Because it is so common among natural and synthetic compounds, and because its conformational features are rather well understood, we shall focus on the six-membered cyclohexane ring in this discussion. In a sample of cyclohexane, the two identical chair conformers are present in equal concentration, and the hydrogens are all equivalent (50% equatorial & 50% axial) due to rapid interconversion of the conformers. When the cyclohexane ring bears a substituent, the two chair conformers are not the same. In one conformer the substituent is axial, in the other it is equatorial. Due to steric hindrance in the axial location, substituent groups prefer to be equatorial and that chair conformer predominates in the equilibrium.

We noted earlier that cycloalkanes having two or more substituents on different ring carbon atoms exist as a pair (sometimes more) of configurational stereoisomers. Now we must examine the way in which favorable ring conformations influence the properties of the configurational isomers. Remember, configurational stereoisomers are stable and do not easily interconvert, whereas, conformational isomers normally interconvert rapidly. In examining possible structures for substituted cyclohexanes, it is useful to follow two principles.

1. Chair conformations are generally more stable than other possibilities.
2. Substituents on chair conformers prefer to occupy equatorial positions due to the increased steric hindrance of axial locations.

The following equations and formulas illustrate how the presence of two or more substituents on a cyclohexane ring perturbs the interconversion of the two chair conformers in ways that can be predicted.

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### Conformational Structures of Disubstituted Cyclohexanes

<table>
<thead>
<tr>
<th>Disubstituted Cyclohexane</th>
<th>Structure 1</th>
<th>Structure 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,1-dimethylcyclohexane</td>
<td><img src="image" alt="1,1-dimethylcyclohexane" /></td>
<td><img src="image" alt="1,1-dimethylcyclohexane" /></td>
</tr>
<tr>
<td>1-t-butyl-1-methylcyclohexane</td>
<td><img src="image" alt="1-t-butyl-1-methylcyclohexane" /></td>
<td><img src="image" alt="1-t-butyl-1-methylcyclohexane" /></td>
</tr>
<tr>
<td>cis-1,2-dimethylcyclohexane</td>
<td><img src="image" alt="cis-1,2-dimethylcyclohexane" /></td>
<td><img src="image" alt="cis-1,2-dimethylcyclohexane" /></td>
</tr>
<tr>
<td>trans-1,2-dimethylcyclohexane</td>
<td><img src="image" alt="trans-1,2-dimethylcyclohexane" /></td>
<td><img src="image" alt="trans-1,2-dimethylcyclohexane" /></td>
</tr>
</tbody>
</table>
In the case of 1,1-disubstituted cyclohexanes, one of the substituents must necessarily be axial and the other equatorial, regardless of which chair conformer is considered. Since the substituents are the same in 1,1-dimethylcyclohexane, the two conformers are identical and present in equal concentration. In 1-t-butyl-1-methylcyclohexane the t-butyl group is much larger than the methyl, and that chair conformer in which the larger group is equatorial will be favored in the equilibrium (> 99%). Consequently, the methyl group in this compound is almost exclusively axial in its orientation.

In the cases of 1,2-, 1,3- and 1,4-disubstituted compounds the analysis is a bit more complex. It is always possible to have both groups equatorial, but whether this requires a cis-relationship or a trans-relationship depends on the relative location of the substituents. As we count around the ring from carbon #1 to #6, the uppermost bond on each carbon changes its orientation from equatorial (or axial) to axial (or equatorial) and back. It is important to remember that the bonds on a given side of a chair ring-conformation always alternate in this fashion. Therefore, it should be clear that for cis-1,2-disubstitution, one of the substituents must be equatorial and the other axial; in the trans-isomer both may be equatorial. Because of the alternating nature of equatorial and axial bonds, the opposite relationship is true for 1,3-disubstitution (cis is all equatorial, trans is equatorial/axial). Finally, 1,4-disubstitution reverts to the 1,2-pattern.

For additional information about six-membered ring conformations [Click Here].

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**Contributors**