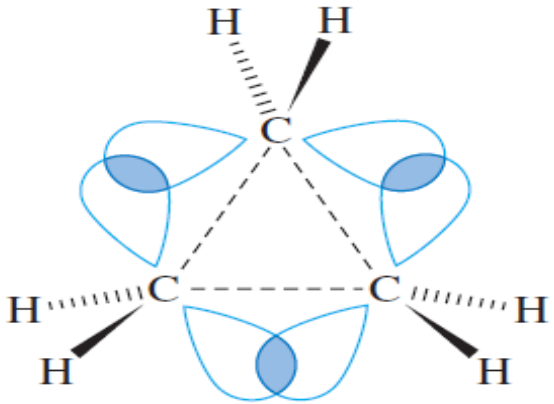
Cycloalkanes

Stability of cycloalkanes



Angle strain (Baeyer strain)

Angle strain + torsional stain = Ring strain

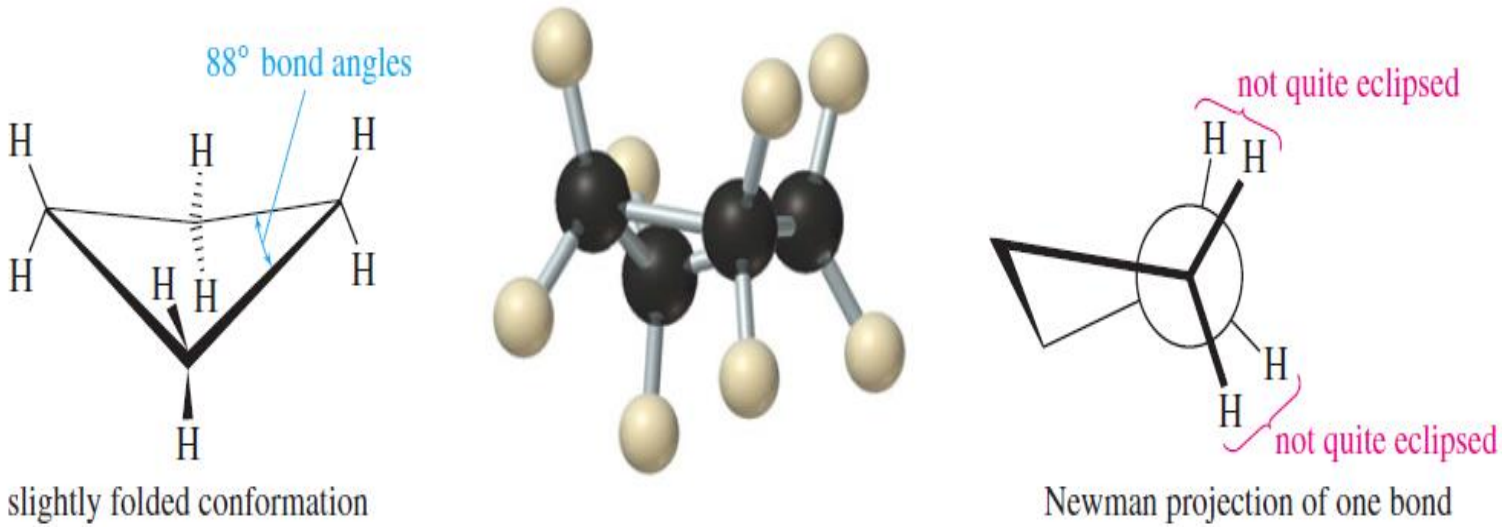


FIGURE 3-17

The conformation of cyclobutane is slightly folded. Folding gives partial relief from the eclipsing of bonds, as shown in the Newman projection. Compare this actual structure with the hypothetical planar structure in Figure 3-14.

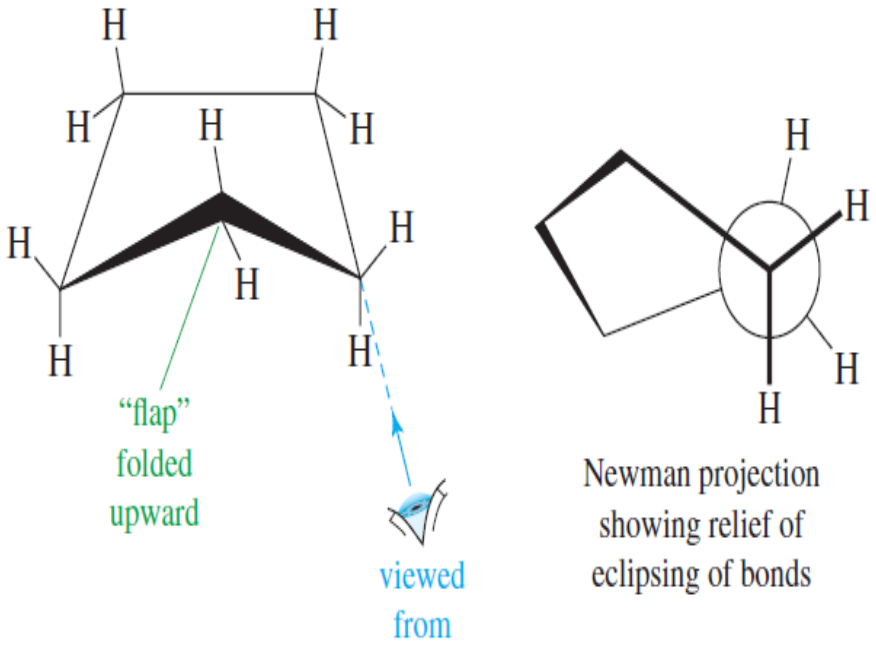
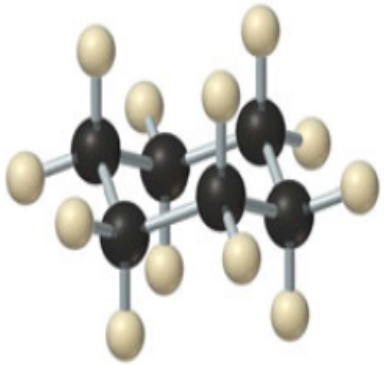
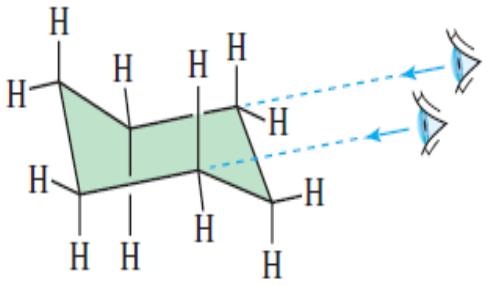


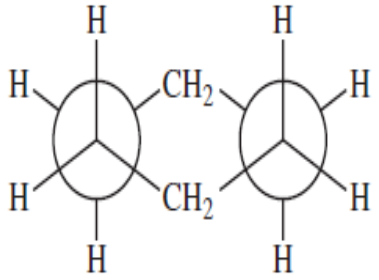
FIGURE 3-18
The conformation of cyclopentane is slightly folded, like the shape of an envelope. This puckered conformation reduces the eclipsing of adjacent CH_2 groups.



chair conformation



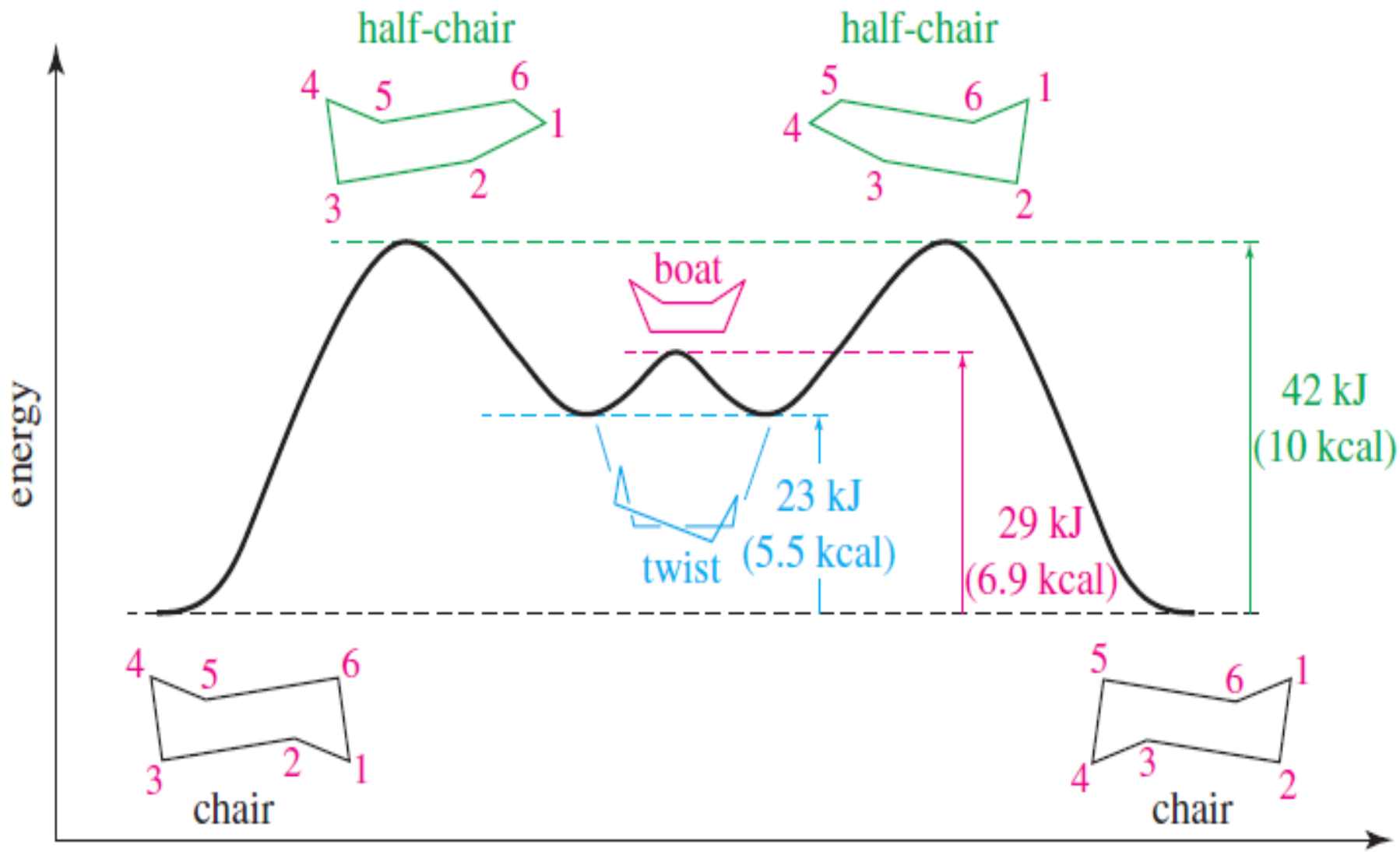
viewed along the "seat" bonds

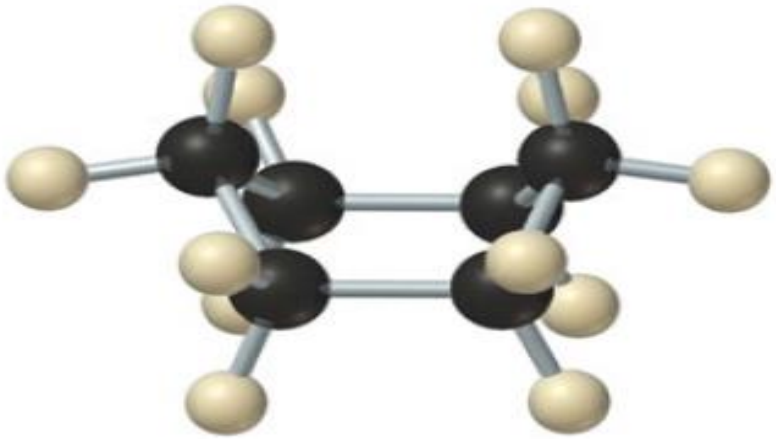


Newman projection

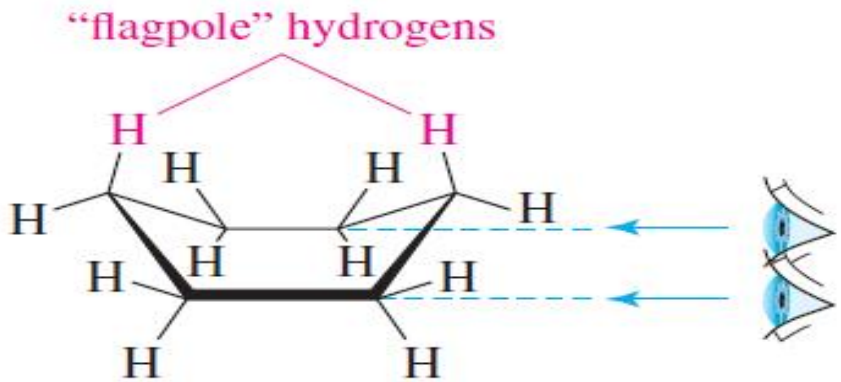
FIGURE 3-19
Viewed from the side, the chair conformation of cyclohexane appears to have one methylene group puckered upward and another puckered downward. Viewed from the Newman projection, the chair has no eclipsing of the carbon–carbon bonds. The bond angles are 109.5°.

Chair conformation; Boat conformation; Twist boat conformation; Half-chair conformation

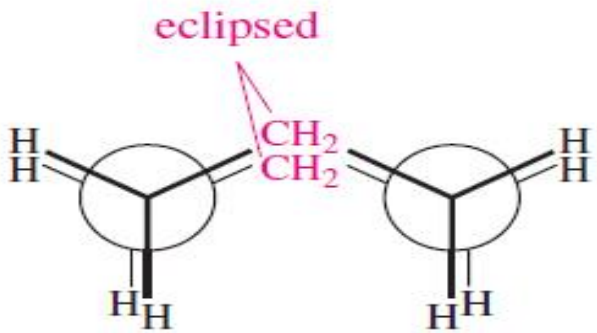

half-chair
half-chair
4
5
6
1
2
3
boat
twist
23 kJ
(5.5 kcal)
29 kJ
(6.9 kcal)
42 kJ
(10 kcal)
energy
chair
chair



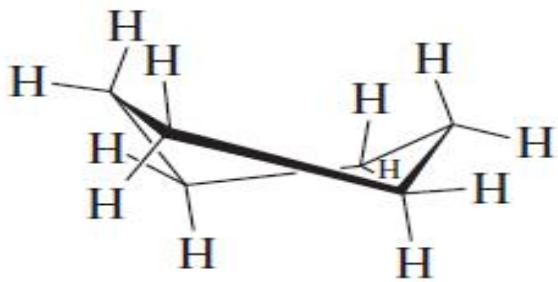
boat conformation



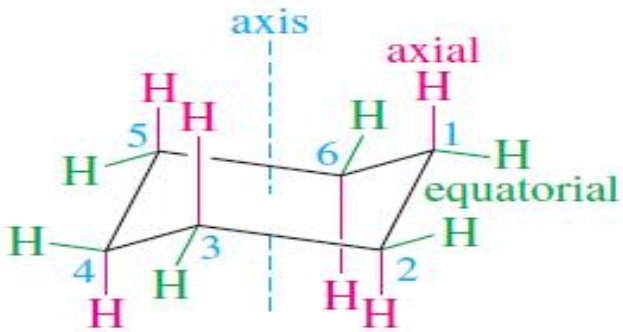
symmetrical boat

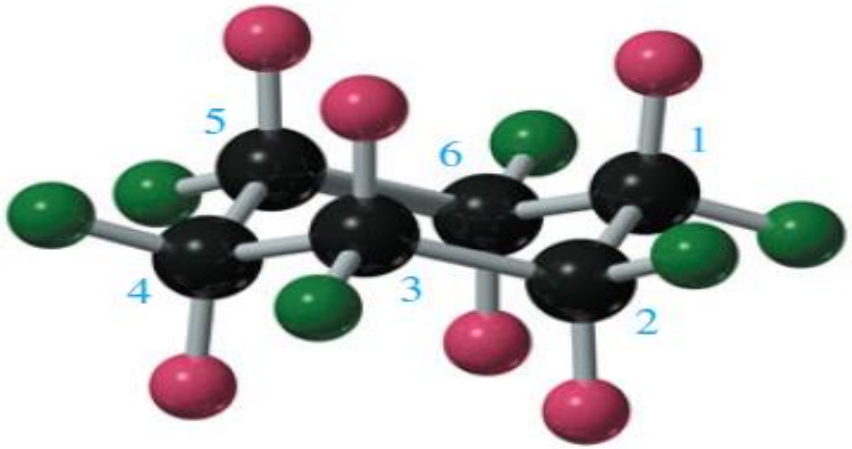


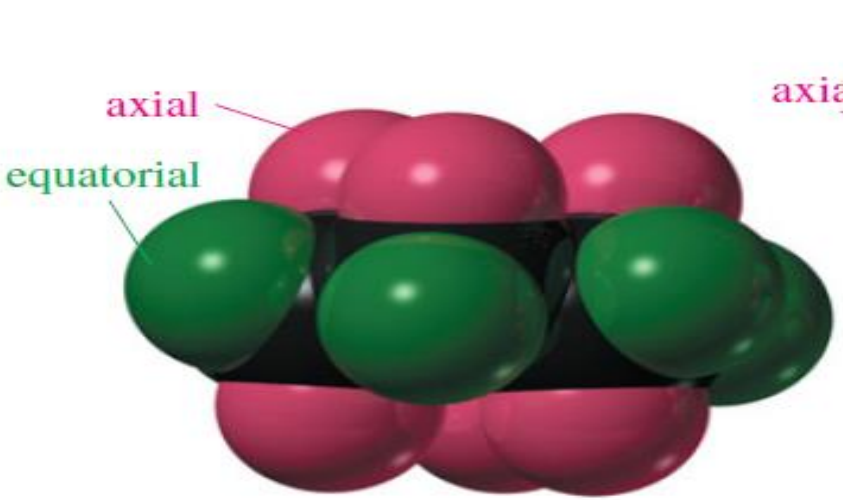
Newman projection



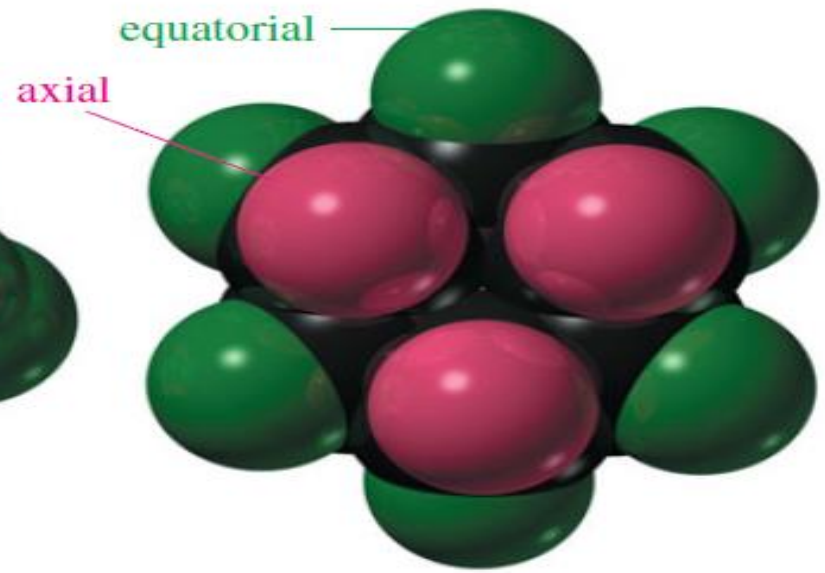
"twist" boat



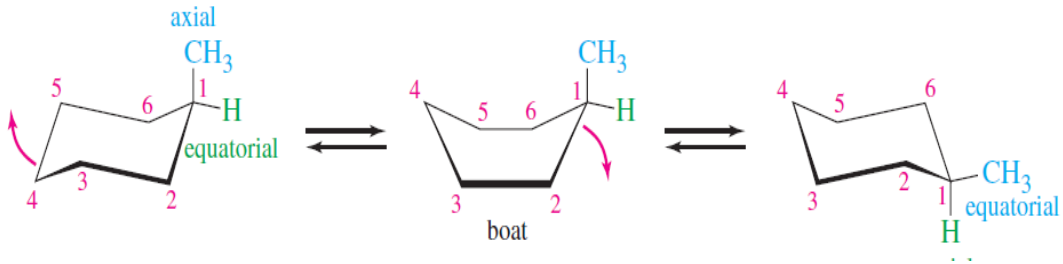


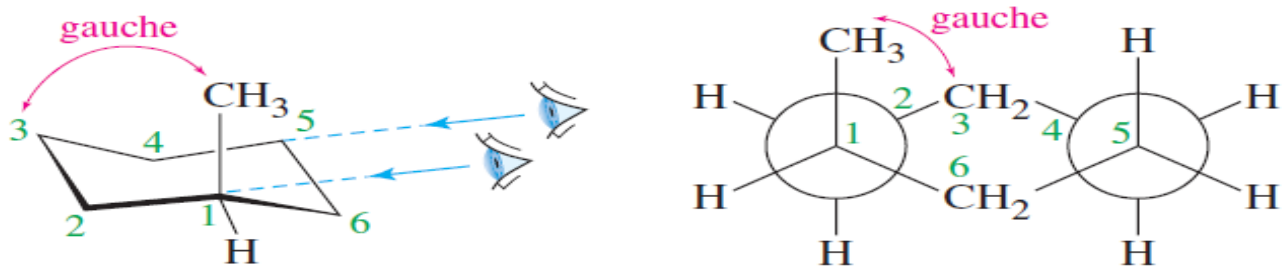


seen from the side



seen from above





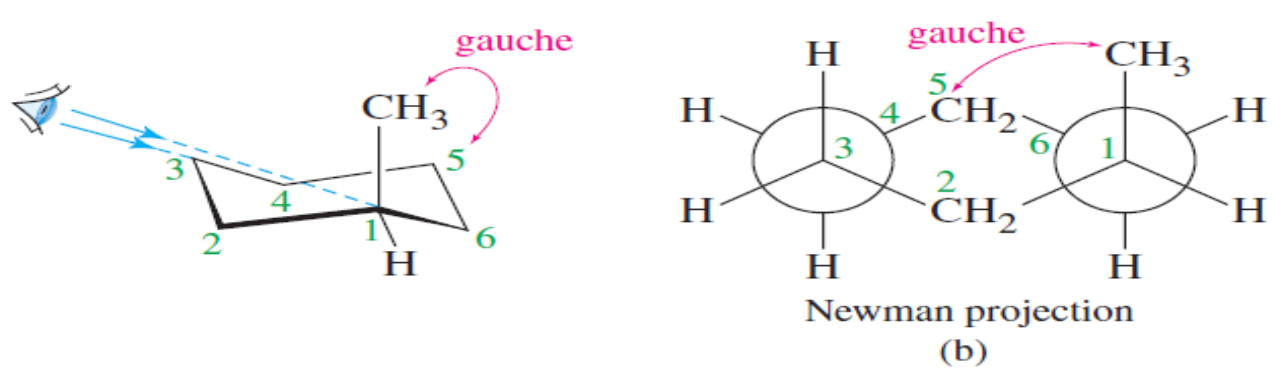
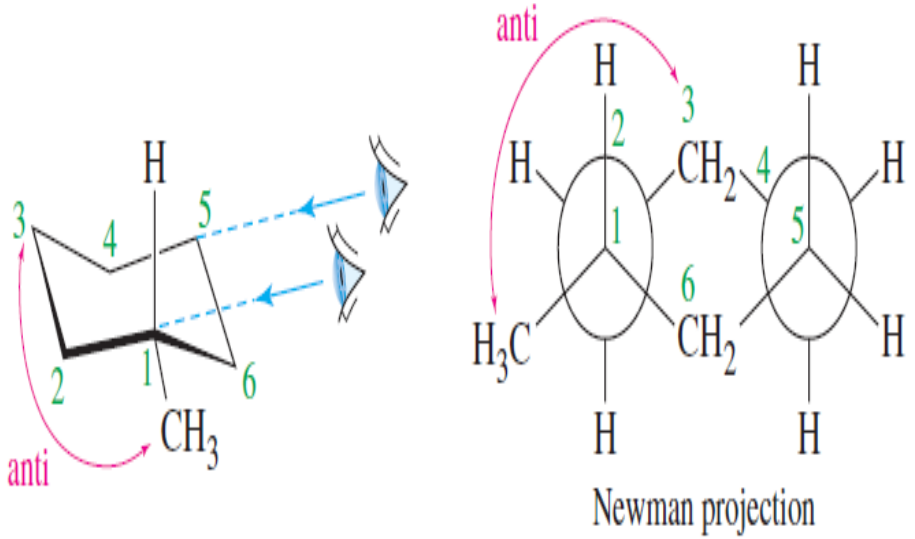


FIGURE 3-24
(a) When the methyl substituent is in an axial position on C1, it is gauche to C3. (b) The axial methyl group on C1 is also gauche to C5 of the ring.

FIGURE 3-25

Looking down the C1—C2 bond of the equatorial conformation. Notice that the methyl group is anti to C3.



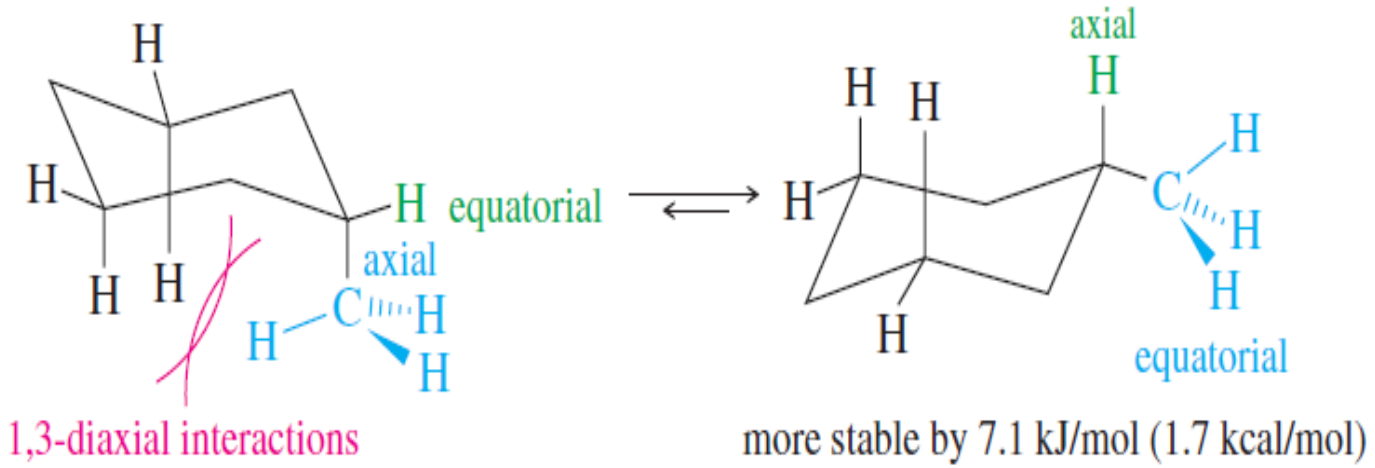
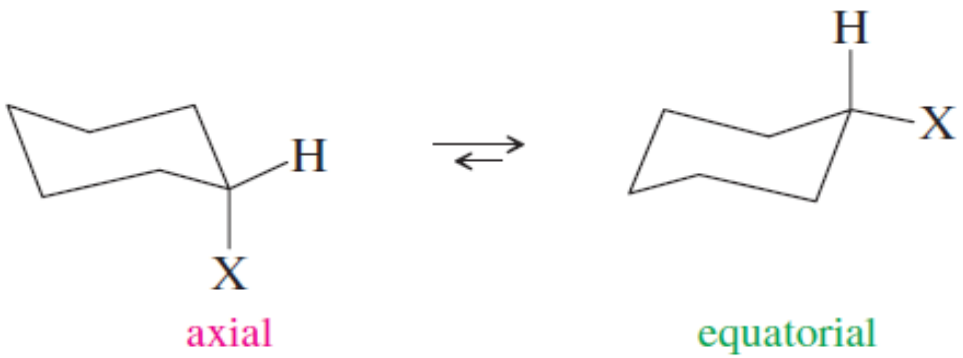
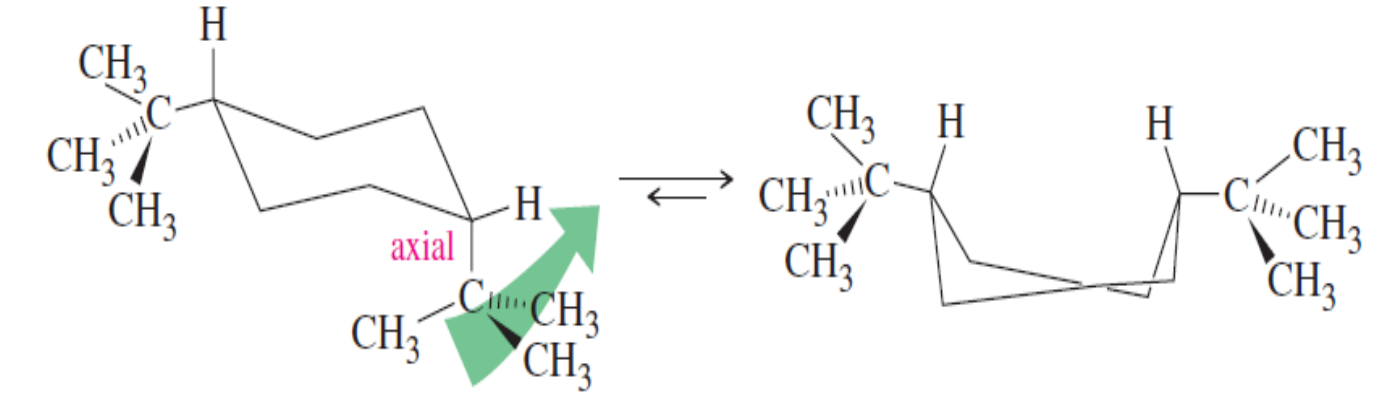


TABLE 3-6 Energy Differences Between the Axial and Equatorial Conformations of Monosubstituted Cyclohexanes

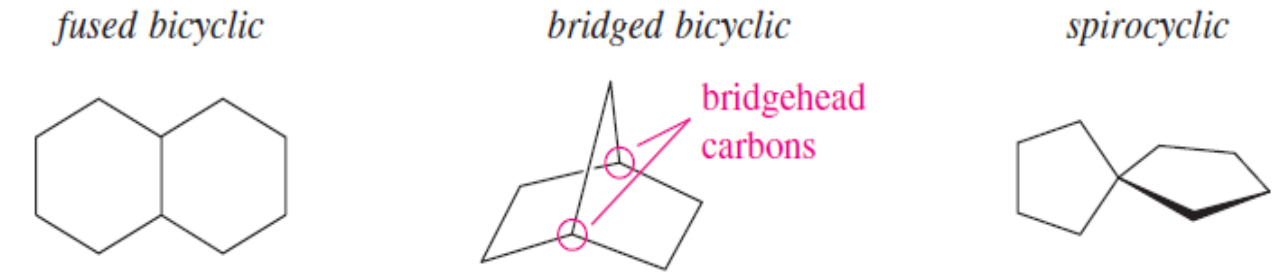


axial ⇌ equatorial

X	ΔG (axial–equatorial) (kJ/mol)	ΔG (axial–equatorial) (kcal/mol)
—F	0.8	0.2
—CN	0.8	0.2
—Cl	2.1	0.5
—Br	2.5	0.6
—OH	4.1	1.0
—COOH	5.9	1.4
—CH_3	7.6	1.8
—CH_2CH_3	7.9	1.9
—$CH(CH_3)_2$	8.8	2.1
—$C(CH_3)_3$	23	5.4



Bicyclic molecules



Fused ring

Bridged ring

Spirocyclic compounds