Only by constructing a model does one at first appreciate fully how cyclohexane can exist in a non-planar, beautifully symmetrical, and apparently entirely strain-free conformation — called the chair conformation — in which all bond angles are perfectly tetrahedral, and all bonds to hydrogen are perfectly staggered:

The hydrogen atoms fall into two groups of six equivalent atoms each: those lying perpendicularly above and below the general overall plane of the carbon ring — termed *axial* hydrogen atoms, and those lying effectively in that plane — termed *equatorial* hydrogen atoms. Each equatorial carbon-hydrogen bond is parallel to the carbon-carbon bonds once removed from it, a fact that is clear from the model and is reproduced in the drawing. The van der Waals radii of each group of three axial hydrogen atoms are just on the verge of overlap; the equatorial hydrogen atoms are substantially more free. Note that the equivalence of the six axial-axial and six equatorial-equatorial hydrogen interactions, seen clearly in a model, is not faithfully delineated in the drawing; in particular, only two of the six close axial-axial hydrogen atom interactions are well represented.

At a cost (that is, with an opposing energy barrier) of only about 11 kcal/mole, equivalent to a rate of approximately $10^5$ per second at room temperature, a
remarkable conformational change takes place, with the molecule flipping to a new chair form. The numbers in the following figure can be used to keep track of exactly which carbon atom transforms to which, as the perspective changes slightly (by 60°):

Those hydrogens that were axial are now equatorial. Those that were equatorial are now axial! Note that the six hydrogen atoms which start out above the plane of the ring remain above the plane, and that the six which start out below the plane of the ring remain below the plane: hydrogens which are "up" remain "up"; those which are
"down" remain "down" — it continues to be true that conformational changes do not entail configurational ones!

As has been said, the axial positions on a cyclohexane ring are potentially hindered, so that a non-hydrogen substituent on cyclohexane is preferred in an equatorial, as opposed to an axial, position; that is, in a conformationally mobile equilibrium the population of molecules having (a greater number of) equatorially substituted conformations will be greater than that of ones having (a greater number of) axially substituted conformations:

Thus, at any given moment, in a sample of methylcyclohexane at room temperature, there are approximately 20 molecules having an equatorial methyl group for each one having an axial methyl group. This fact corresponds to an energy difference (so-called "A-value" for a methyl group) of approximately 1.8 kcal/mole at room
temperature, the axial-methyl conformation lying at the higher energy. It is instructive to compare this situation with the conformational analysis of n-butane carried out previously, in segment 2.03. In the second line of the preceding figure the backbone of n-butane is carved out of the methylcyclohexane conformations of the first line. From the equatorial-methyl form the anti conformation of n-butane is obtained; but, in the axial-methyl form, the gauche conformation of n-butane is found. Furthermore, although only one gauche interaction is emphasized in the figure, it is evident that there are two of these, one on each side of the axial methyl group. Thus, the A-value of 1.8 kcal/mole (2 X 0.9) for a methyl group is in good agreement with the value of 0.9 kcal/mole already given as the cost of having n-butane in the gauche rather than in the anti conformation.

Extending the analysis in a similar vein to \textit{cis}-1,3-dimethylcyclohexane, the final figure shows that the two methyl groups in this case either can be both equatorial or both axial; and its second line makes the comparison with n-pentane, again by excising the appropriate portions of the structures. The diaxial-dimethyl conformation of \textit{cis}-1,3-dimethylcyclohexane is seen to incorporate the highly unfavorable gauche-gauche (syn) conformation which already has been recognized in n-pentane, in segment 2.04. For all practical purposes, \textit{cis}-1,3-dimethylcyclohexane is locked in the diequatorial-dimethyl conformation, which incorporates instead the most favorable pentane conformation (anti-anti).
conformation of cis-1,3-dimethylcyclohexane

COMPARE:

conformation of \textit{n}-pentane

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