

SYMMETRY IN BIOLOGY

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Symmetry is a mathematical concept and has an aesthetic appeal. It is basically a regular pattern, which is repeated. The simplest form we are familiar with is Bilateral symmetry of the human body where the left half is similar to the right half (although internally some organs are displaced to one side).

Symmetries can be found from the subcellular world (centrioles and microtubules within cells) to the spiral form of galaxies in the universe. Before looking at symmetries in the biological world let us look at the basic forms of symmetries frequently encountered.

The most common and important types of symmetry are: *Reflections*, *Rotations* and *Translations*. In Reflections, the left half is similar to the right half e.g. bilateral symmetry of the human body.



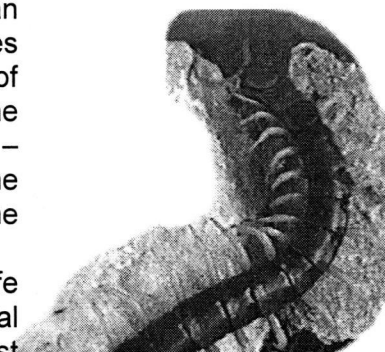
In Rotations the same units are repeated in circles e.g. The petals of a flower. Translations are symmetries in which units are repeated along on axis e.g. centipedes, fern leaves, honey combs.

Symmetry also has a precise mathematical characterisation. Reflections, rotations and translations are mathematical concepts. Each of these symmetry types is a *transformation*. In other words it is a rule for moving something around. Thus an object is considered symmetrical if following a transformation it is left invariant (i.e. unchanged in appearance).

Symmetry in the Animal Kingdom

Life begins amongst animals as a spherical cell (fertilized egg) which undergoes repeated divisions to form an embryo. In the case of the frog embryo the egg undergoes numerous divisions to become a spherical blastula of thousands of small cells. The rotational symmetry of the blastula is lost as the process called gastrulation begins – the blastula turns part of itself inwards. Thus gradually the initial rotational symmetry is broken ending up with the bilateral symmetry of the adult.

Arthropods are regarded as the most successful form of life that has evolved on earth. There are very few ecological niches uncolonised by them. They are also the most symmetrical organisms one could encounter. Whereas most insects show bilateral symmetry, segmented creatures such as centipedes and millipedes have translational symmetry.



Another symmetric feature is handedness or chirality. This however is not equally distributed in the animal kingdom. We eat and write with our right hands, most sportsmen (and women) are right-handed (cricket, tennis, golf etc.), mothers (and fathers also) cradle babies on the left hand. Shells of snails are exclusively right handed when viewed from the top (except in

very few species). Thus somewhere during development from a perfectly symmetrical egg a left or right bias was introduced which is reflected in the adult organism.

Symmetry in the Plant Kingdom

The three forms of symmetry mentioned at the beginning can be observed in the plant kingdom also. Translational symmetry is seen in ferns or coconut leaflets where the same leaf form is repeated at equal intervals and in the same orientation along the leaf axis.

Radial or rotational symmetry is the repetition of similar elements around an axis. This is obvious amongst flowers and fruits. Although bilateral symmetry is common in the animal kingdom, numerous examples are also present in plant leaves and zygomorphic flowers (e.g. orchids) show bilateral symmetry, about the midrib.

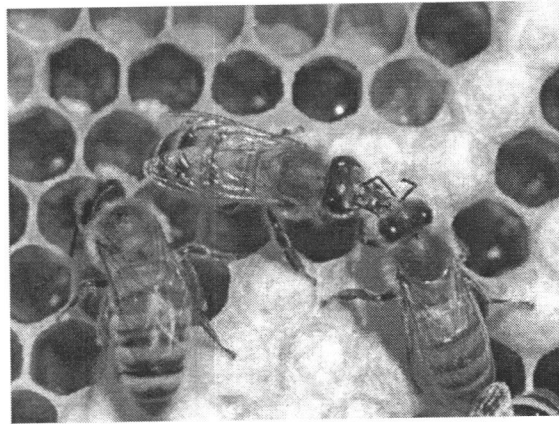


A special form of symmetry observed in biology is complementary symmetry (or anti-symmetry). Two dissimilar but interlocking structure elements fit together to enable a particular function. Anti-symmetrical molecular structures are common in recognition and multiplication process: enzymes/substrate, receptors/ ligands, antibodies/antigens. The complementary bases of the polynucleotide chain of the DNA double helix and codon/anticodon in the DNA translation processes are also anti-symmetrical.

The limited symmetry displayed in biological patterns is due to the fact that each additional element is newly formed. This is never repeated exactly because the control of such processes is between the balance of activators in the cells besides genetic and environmental interactions. Only such bipolar control systems are capable of contributing to adaptation and evolution of organisms. Exact regularity without any variations would not allow natural selection to act and thus prevent manifestation of any form of life.

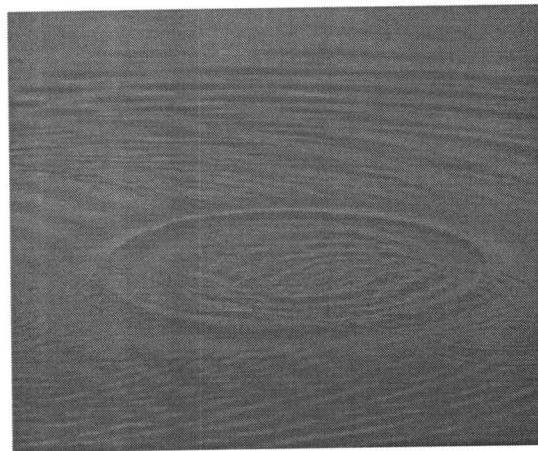
Where do symmetries of natural patterns come from?

To understand this one has to look into breaking of symmetry. Perfect symmetry is repetitive and predictable such as a blank wall or a still pond. An ideal mathematical plane has a lot of symmetry since every part of it is identical to every other part. One may rotate it through any angle, reflect it along any line or translate the plane through any distance in any direction: it will look exactly the same. However, if a pebble is tossed into a still pond ripples are formed which keep moving outwards from the pond of impact. The symmetry of the still pond is broken by creating a pattern of circular ripples. The pond now has lost some of its symmetry, but not all, which has created a pattern. It now has rotational symmetry. In the case of the pond the symmetry breaking had a cause: the pebble. Thus natural patterns may be regarded as the result of loss of some symmetry.



Women use a black spot asymmetrically placed on their cheek as part of their make-up arsenal. Whoever thought their purpose was to break the symmetry of their face? However, breaking of symmetry would not always lead to aesthetic appeal: imagine men with an asymmetric moustache or beard!

This is a brief introduction to the world of symmetry (and breaking of symmetry) which all of us take for granted due to its uniformity and monotonous repetition. The following references gives the lay reader more exciting fare on symmetry.



References:

1. R.V.Jean and D.Barabé. eds. *Symmetry in Plants*. Singapore: *World Scientific* (1998).
2. I. Stewart. *Nature's Numbers*. London: *Weidenfield and Nicholson*. 73-91 (1995).
3. I. Stewart and M. Golubitsky. *Fearful Symmetry*. Harmondsworth: *Penguin*. 176-180 (1992).

* *This article first appeared in Pragñā, Vol. XIII, No. 2 & 3, 2000.*