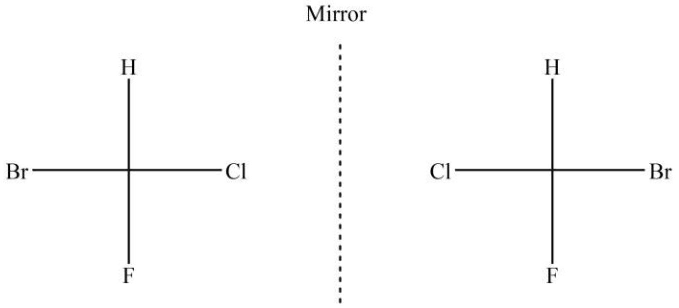
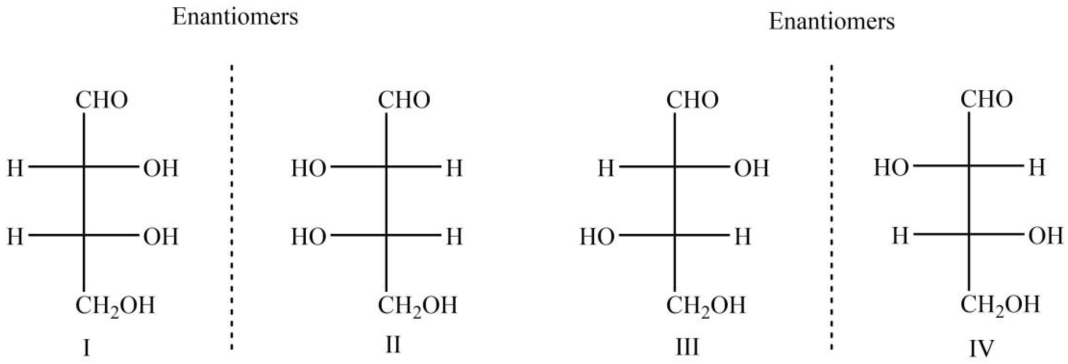
❖ Molecules with More Than One Chiral Centre: Diastereomerism

In most organic molecules, the optical activity or the chirality arises when all the four groups around an *sp*^{3} hybridized carbon become different. Such carbon centers are typically called as chiral centers. Furthermore, it is also a quite well-known fact that the odd number of exchanges at a chiral center produce enantiomers. For instance, consider the case of CHClBrF.



However, if the organic molecule contains more than one chiral center, different possibilities of odd and even exchanges at these stereocenters may generate identical, enantiomers, or diastereomers. Unlike enantiomers, which are non-superimposable mirror images; diastereomers are simply the non-mirror-image stereomers. For instance, consider the case of an organic molecule with two chiral centers unsymmetrical ends.



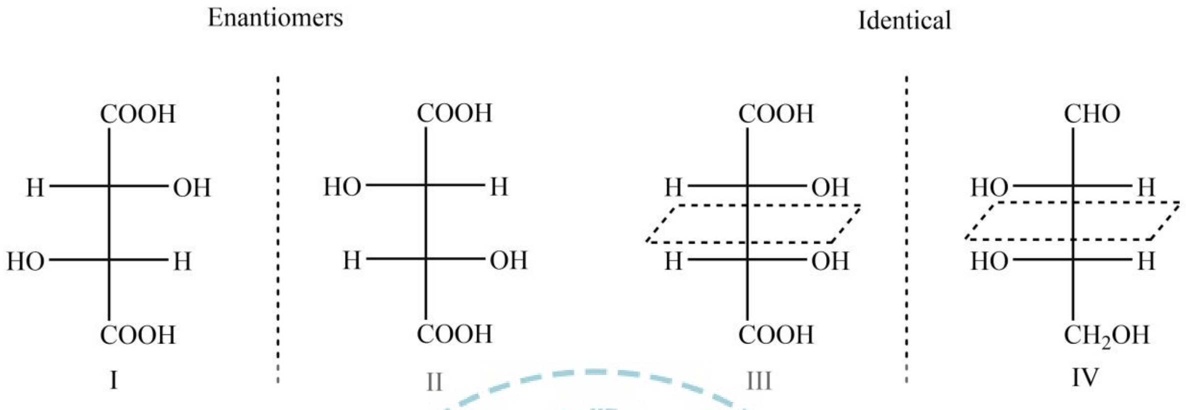
It is obvious that the odd number of exchanges at both chiral centers is creating non-superimposable mirror images (enantiomers); whereas the odd exchange at one chiral center and even exchange at other chiral centers is producing non-mirror-image isomers (diastereomers). It is also worthy to note that the even number of exchanges at both chiral centers will generate identical molecules just like in the case of molecules with a single chiral center. The calculation of the total number of optically active and meso forms for organic molecules with more than *n* chiral centers with unsymmetrical ends can be obtained by the following relations.

$$Number\ of\ optically\ active\ isomers = 2^n$$

$$Number\ of\ meso\ forms = 0$$

$$Total\ number\ of\ isomers = 2^n + 0$$

On the other hand, if we consider the case of an organic molecule with two chiral centers and symmetrical ends, the possibility of a meso compound also arises. The most popular example to prove the concept is tartaric acid.



It is obvious that the odd number of exchanges at both chiral centers in L-tartaric acid is creating a non-superimposable mirror image (R-tartaric); whereas the odd exchange at one chiral center and even exchange at other chiral center is producing non-mirror-image isomers (diastereomers). However, structures III and IV are identical although they are produced by odd-odd exchanges at both chiral centers. The obviously because of the presence of the symmetry plane perpendicular to the carbon-carbon bond. Such compounds are called as meso form. It is also worthy to note that the even number of exchanges at both chiral centers will generate identical molecules just like in the case of molecules with a single chiral center.

The calculation of the total number of optically active and meso forms for organic molecules with more than n chiral centers with symmetrical ends can be obtained by using the following relations.

i) When the number of chiral centers is even:

$$Number\ of\ optically\ active\ isomers = 2^{(n-1)}$$

$$Number\ of\ meso\ forms = 2^{\left(\frac{n}{2}-1\right)}$$

$$Total\ number\ of\ isomers = 2^{(n-1)} + 2^{\left(\frac{n}{2}-1\right)}$$

ii) When the number of chiral centers is odd:

$$Number\ of\ optically\ active\ isomers = 2^{(n-1)} - 2^{\left(\frac{n}{2}-\frac{1}{2}\right)}$$

$$Number\ of\ meso\ forms = 2^{\left(\frac{n}{2}-\frac{1}{2}\right)}$$

$$Total\ number\ of\ isomers = 2^{(n-1)}$$

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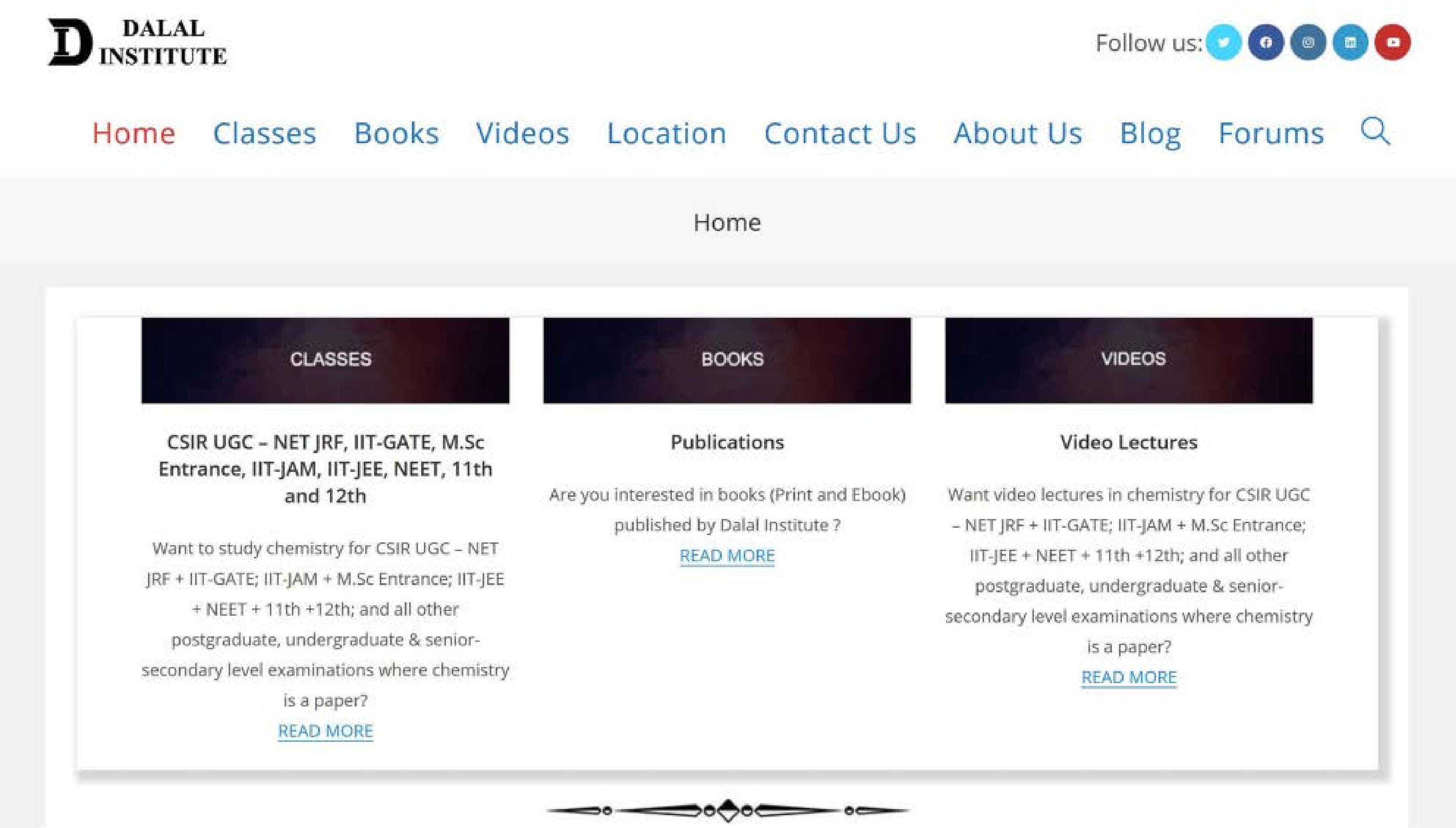

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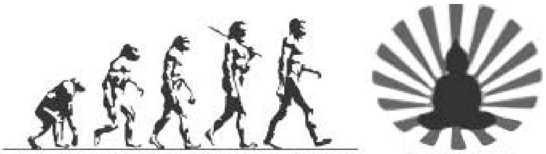

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