tools listed to go directly to them. Also, if you have any questions about how to study, [click here to read about the way I learned to study](#). I never earned a grade lower than an A after I started using this method during my own college career.

I understand that most of you are headed to the health professions, so you may be wondering if mastering synthesis problems will be important for you. I assert that it is. Solving a synthesis problem involves the detailed evaluation of a complex molecule while looking for KREs, then working backwards to the starting materials by analyzing possible reactions involved by thinking through your roadmaps, possibly applying your understanding of mechanism to make sure you predict the correct product for each reaction. This is the exact type of thinking you will need to diagnose a patient. A patient will present various complex combinations of symptoms, then you must evaluate which of these are important, then analyze, apply and understand how the patient got that way and how to get them back to their starting state (healthy) again. In other words, you will learn the "KREs of diagnosis" then work backwards to understand what happened to the originally healthy patient! Therefore, learning how to solve synthesis problems will teach you how to use higher level thinking skills, exactly the kind you will need to develop as a health care professional!

Electrons should be thought of as waves.

Orbitals are described by wave equations.

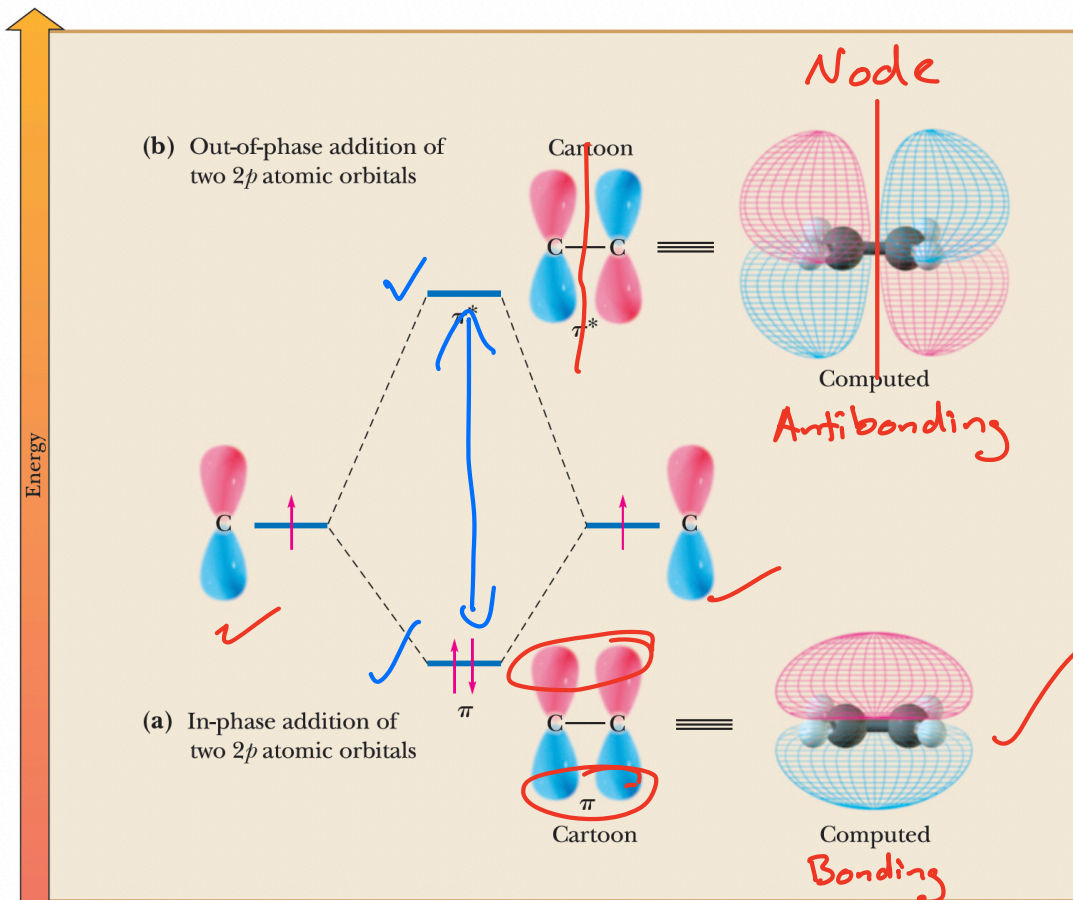
Like waves \rightarrow orbitals can add constructively and destructively

When adding atomic orbitals, you get as many new molecular orbitals as there are component atomic orbitals

\rightarrow Half of these are bonding molecular orbitals

\rightarrow Half of these are antibonding molecular orbitals

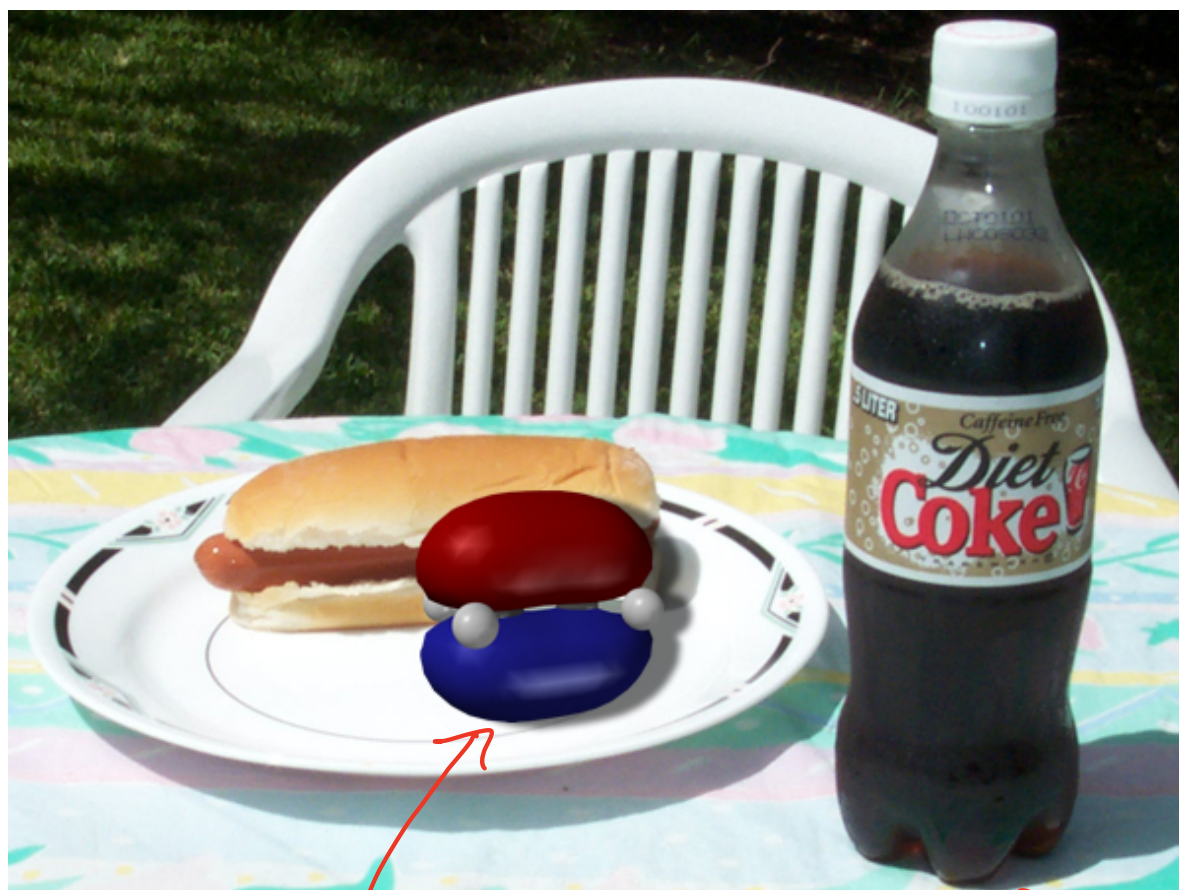
For molecules with adjacent 2p orbitals that overlap the resulting molecular orbitals extend over all the atoms!



[Watch a video explanation](#)

FIGURE 1.21

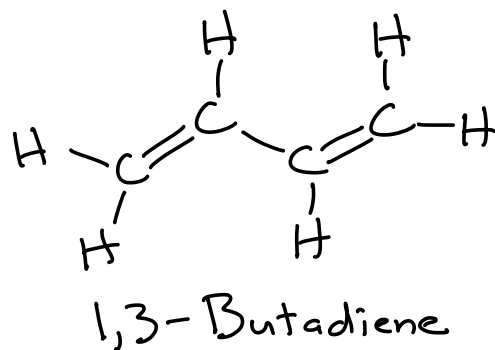
Molecular orbital mixing diagram for the creation of any C—C π bond. (a) Addition of two p atomic orbitals in phase leads to a π orbital that is lower in energy than the two separate starting orbitals. When populated with two electrons, the π orbital gives a π bond. (b) Addition of the p orbitals in an out-of-phase manner (meaning a reversal of phasing in one of the starting orbitals) leads to a π^* orbital. Population of this orbital with one or two electrons leads to weakening or cleavage of the π bond, respectively.

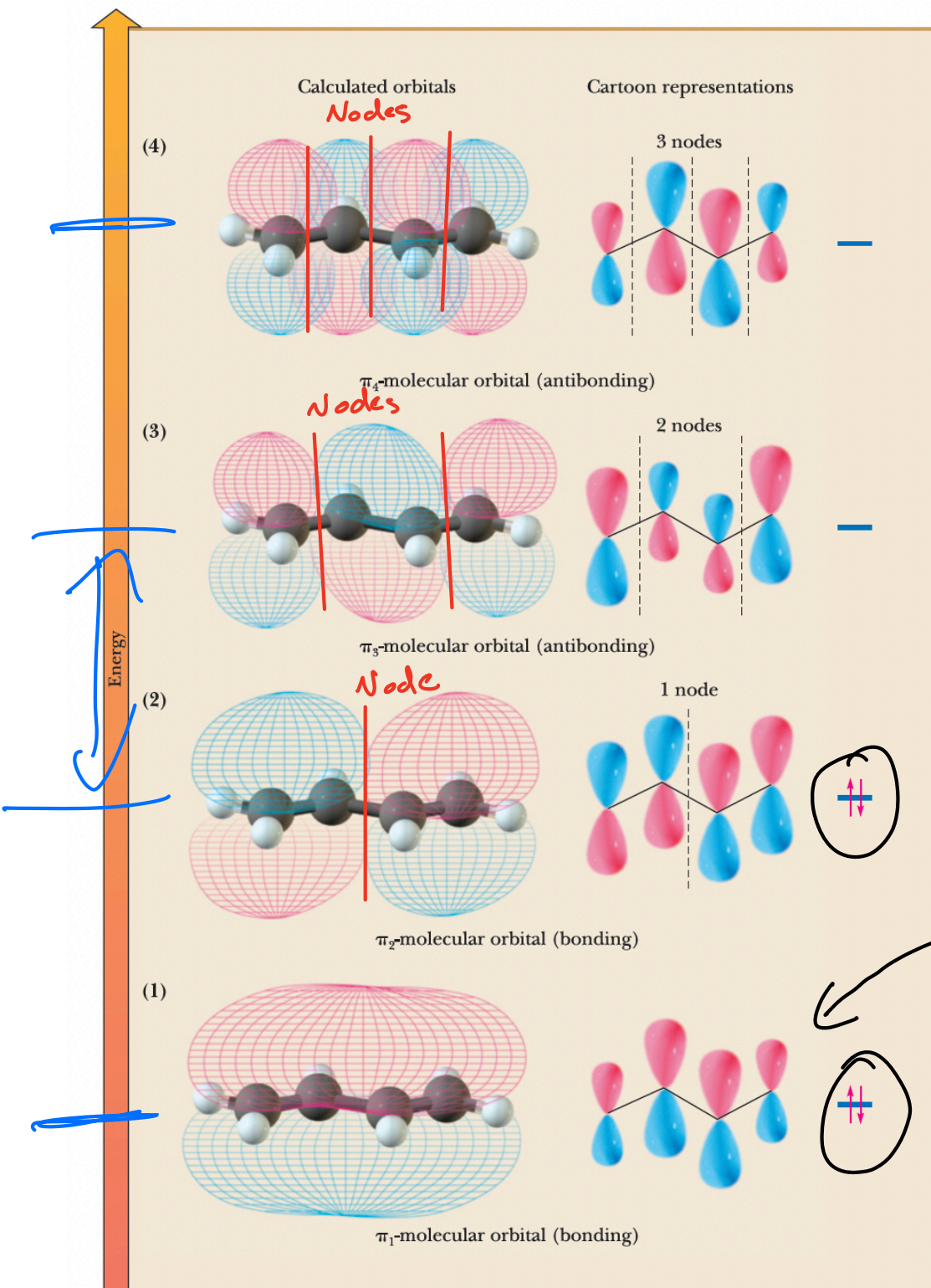


TS bonding orbitals
look like hot dog
buns → formed from
overlap of 2p orbitals
↓
"to pee"

If you
drink a lot
of this you
have 2 p!
(to pee)

The same applies when there are
4 atoms, each with an overlapping
2p orbital:





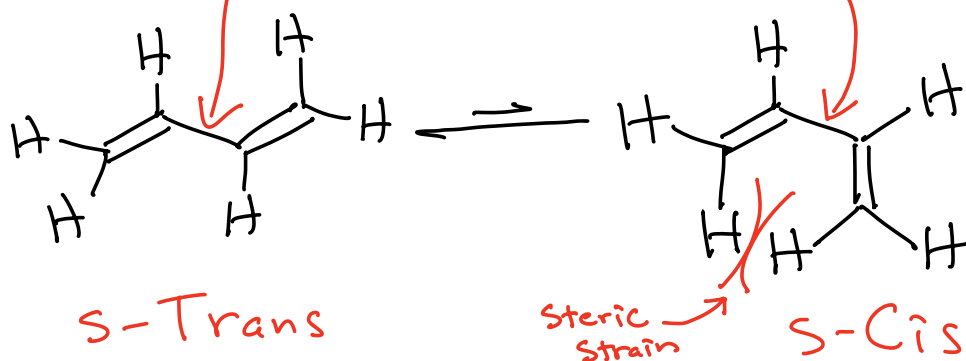
[Watch a video explanation](#)

" π -way" orbital \rightarrow a "highway" for π electrons

FIGURE 20.2 Structure of 1,3-butadiene—molecular orbital model. Combination of four parallel 2p atomic orbitals gives two π -bonding MOs and two π -antibonding MOs. In the ground state, each π -bonding MO is filled with two spin-paired electrons. The π -antibonding MOs are unoccupied.

Consequence of the " π -way"
molecular orbital \rightarrow The bond between
the middle two carbon atoms
is not a normal sigma bond

\rightarrow Partial π bond
 \rightarrow Does NOT rotate freely



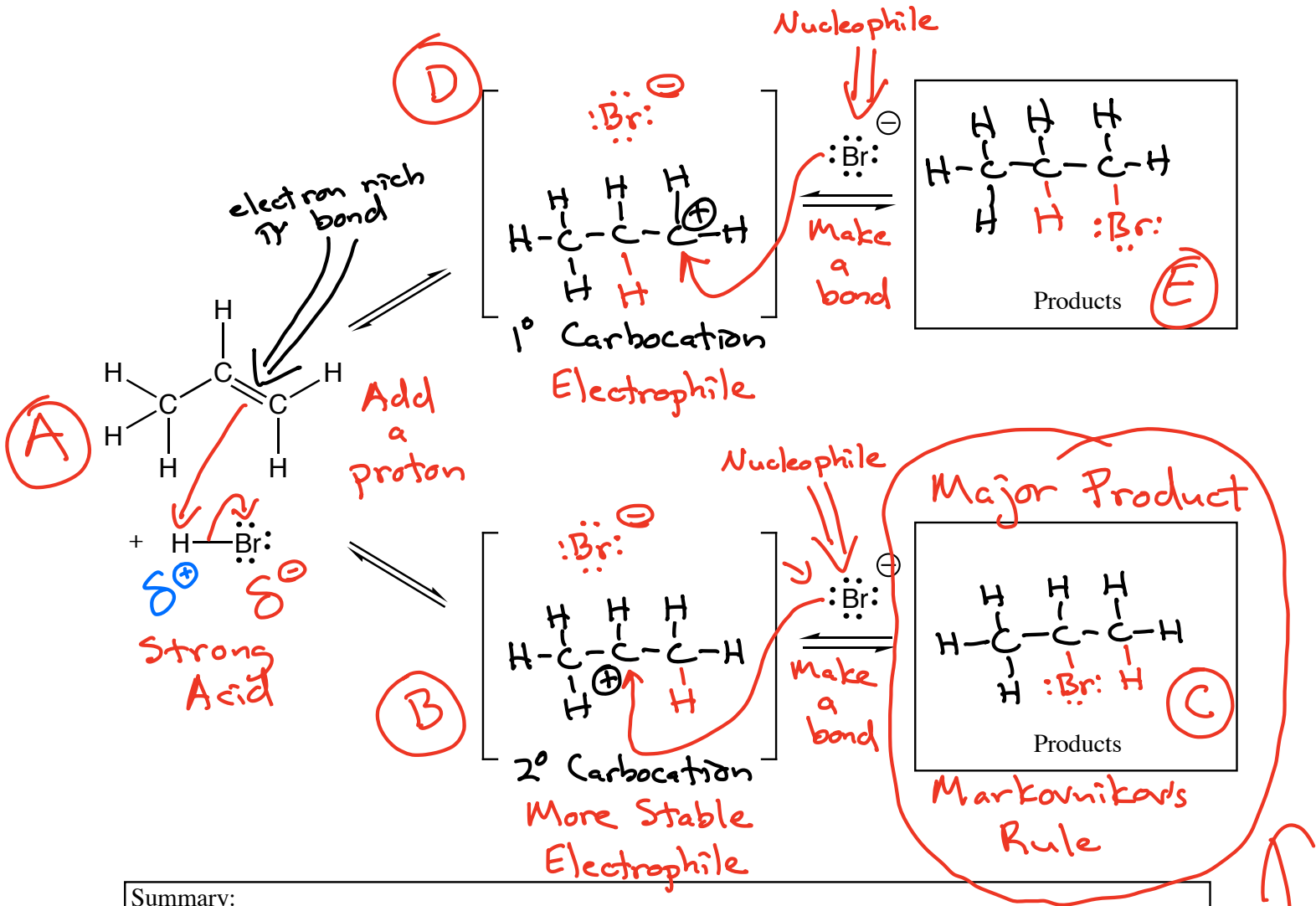
More stable

Less stable due
to some
steric strain



Addition of H-X to an Alkene

X = Cl, Br, I
but not F



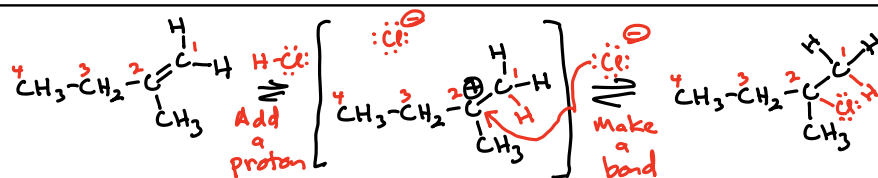
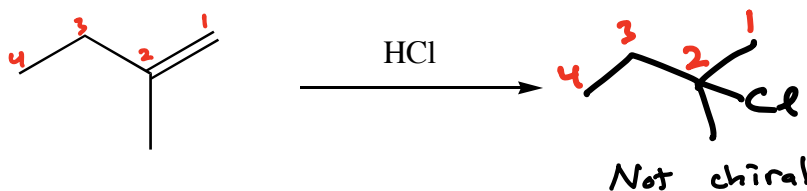
Summary:

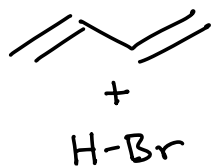
The alkene pi bond reacts with H-X to add a proton to create a carbocation intermediate that makes a bond with X⁻ to give the product

Regiochemistry: **Markovnikov's Rule**

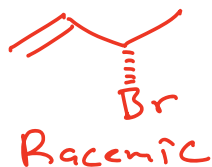
Stereochemistry: **Mixed (time capsule) → Racemic Product**

Example:





1,2 addition



1,4 addition



Temperature of
Reaction

-78°C

90%

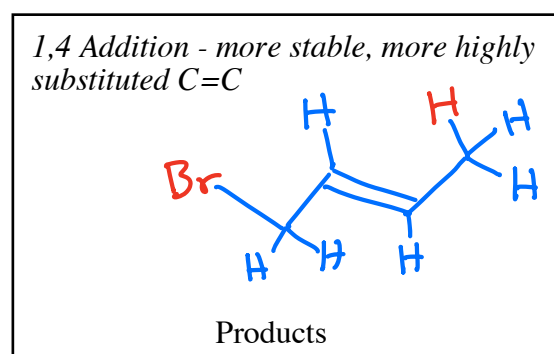
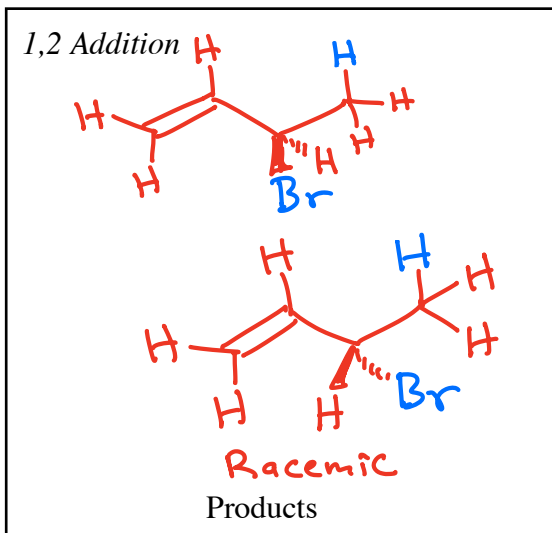
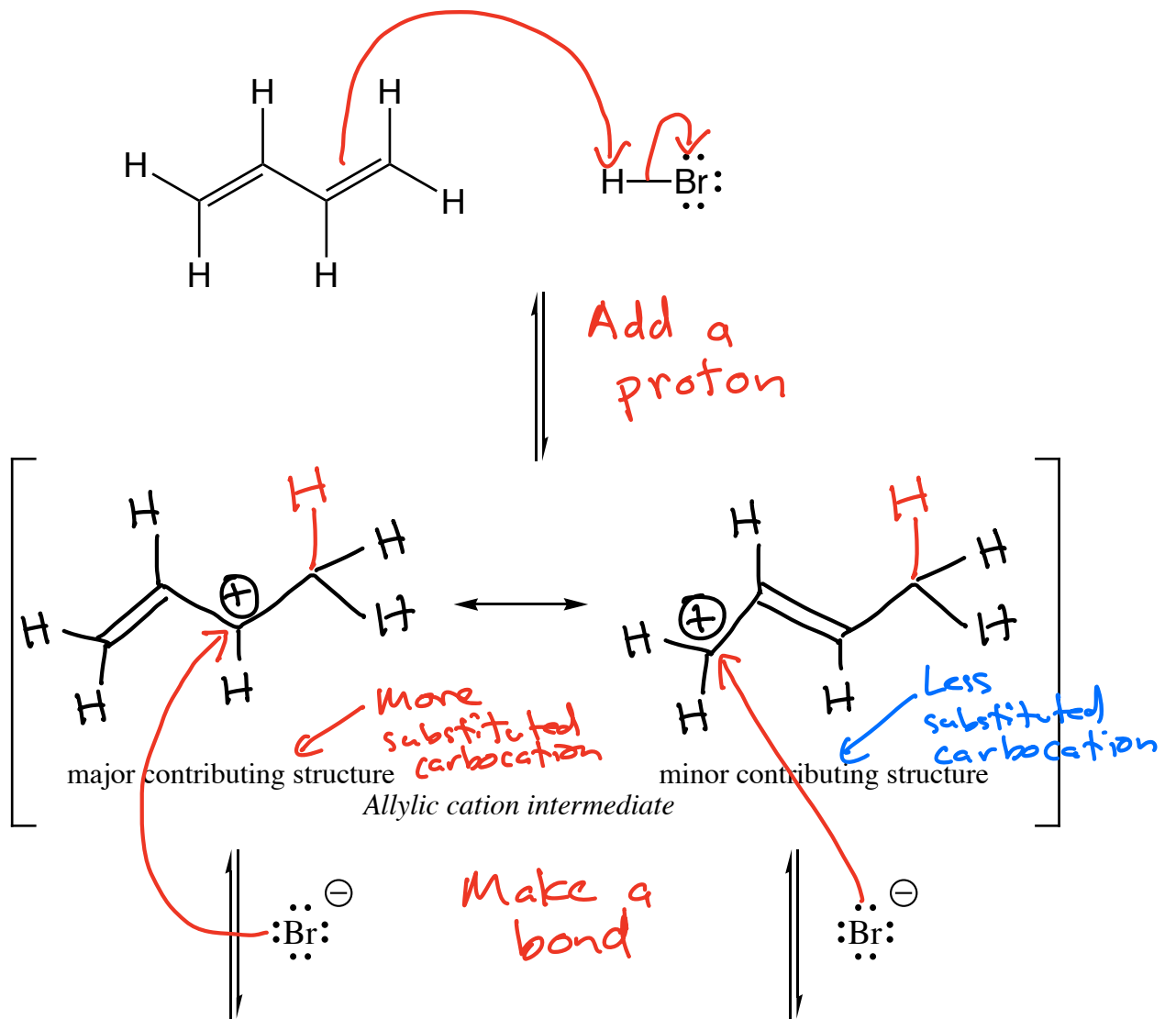
10%

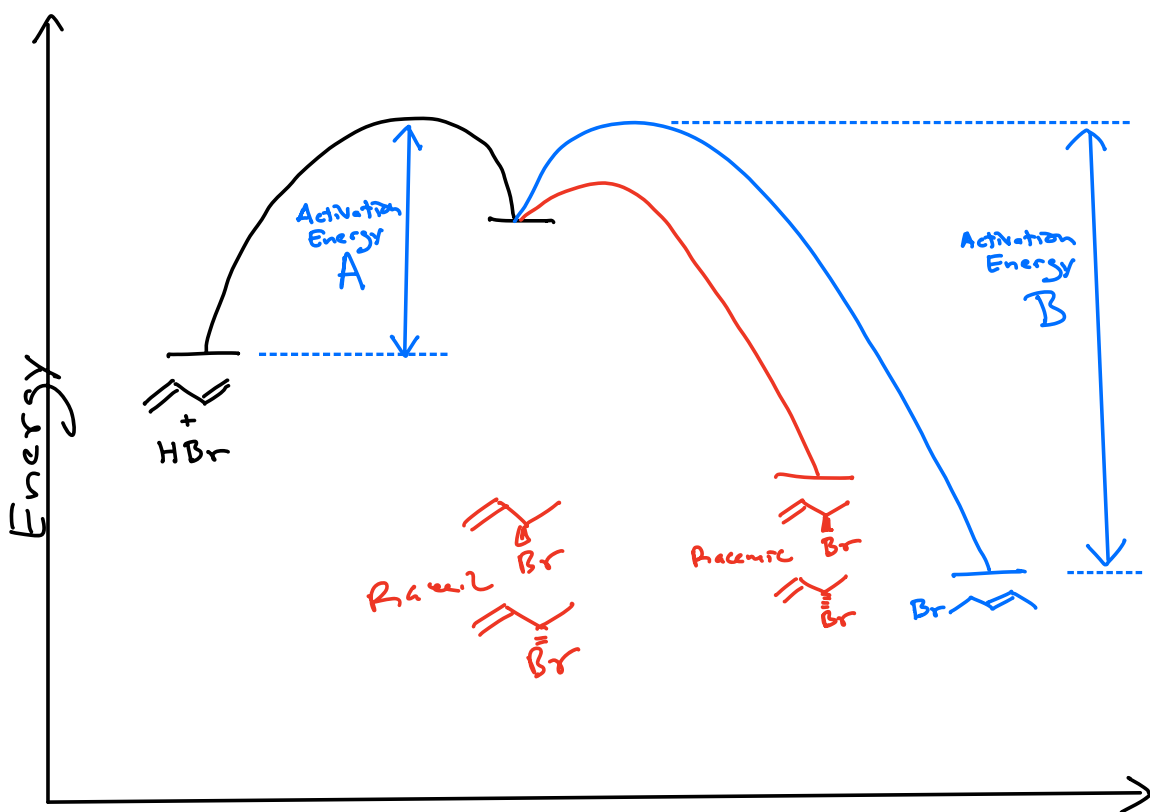
+40°C

15%

85%

H-X reacting with conjugated dienes





Low temperature \rightarrow Molecules have enough energy to get over activation energy A, but not enough energy to get over activation energy B.

Kinetic Control
 "Fastest" wins

High temperature \rightarrow Molecules have enough energy to get over activation energy A and activation energy B

Thermodynamic Control
 Most stable product wins

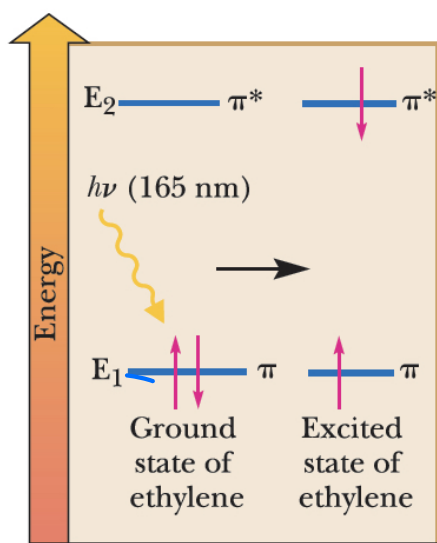


FIGURE 20.6 A $\pi \rightarrow \pi^*$ transition in excitation of ethylene. Absorption of ultraviolet radiation causes a transition of an electron from a π -bonding MO in the ground state to a π -antibonding MO in the excited state. There is no change in electron spin.

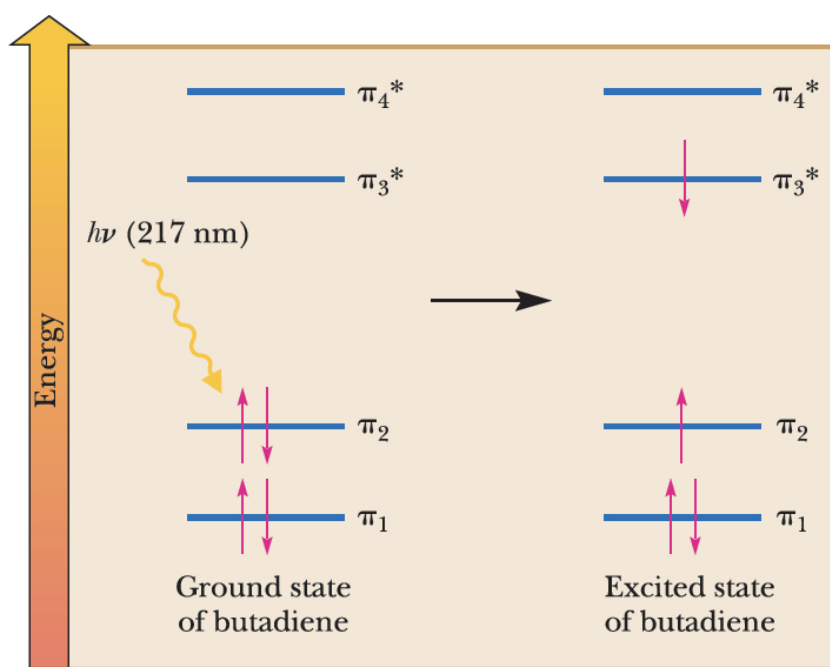


FIGURE 20.7 Electronic excitation of 1,3-butadiene; a $\pi \rightarrow \pi^*$ transition.

As you add 2p orbitals \rightarrow
the energy gap between
the highest filled
 π molecular orbital
and the lowest unfilled
 π molecular orbitals
gets smaller \Rightarrow leads
to longer wavelength
of light photon of
the correct energy
to be absorbed.

← Energy

Light source
↙ ↘

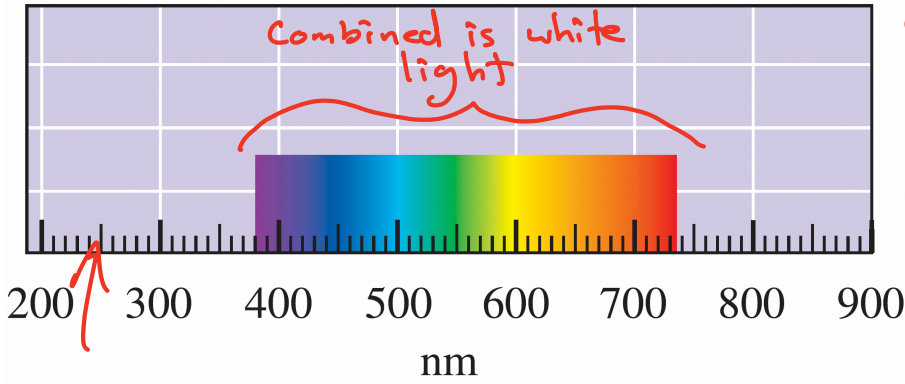
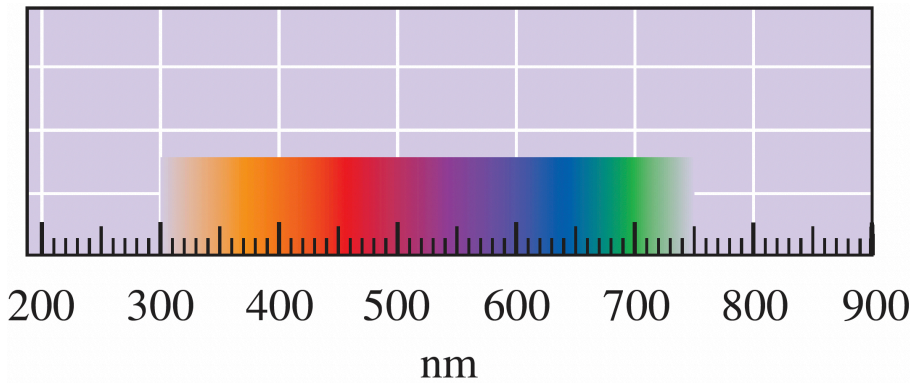
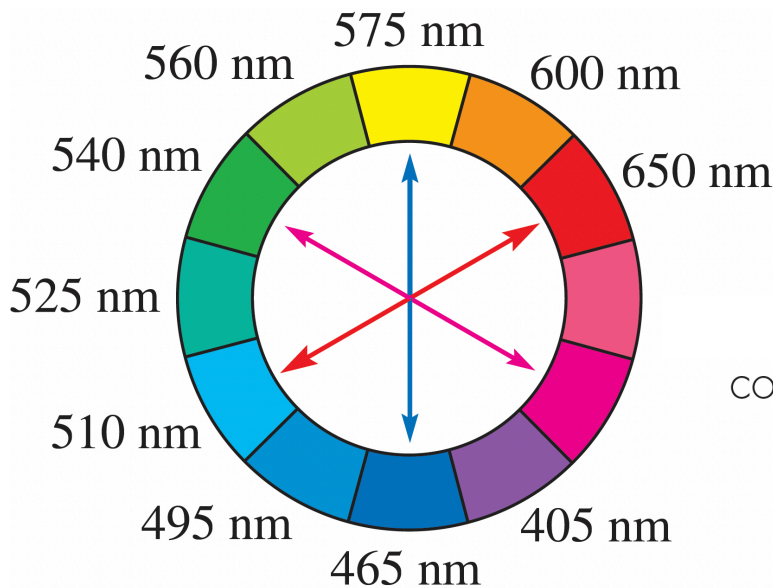


FIGURE 20.5 (a) Visible light color-wavelength correlation.

*** We "see" the wavelengths reflected minus the wavelengths absorbed ***

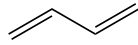


(b) Approximate color of substance (reflected light) if a single wavelength (i.e., the wavelength listed on the numerical scale of the x-axis) is absorbed.



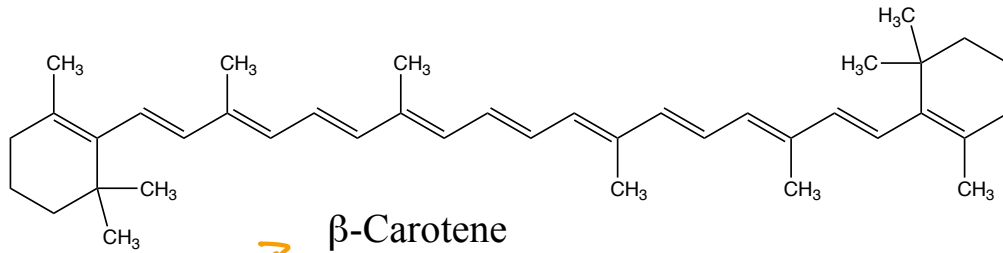
(c) Complementary colors on a color wheel.

Colored arrows are complementary



Butadiene

$\lambda_{\max} = 217 \text{ nm}$

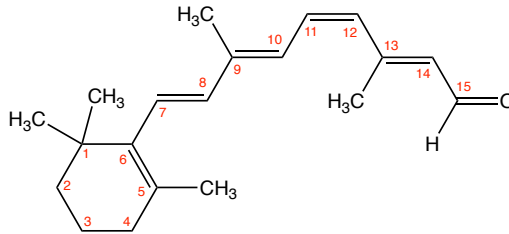


β -Carotene

$\lambda_{\max} = 455 \text{ nm}, 483 \text{ nm}$

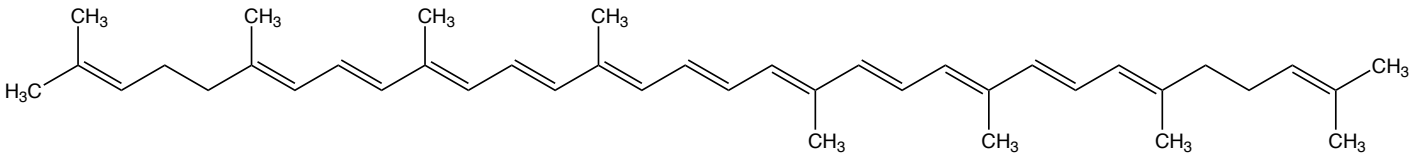
The orange color in carrots

β -Carotene is converted to 11-cis-retinal in our bodies



11-cis-Retinal

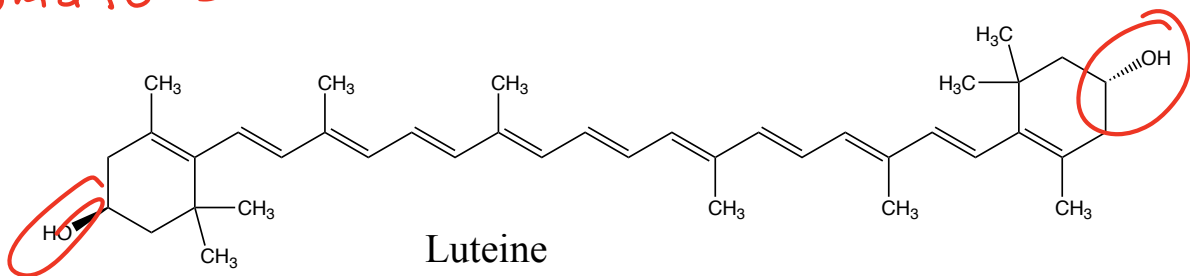
$\lambda_{\max} = 380 \text{ nm}$



The red color of tomatoes

Lycopene

$\lambda_{\max} = 443 \text{ nm}, 471 \text{ nm}, 502 \text{ nm}$



Luteine

$\lambda_{\max} = 445 \text{ nm}, 474 \text{ nm}$

Organic Chemistry is the study of carbon-containing molecules. This class has two points.

The first point of the class is to understand the organic chemistry of living systems. We will teach you how to think about and understand the most amazing molecules on the planet!!

You will learn how MRI scans work. 1/12/23

You will learn the basic principles of pharmaceutical science and how many drugs work. 1/19/23

You will learn about the special bond that holds carbohydrates such as glucose in six-membered rings, connects carbohydrate monomers together to make complex carbohydrate structures and is critical to DNA and RNA structure.

1/26/23

You will learn how soap is made from animal fat and how it works to keep us clean. 2/16/23

You will learn the important structural reason proteins, the most important molecular machines in our bodies, can support the chemistry of life.

2/14/23

You will learn how important antibiotics like penicillins work, including ones that make stable covalent bonds as part of their mode of action.

3/7/23

You will learn why carrots are orange and tomatoes are red. 3/28/23

You will learn the very cool reason that the DNA and RNA bases are entirely flat so they can stack in the double helix structure.

You will learn even more about why fentanyl is such a devastating part of the opioid problem and how Naloxone is an antidote for a fentanyl overdose.

You will learn even more details about why Magic Johnson is still alive, decades after contracting HIV, and how the same strategy is being used to fight COVID.

You will learn about the surprising chemical reason the Pfizer and Moderna mRNA vaccines elicit strong immune responses.

The second point of organic chemistry is the synthesis of complex molecules from simpler ones by making and breaking specific bonds, especially carbon-carbon bonds.

You will learn how carbon-metal bonds lead to new carbon-carbon bonds. 1/17/23

You will learn how most reactions of carbonyl compounds involve only the four common mechanistic elements operating in only a few common patterns.

1/17/23

You will learn how, by simply adding a catalytic amount of base like HO^- to aldehydes or ketones, you can make new carbon-carbon bonds, giving complicated and useful products. 2/28/23

You will learn a reaction that can convert vinegar and vodka into a common solvent. 2/16/23

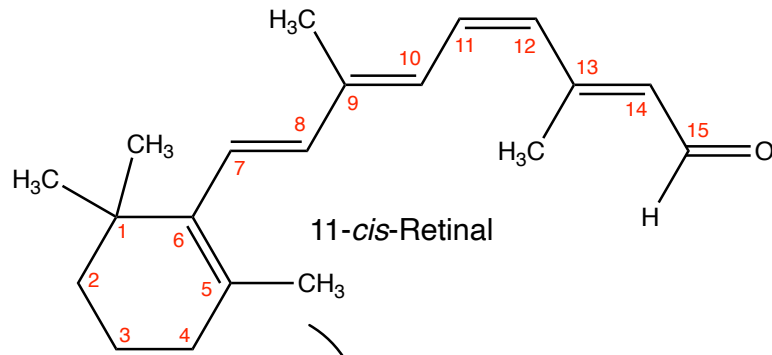
You will learn why molecules with six-membered rings and alternating double bonds are stable.

You will learn a reaction that can turn model airplane glue into a powerful explosive.

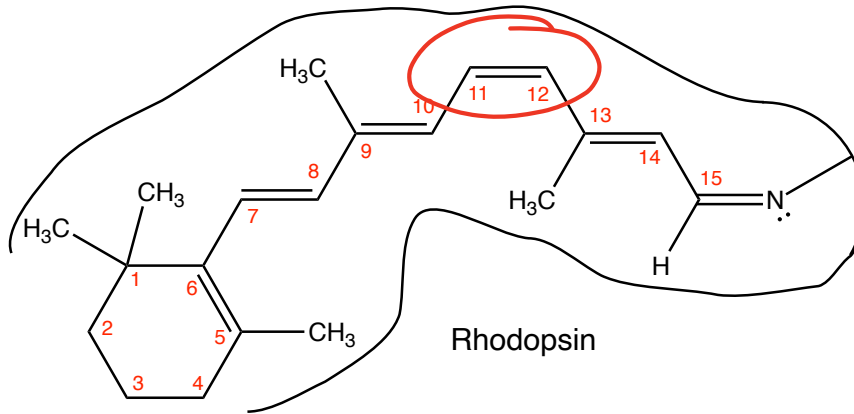
Most important, you will develop powerful critical thinking skills:

1. You will learn how to look at a molecule and accurately predict which atoms will react to make new bonds, and which bonds will break during reactions.
2. You will learn how to analyze a complex molecule's structure so that you can predict ways to make it via multiple reactions starting with less complex starting molecules.

How vision works

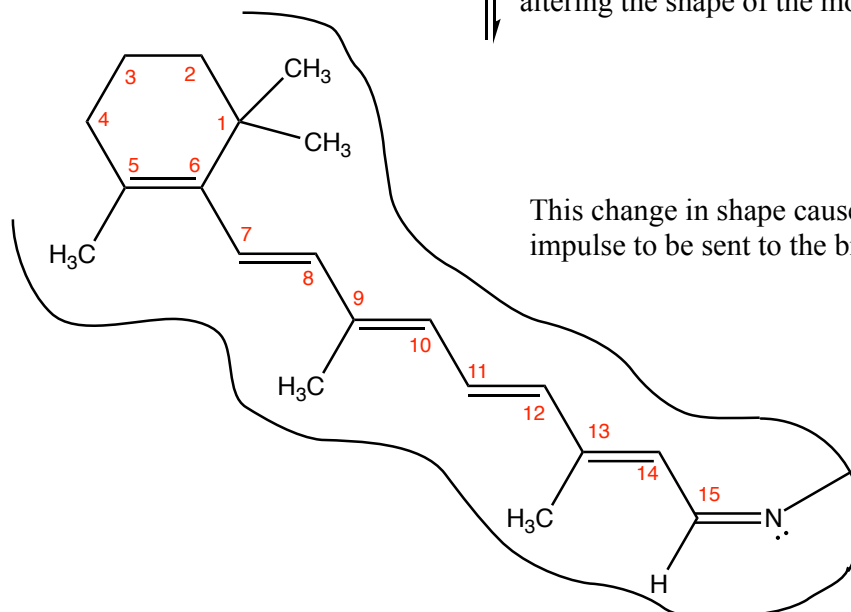


$\text{H}_2\ddot{\text{N}}\text{---}$ Binds to an -NH_2 group from the amino acid lysine in the protein opsin



As the light is absorbed, a bonding π electron is excited into a π antibonding orbital \rightarrow that effectively breaks the $\text{C}_{11}\text{-C}_{12}$ π bond so it can rotate to the more stable all trans form!

Molecule resets \updownarrow A photon of visible light is absorbed by the retinal, isomerizing the *cis* bond to *trans*, dramatically altering the shape of the molecule



A green laser is entirely absorbed by the red blood (hemoglobin) in your finger because for blood to appear red it must absorb blue and green, while reflecting red.

A red laser is not absorbed by the red blood in your finger — otherwise blood would not be red!!