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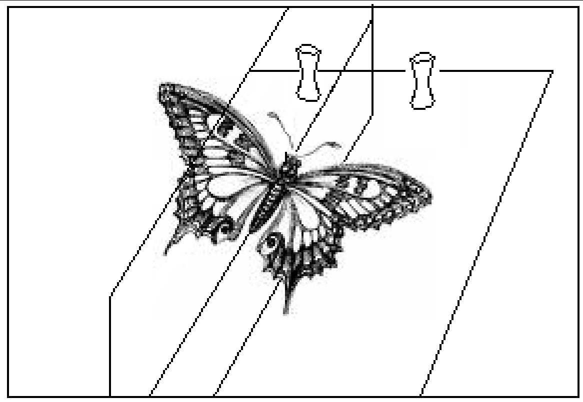
Genes and nature’s mirror

Being left or right handed goes deeper than appearances, says S.Ananthanarayanan.

We say things are symmetric when they look the same whichever way we look at them. But there can be many ways of looking at a thing differently. We could turn it around. We could see it through a mirror (which is interchanging left and right) or we could turn it upside down. Every time the thing looks the same, we say it has a certain type of symmetry. Nature is full of symmetry and also full of kinds of opposite of symmetry, or ***asymmetry***.

For instance, a butterfly often has a symmetrical pattern on its wings. If we imagined a mirror going straight through the length of its body, each side is like the reflection of the other side in the mirror. The butterfly has lateral symmetry. But still, it has its head and eyes at one end and along its length the butterfly is not longitudinally symmetrical.



The human body also has symmetry – we do look like ourselves when we are seen through a mirror. Yet, the symmetry is partial. If we were seen through a mirror to do some things, like writing, the right handed would appear left handed in the mirror, and vice versa.

And even this partial symmetry is ‘skin deep’. Behind out skin, our heart lies largely to our left, the liver and appendix are to our right, the hemispheres of the brain are different – we are quite ***asymmetric***, really.

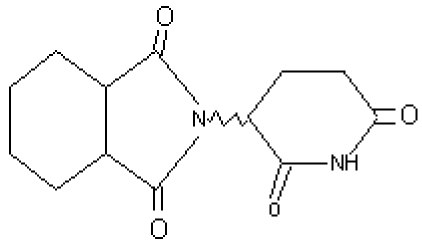
Symmetry in chemicals

Chemical reactions take place by exchange, addition or removal of atoms of elements in combination with other atoms, in such a way that the products have less energy than the initial reagents plus any external energy that is supplied. Something like a ball would roll down a hill, if it could, rather than stay perched on the summit.

In such reactions, normally, it makes little difference if an atom were attached to one side of a group of other atoms, rather than the other side, even when the two sides not look alike. For example, if more than one kind of atom were attached, say to a carbon atom, then a third atom getting attached would have a choice of which way to join the group, on the side of the first atom of on the side of the second?. Either way, the product would be chemically the same molecule, except that the two forms would be mirror images. And unless the mirror molecules have further symmetries, they can generally not be superimposed on each other, like left and right hands are the same, till one tries to wear a left hand glove on a right hand, or vice versa.

This asymmetry manifests itself in some further chemical reactions – where a right handed molecule will react only with a similar right handed reagent, when the reagent has two forms, and so on. As the asymmetry of the human body extends right down to the chemicals and enzymes that regulate its working, many drugs of medicines can be ineffective or positively harmful if they have two mirror image forms and the wrong form is administered.

Drug synthesis

 thalidomide	The drug, Thalidomide, a sedative that was prescribed to pregnant women in the 1950s, led to serious birth defects in the children born. Here, one mirror image of thalidomide was harmless but not the other, and both forms got produced during manufacture. The challenge since then has been to separately test the structural varieties of the same drug and then to ensure that only the useful and harmless form is actually packaged.

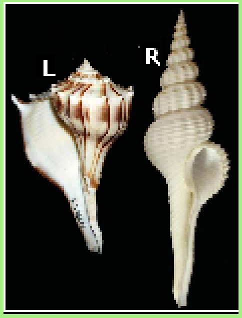
A more every day example is a chemical called carvone, which comes in one mirror form in caraway, or cummin seeds (jeera). But the other, chemically equivalent form, which is found in mint (pudina) affects the olfactory (smell) system quite differently

Creating a chosen form of a chemical in the laboratory is easier said than done. There are ‘correctly oriented’ catalysts which promote binding of atoms to specific sides of chemical groups, to result in one or other form of the product. But this can get difficult when the molecules being produced have several components and very creative methods have been devised – a kind of Rubik’s cube problem of chemical synthesis.

Biological development

A great mystery has been – how did things get this way in the animal kingdom? What makes the body develop with the heart to one side and the liver in the other? One group of simple animals show ***radial*** symmetry, which means they are the same from all directions and only have a top and bottom. Examples are sea anemones, jelly fish or sea stars – generally animals that do not move about. The other group consists of the ones with bilateral symmetry, or mirror image symmetry. This form is good for motion in one direction, promotes the development of a central nervous system and favours ‘***cephalisation***’, or the ‘formation of a head’ (!).

The development of this group of animals goes back to before the Cambrian period, 550 million years ago. In this group, during development of the embryo, there is the formation of a dent which later deepens, for either the anus or the mouth, thus defining an axis around which there could be more or less bilateral symmetry. As for the appearance of asymmetry, or location of organs on one or the other side, this is found to arise from a molecule called '***nodal***', which signals the embryo to develop organs on one or other side. Deficiency in nodal is found to produce 'randomisation of left-right asymmetry of visceral organs'.



The journal, ***Nature***, carries a report of Christina Grand and Nipam Patel, who have worked on two kinds of snails that show distinct left or right handedness – in the way their shells spiral. The species were selected because in this case the whole genetic sequence has been worked out and working on the genetic bases for the separation of the RH or LH form was feasible. The work concludes that the genetic basis for 'handedness' is an ancestral feature which has arisen along with the development of bilaterally symmetric animals.