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Right-Left Symmetry of Flowers

by

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Some of the major developments in physics, chemistry and biology are results of investigations connected with problems of right-left symmetry. The discovery of non-conservation of parity[1,2] in beta deacy led to the development of the weak interaction theory. The pioneering work of Pasteur on rotation of the plane of polarized light by optically active substances opened up the field of biological stereochemistry. The right and left asymmetries present in human beings and animals have given important clues to problems in genetics.[3] In this paper we discuss a right-left symmetry property in the plant kingdom which might have important implications on fundamental problems of biology.

The flowers of some plants define a right or left handness from the sense in which the petals are twisted (in flowers with imbricated petals this twisting is seen in the opened flower as well as in the bud, in some actinomorphic flowers the twisting is apparent only in the flower bud). Certain species and even entire families of plants have only one type of flowers with either, anticlockwise (right-handed or dextral) or clockwise (left-handed or sinistral) twisted petals. Apocynaceae is an example of a family where the flowers seem to be entirely right-handed. Almost all species of Apocynaceae found in Sri Lanka have dextral flowers. After examination of more than 10^6 flowers of Plumeria rubra (Apocynaceae) from 875 trees growing in different localities, we did not find a single flower that is left-handed. Most probably the flower corresponding to the mirror image of the familiar one (Fig. 1) does not exist. The geographical location of the plant, the time of the year in which the flowers are produced or other environmental factors does not seem to change the handness of the flowers of Plumeria rubra. Similarly the flowers of Turnera ulmifolia are dextral. An examination of a sample of Turnera flowers (more than 10^6) collected from a large number of plants growing in varying geographical

1. Lee, T. D. and Yang, C. N., 1956. 'Nonconservation of Parity in Weak Interactions', Phys. Rev. 104, p. 254.
2. Sakurai, J. J. 1964, 'Parity' Invariance Principles and Elementary Particles. pp. 32P81 Princeton University Press, 1964.

locations and different soils did not reveal the existence of a single sinistra flower. The flowers of Osbeckia octanda (Melastomaceae) are entirely left-handed. The convolulaceae family has species bearing flowers of either type. Numerous other examples can be given of plants that bear flowers of only one-handness.

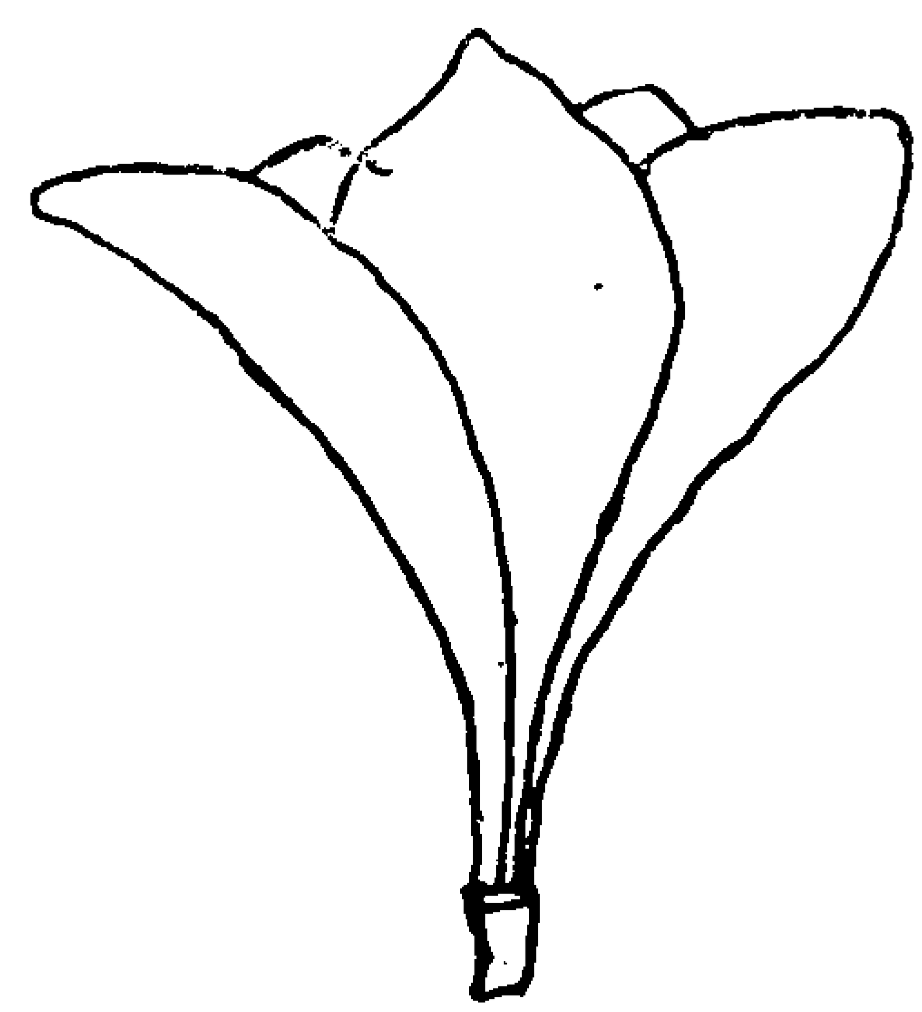
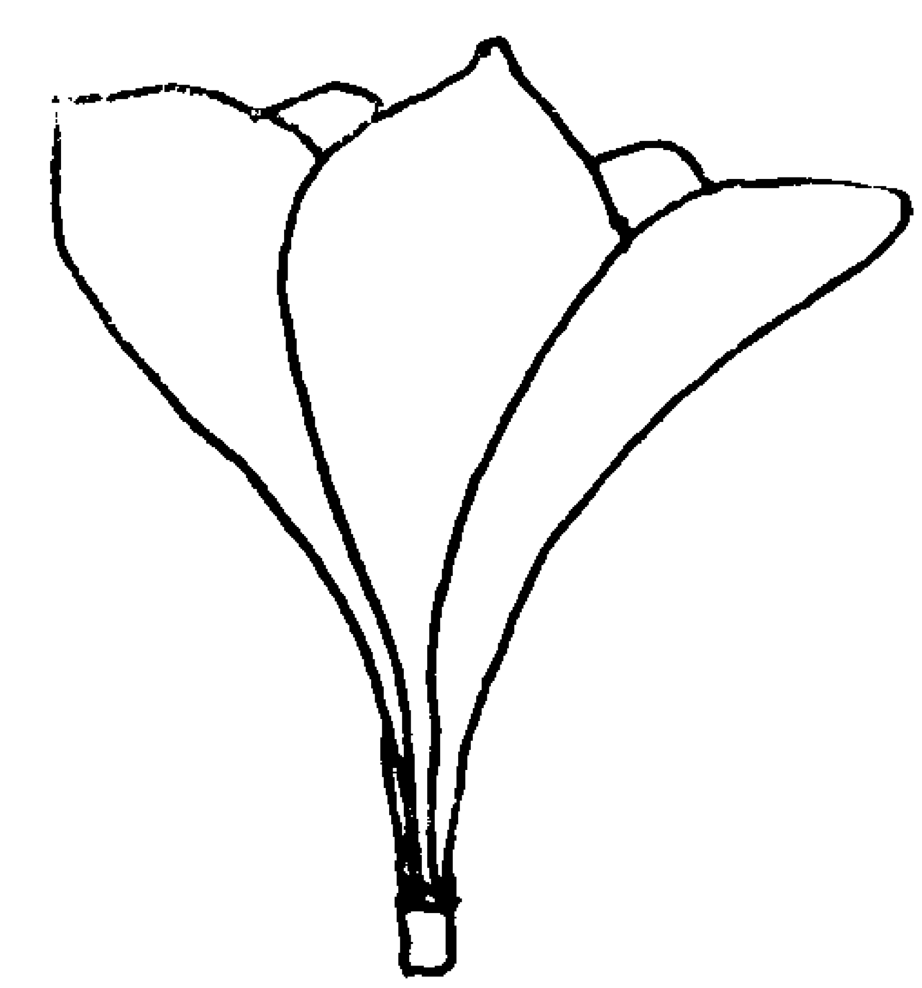


Fig. 1. Mirror image of the Plumeria Flower



Plumeria Flower (Right-handed)

There are also plants which bear both right-handed and left-handed flowers in the same bloom (Fig. 2). We have examined the daily bloom of Hibiscus rosa-sinensis, Urena lobata and Abutilon muticum belonging to the malvaceae family for a period of several months. In all these cases the average of the daily percentage of right-handed (left-handed) flowers taken over several months is very close to 50% indicating that these plants have a tendency to preserve the right-left symmetry of their flowers. However, the amazing thing is that the percentage of right-handed flowers taken over durations between 5–30 days shows statistically significant variations from the 50% mean. These variations are complex and even in plants of the same kind the pattern of variations differ from plant to plant . The variations of the percentage of right-handed flowers in the malvaceae family seems to be periodic. Oscillations with periods 4–5 and 20-26 days are identifiable in both Hibiscus rosa-sinensis and Urena lobata. Our preliminary data analysis indicates that the phase of oscillation differs from plant to plant. If the phase differs from plant to plant, the oscillations cannot be a rhythm entrained by a geographical periodicity. A great deal of further investigations are necessary to ascertain the exact nature of these time-variations.

The presence of flowers of only one-handness in given species of plants or the occurrence of both right-handed and left-handed flowers in the same plant with unequal probabilities is a violation of right-left symmetry or parity.

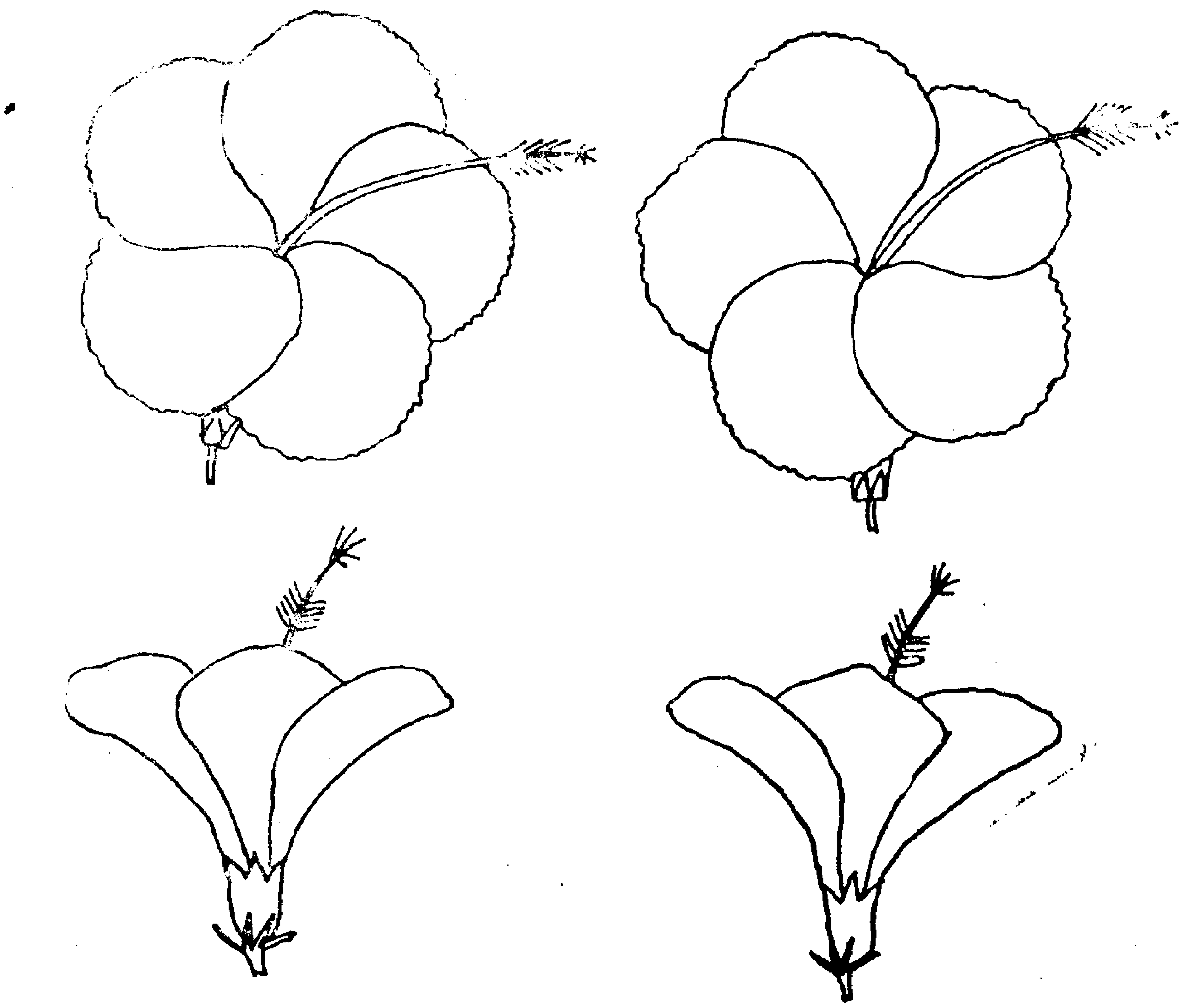


Fig. 2—Right-handed shoe flower Left-handed shoe flower

Strong and electromagnetic interactions conserve parity. The life processes depend on chemical forces which are electromagnetic. Hence any right-left symmetry violations in a living organism must be either, parity violations introduced from right-left asymmetries in the environment or genetic inheritance of a right-left asymmetry.

All familiar examples of right-left symmetry violations present in living organisms are of the latter type[3–4]. The presence of only L or D isomers of certain organic compounds in the living matter could be regarded as genetic, because it can attribute to the monophyletic origin of life.[5] Other macroscopic right-left asymmetries present in living organisms are inherited characters developed at later stages of evolution. The heart of most human beings lies more towards the left hand side of the body. Sea shells with a left-handed twist are rare. Above asymmetries can be explained as characters acquired by inheritance. One feature common to such asymmetries is that the inversion

3. Caspar, E., 'Cytoplasmic Inheritance', Advances in Genetics, 2, pp. 1-66.
4. Weyl, H. Symmetry, Princeton University Press, 1952.
5. Lederberg, J. 1965, 'Signs of Life: Criterion-System of Exobiology', Nature 207, p 9.

(mirror image) also happen to exist with a lesser probability. Human beings with heart in the right-hand side are also found with a probability one in five thousand[r]. The left-handed sea shells of given species are also rarely seen. However, as discussed earlier the flowers of some plants seem to maintain only one-handness without exceptions. According to our investigations the probability of finding a left-handed flower in Plumeria rubra or Turnera ulimifolia is less than 1 in 10^6. Perhaps in these species the inverted flower is nonexistent. Also we have found that the flowers of the above two plants found in different localities and solis have same handness without exceptions. The same is true of large number of other plants which bears only one type of flowers. Turnera ulimifolia plants grown for several months under an artificial light source (kept on for every alternate 12 hours) which provided a symmetrical illumination developed right-handed flowers. Magnetic fields several orders of magnitude higher than the earth's magnetic field did not influence the handness of the flowers of Turnera and Urena. Magnetic fields were used because they can distinguish right from left . Again mechanical twists and circularly polarized light had no effect on the handness of the flowers of above plants.

A fundamental principle to remember in understanding the breaking of right-left symmetry isthat 'only assymmetry can beget assymmetry'. Thus only right-left distinguishable perturbations can introduce a right-left disparity in a symmetric system. The factors in the environment that could introduce right-left distinguishable perturbations over a large region of space are quite few. As mentioned earlier circularly polarized light can distinguish right from left. The Faraday effect[6] from earth's magnetic field can produce circularly polarized light. However, our experiments on exposure of Urena plants to circularly polarized light rule out this possibility. Another factor present in the environment capable of distinguishing right-left difference is the Coriolis force due to the rotation of the earth. If the Coriolis force is responsible for determination of the handness of flowers, then the sense of twisting of the petals of flowers of a given species of plants in the Northern hemisphere must be opposite to that in the Southern hemisphere. As such effects are not seen the Coriolis force cannot be the determining factor (Photographs of the flowers of Plumeria rubra growing in South America indicate that they also have the same handness as those of Plumeria rubra in the Northern hemisphere). Further investigations are necessary to understand the mechanism that determine the unique handness of the flowers in some species of plants. It is possible that the asymmetry is chemical or cellular. A chemical asymmetry can arise from the presence of only one type of optical isomers of certain

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6. Jakson, W. D., Classical Electrodynamics, John Wiley, New York, 1967.

carbonic compounds in the plant tissue. A cellular assymmetry can be genetical. The circular DNA present in plastids[7] can have right or left topological confirmations and the presence of only one confirmation of circular DNA could determine a unique helicity.

In the case of plants that produce both right-handed and left-handed flowers the situation seems to be different. The presence of both types of flowers in the same plant indicates that in this case there is no mechanism that strictly controls the handness of the flowers. The time variations of the probability of occurrence of right-handed and left-handed flowers that we have observed in the plants of the malvaceae family suggests an oscillatory interaction between two internal factors tending to produce a balance between right and left-handed flowers. Perhaps there are two types of cells, one type producing dextral flowers and the other type producing sinistral flowers A competitive interaction between the two types could produce oscillations.

The presence of two types of cells differing only by a right-left attribute could have important implications on fundamental problems of cell proliferation, differentiation, migration and assembly. Recent investigations[8] indicate that the two daughter cells produced cell division are sometimes non-identical; they are mirror images migrating in mirror symmetric paths. Perhaps the existence of non-identical mirror image cells is basic to the process of differentiation. It is possible that identical cells can never be initiated to differentiate, the presence of two species of cells differing at least by a right-left attribute is a necessary requirement for the initiation of cellular differentiation.

ACKNOWLEDGEMENTS

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7. Sager, R. 1972, 'Cytoplasmic DNA's' Cytoplasmic Genes in Organelles, pp. 13P41 Academic Press.
8. Guenther, A. B., 1978, Scientific American, p. 69.