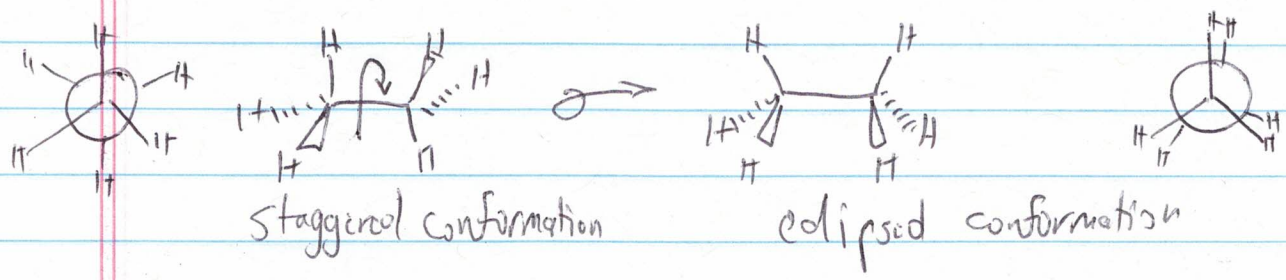


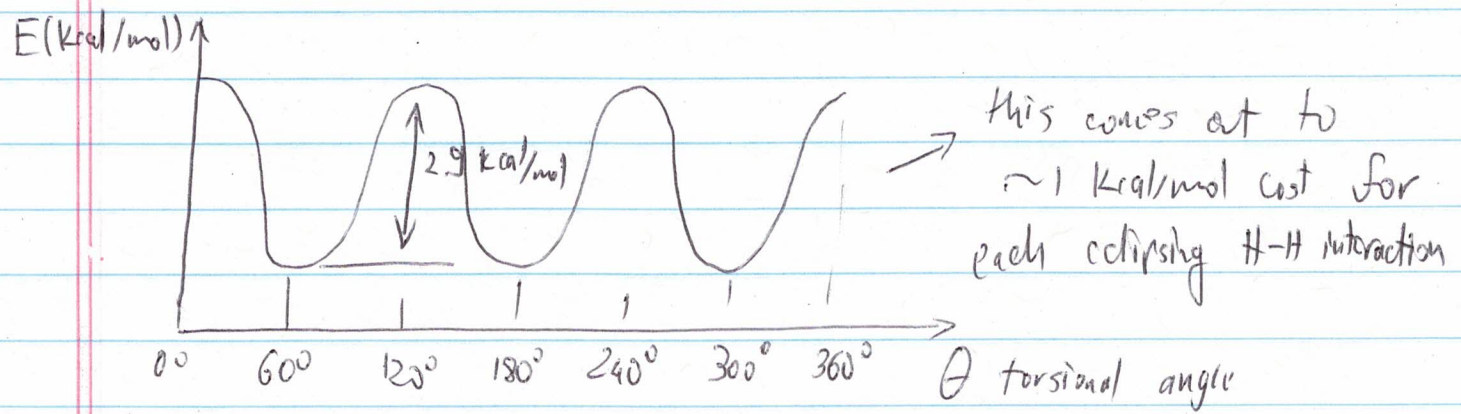
Lecture XVII = Conformational Analysis of Acyclic Molecules 02-24-2020

Most molecules are not rigid and the most common movement within a molecule is rotation around single bonds.

In ethane:



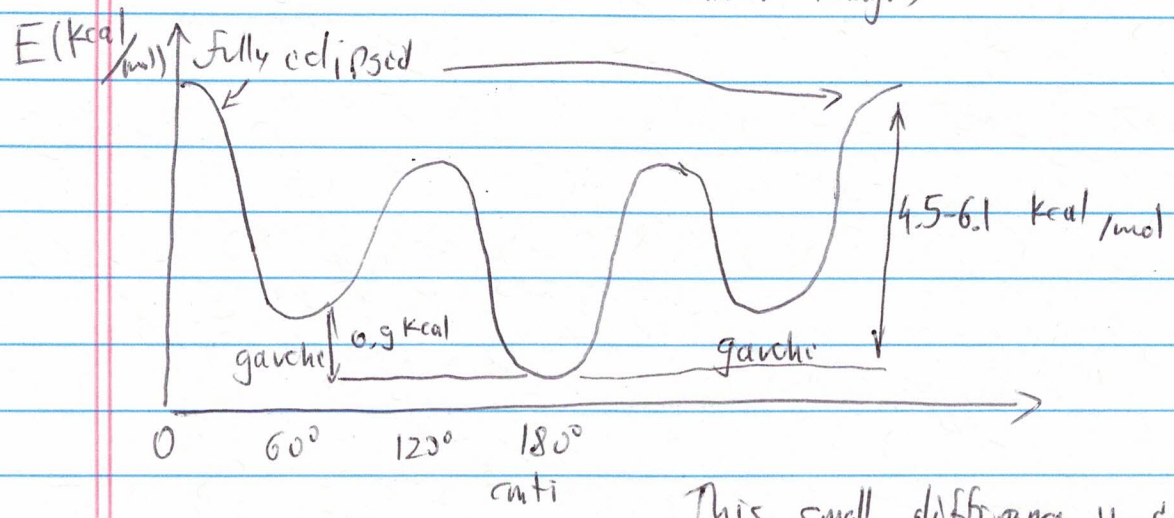
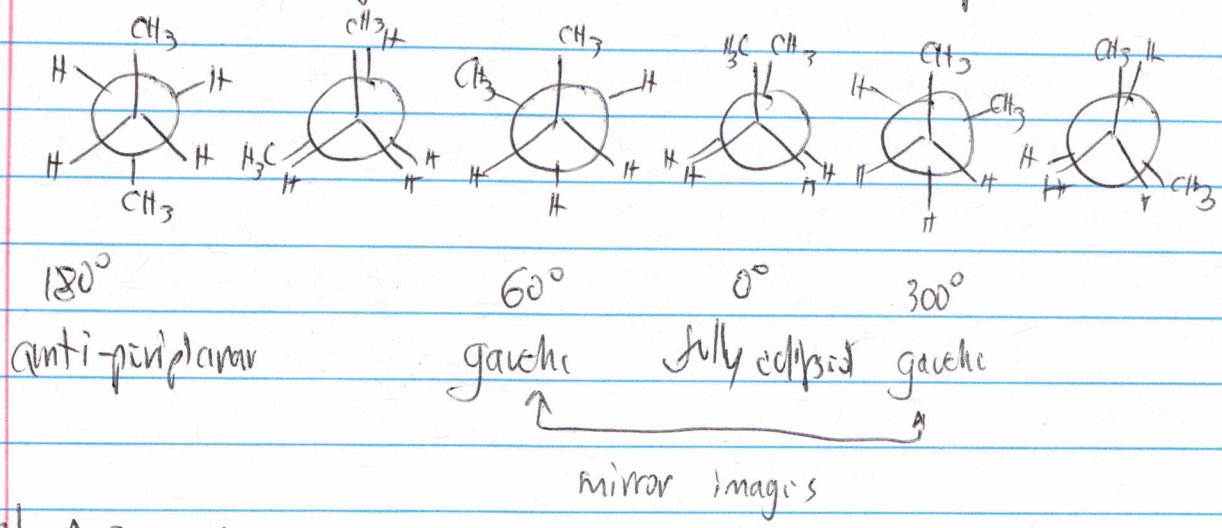
There is an infinite number of *n*-butane orientations as well, but these are the most important ones. Eclipsed are energy maxima, and staggered ones are minima.



Low barrier means essentially free rotation - rotamers of ethane cannot be isolated. The three staggered conformations are degenerate and cannot be distinguished.

Similar situation is seen in propane and other molecules of  $\text{CH}_3\text{CH}_2\text{X}$  type. One large barrier, three degenerate staggered orientations.

In butane, things become a bit more complex:



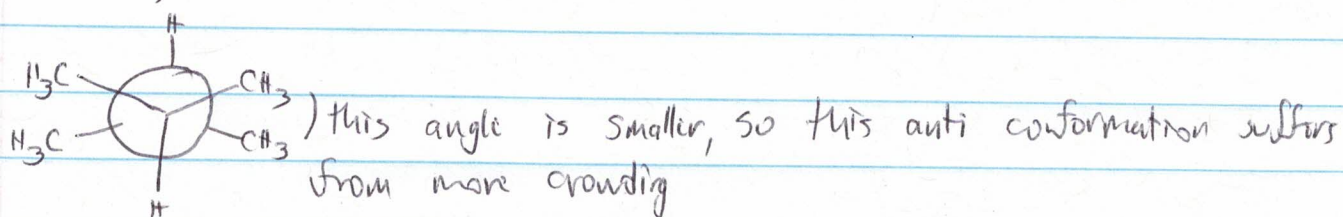
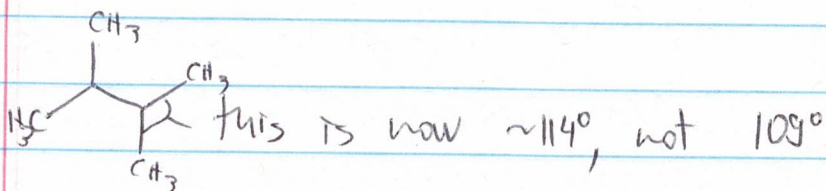
This small difference in energy between anti and gauche conformers means that they both exist in  $\approx 2.3:1$  ratio.

In butane, rotation around C1-C2 and C3-C4 bonds is also possible, but that case is similar to ethane in propane.

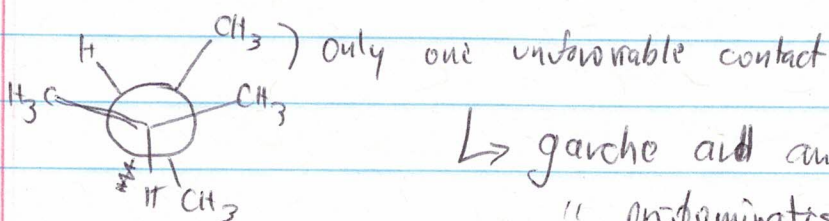
In pentane, additional complexity is introduced by the fact that there are two internal C-C bonds. There is a total of nine doubly staggered conformations, vs. three in butane.

Branched alkenes can be similarly analyzed, but there are some interesting special cases.





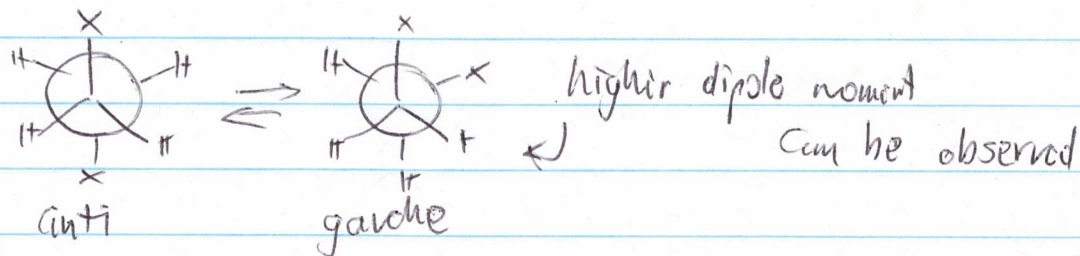
anti



$\rightarrow$  gauche and anti are close in energy, so " predominates for statistical reasons

gauche

What happens if we switch from hydrocarbons to molecules with polar functional groups? Pihaloethanes are a classical case:



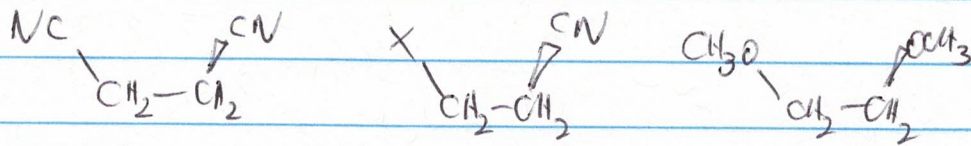
anti is 0.9-1.3 kcal/mol more stable in 1,2-dichloroethane  
" " 1.4-1.8 " " " " " 1,2-dibromoethane

Presumably dipole repulsion is behind the lowered stability of the gauche conformer.

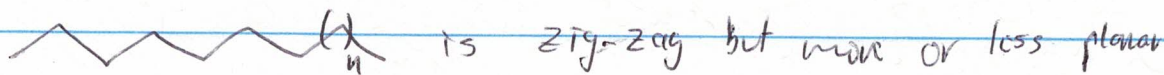
For difluoroethane, gauche is favored! by about 0.6-0.9 kcal/mol. The explanation is quite complex, but it comes from preference of neighbouring fluorines to be @  $90^\circ$  angle. Actual  $\ominus$  in this gauche

Conformation is 71°. Polar solvents favor gauche conformer even more - in pure liquid,  $\Delta E$  is 2.0-2.6 kcal/mol.

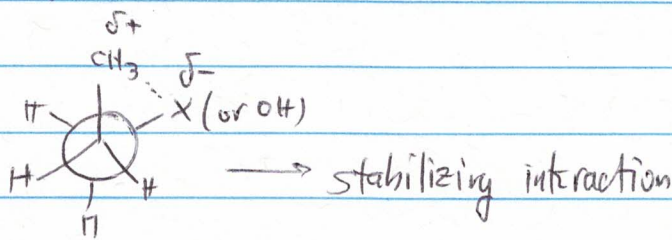
Similar preference is seen in:



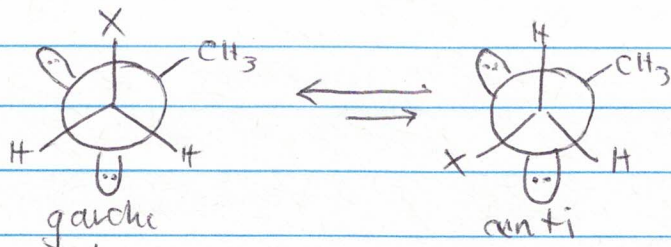
Because of this, while:



What about CH3CH2CH2OH and CH3CH2CH2X? In all of them, gauche is just a little more stable than anti?



Next, let's look at CH3O-CH2-X  $X = \text{halogen, OR, SR}$ . These are important as models for sugars. Gauche conformation is favored across both C-O bonds:

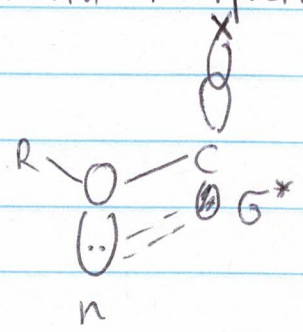


Favored by ~1 kcal/mol even though now crowded

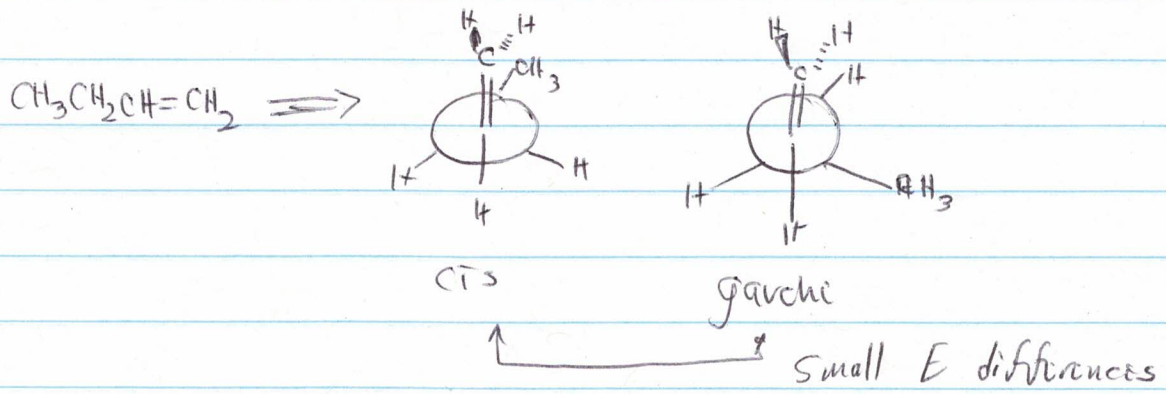
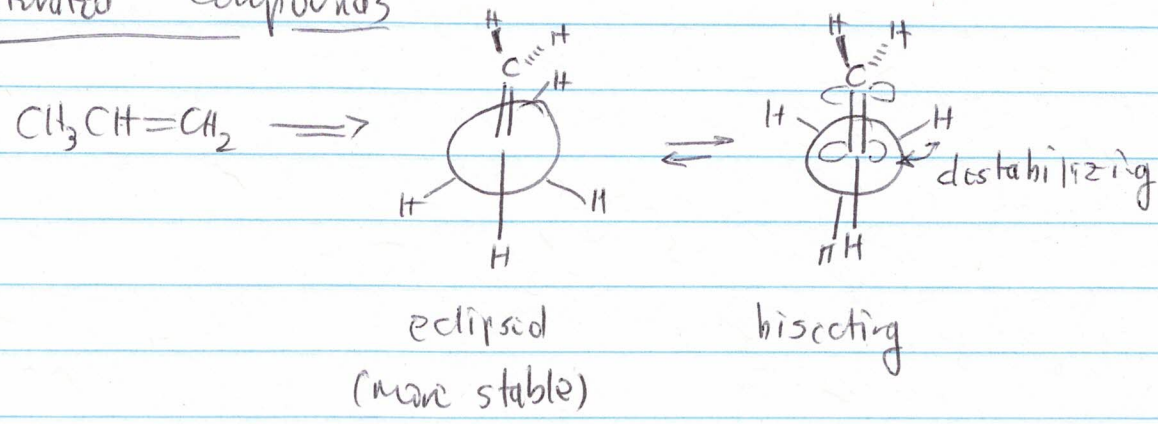
This is an example of anomeric effect: a stereoelectronic effect in which the best donor orients itself anti to the best acceptor.



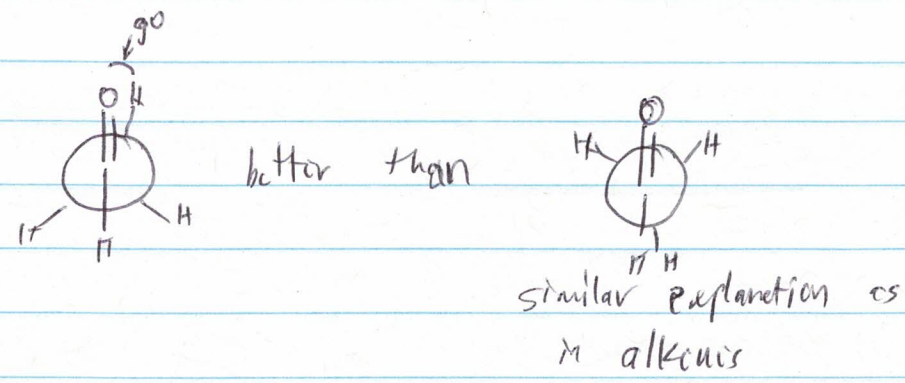
Conversely, eclipsing btw a lone pair and X is quite unstable, Orbital interpretation:



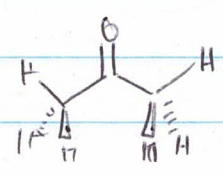
Unsaturated Compounds



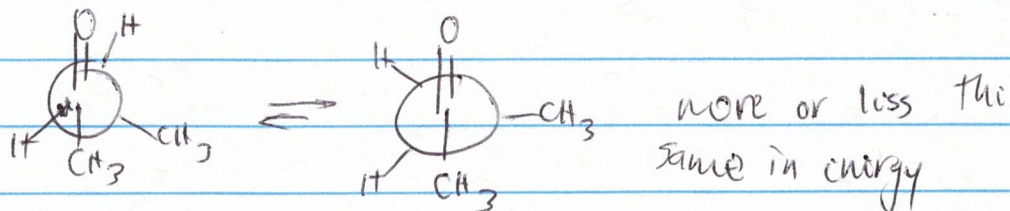
Aldehydes are similar:



Acetone:



Other ketones:



Aldimines prefer cis, all other C=N derivatives gauche orientation.