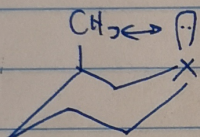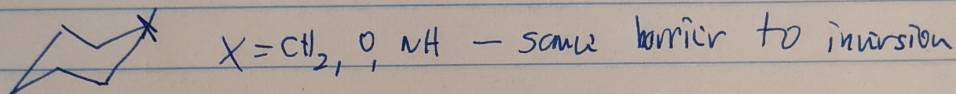Lecture XXII: Conformations of Other Rings   03-25-2020
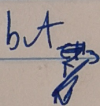
Six membered saturated heterocycles generally all exist in the
form of a chair:
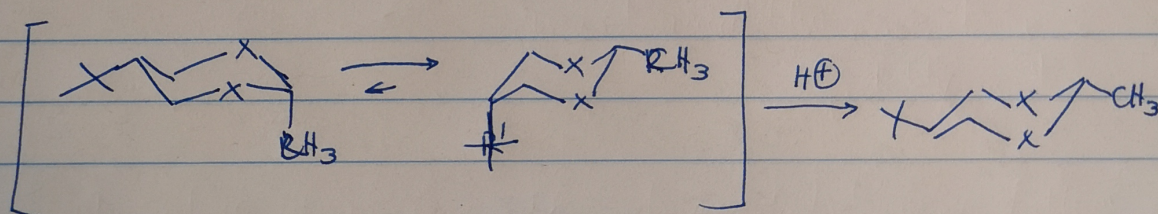

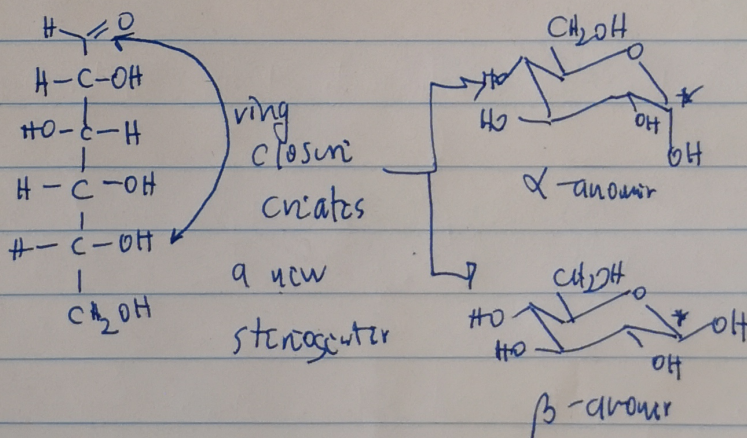$X = CH_2, O, NH$ — same barrier to inversion

$CH_3 \leftrightarrow \ddot{O}$

A less serine repulsion:

$A = 1.43, X = O$ $A = 1.40, X = S$

$A = 2.2$ for $\overset{H}{\underset{\overset{\oplus}{N}-CH_3}{}}$ because of solvation

Diheterosubstituted 1,3-dioxanes and 1,3-dithianes can be equilibrated
with acid:

$\xrightarrow{H^{\oplus}}$

Sugars also exist in pyranose form:

$H-C-OH$
$HO-C-H$
$H-C-OH$
$H-C-OH$
CH_2OH

ring
closure
creates
a new
stereocenter

α-anomer

β-anomer

C1 is called anomeric carbon. The two anomers can be separated.

$\qquad$ xtallize from ethanol $\Rightarrow$ α-anomer $[\alpha]_D^{20}$ +112.2°

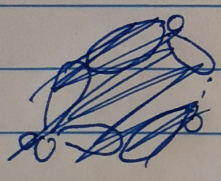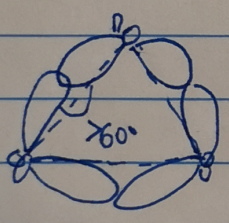$\qquad$ " $\qquad$ " pyridine or syrup $\Rightarrow$ β-anomer $[\alpha]_D^{20}$ +~~52~~ 17.5°

When dissolved in water, their $[\alpha]_D^{20}$ eventually reaches $[\alpha]_D^{20}$ +52.7°.
This is called mutarotation. Equilibrium ratio is 36% α and 64% β
which is unusually shifted toward α: this is called the <u>anomeric</u>
effect:

| favored | higher dipole but lower repulsion between O lone pairs. |

Rings Smaller than Cyclohexane

Cyclopropane has to be planar:
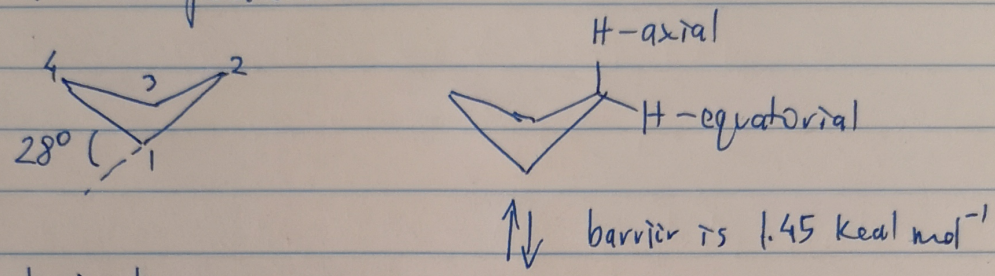
 but the inter-orbital angle is actually higher

 propane
cyclo~~hexane~~ is not as strained as its structure would suggest, but it is fully eclipsed
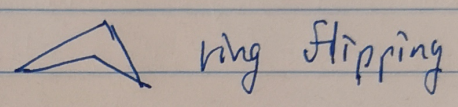
 is even more strained but it is still found in nature!

Cyclobutane is not planar, as to avoid all-eclipsing interactions
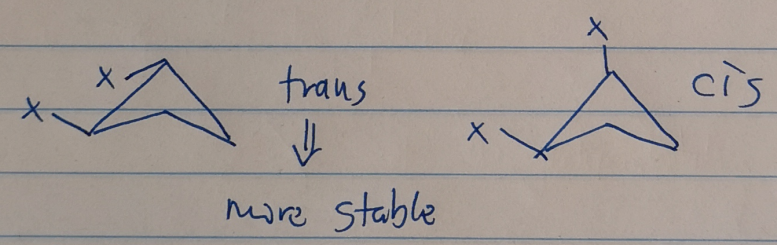
Instead it is puckered:

H-axial

H-equatorial

28° (∠1

↑↓ barrier is 1.45 kcal mol⁻¹

This low barrier becomes even
lower in heterocyclobutanes
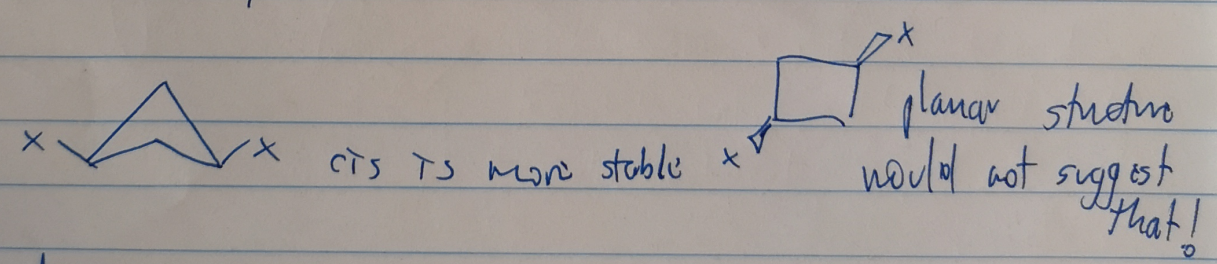
△ ring flipping

$X = S$, 0.75 kcal mol⁻¹
$X = NH$, 1.26 " "
$X = Se$, 1.07 " "
$X = O$, 0.1 " " ⟹ planar

1,2-disubstituted cyclobutanes

X___X trans   X cis
more stable

1,3-disubstituted cyclobutanes:

X___X cis is more stable   planar structure
would not suggest
that!

Cyclopentane

108° ⟹ no angle strain, but a lot of torsional eclipsing
strain if all carbons remain in one plane
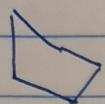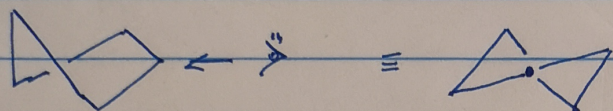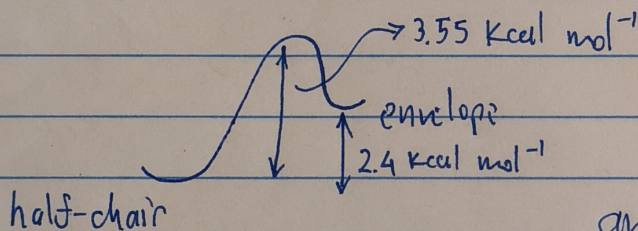
 envelope conformation — four carbons in one plane

half-chair : three carbons in one plane

But the energy landscape is much more shallow then in the case of cyclohexane:
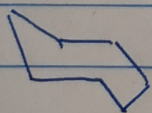

3.55 Kcal mol^{-1}

envelope
2.4 Kcal mol^{-1}

half-chair

the puckered atom goes around the ring very fast pseudorotation — five membered ring is very flexible
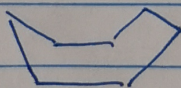
Larger rings than cyclohexane

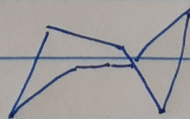These now start having multiple minima : C4 and C5 had very shallow ones, C6 had one deep one.
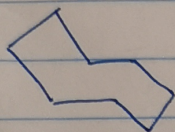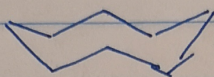
Cycloheptane :

chair   boat   twisted chair
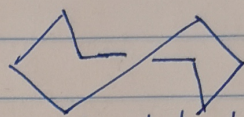
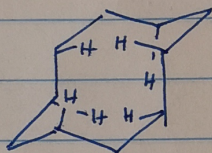these largely parallel their
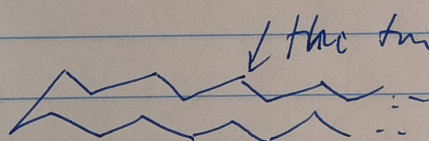
Cyclooctane:

chair   crown   twisted boat chair

Cyclodecane can superimpose onto the diamond lattice:

similar situation repeats itself for C14

very good review of conformations of higher rings has been posted online. Interesting example is $C_{30}H_{60}$:

↙ the two edges come close to
                                    Maximize
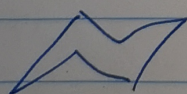   vdW contacts

I-strain

angle
strain is higher in sp^2 than sp^3
if TS is ~~sp²~~ sp^2 - rxn slows down

is higher than cyclohexane

eclipsing strain is higher in sp^3 than sp^2
sp^3 TS are slowing rxns down

                                    transition
is an exception: perfect as sp^3, so sp^3 states again slow
things down