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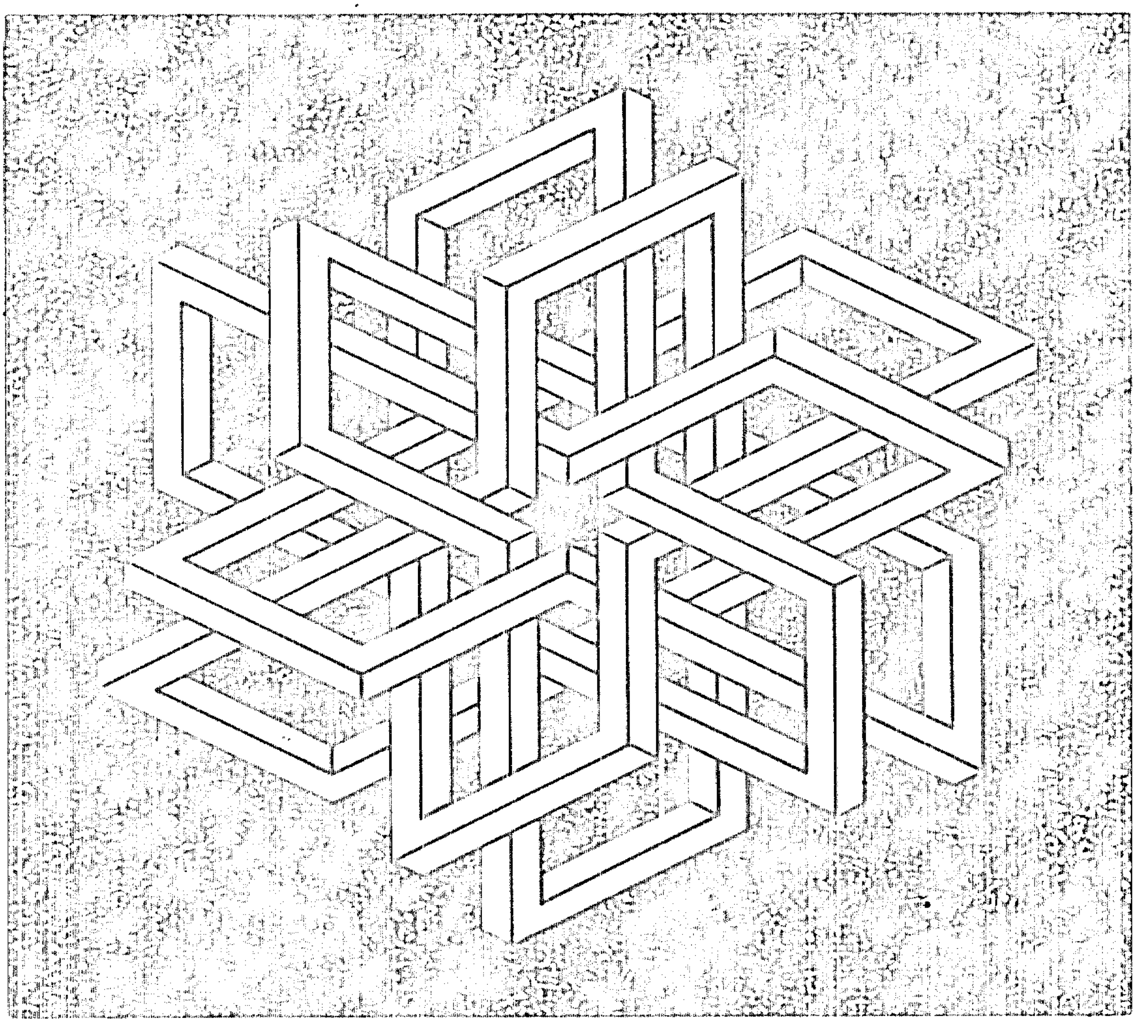

PATTERNS IN PLANTS, AND MORPHOGENETICAL PARALLELISM

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The *systemic and holistic viewpoint* I introduced in the study of primordial patterns in plant drove me to stress the fact of the presence, in other areas of nature, of symmetric patterns similar to those found on plants. Showing parallelism between structures with various substrata, structural correspondances and similarities, is what general comparative morphology is about. It proceeds from a synthetic and analogical approach, and it attributes more importance to resemblances than to differences. The phenomenon of morphogenetical parallelism allows us to extend the methods used for studying the symmetry of plant patterns to other fields, such as the study of microorganisms and viruses. On the other hand the methods of other fields such as crystallography, can be applied to phyllotaxis precisely because of structural parallelism. The principles of physics that pertain to crystallization are the same regardless whether nature deals with protein molecules in viral capsids, with atoms in a crystal lattice, or with primordia in a phyllotactic pattern. The physical environment must be structurally the same in every case. In physics Maxwell has shown that the action of a magnet on steel and the passage of a light beam through the air, two phenomena which seem to be worlds apart, have in fact a lot in common. Meyen (1973) used the word nomothetics to describe this orientation of research in which one looks for general principles, common structures and universality among various sets of organisms or objects. It is possible to bring understanding by showing the parallelism and convergences between structures and functions in one field, and those in other areas. The *phylogenetic viewpoint* I stressed in phyllotaxis drove me to look in the plant kingdom for ancestors of the phyllotactic patterns. Looking at the nice application of morphogenetical parallelism that relates crystal growth to phyllotactic pattern generation, leads us to move beyond the beginning of plant evolution with ancestral land plants and algae. Darwinism and neo-Darwinism generally consider that biological patterns are the outcome of genetic activities. But there are no genes in minerals. In any attempt to deal with major issues of phyllotaxis, the critique of genocentrism generally addressed at neo-Darwinism is of particular significance. Using the tenets of autoevolutionism (Lima de Faria, 1988) which appears as a key for understanding phyllotactic patterns, a step further can apparently be made regarding their origins. One of these tenets is that we simply have to go back to the evolutions of minerals and chemicals to integrate biological evolution into its natural context. In autoevolutionism, morphogenetical parallelism is called homology, isofunctionalism, and isomorphism. The latter term is the one used in systems research. According to Meyen (1973), "from the point of view of the spatial position of elements, the flower having juxtaposed sepals and petals will be closer to carbohydrate molecules with the same arrangement of hydrogen atoms, than to other flowers bearing alternating sepals and petals". This point of view has important consequences on the search for insights into the problem of phyllotaxis. Trying to explain the same structure observable in many areas by referring to one context only, botanical or not, seems to be impossible. But "for the overwhelming majority of biologists, the comparison of flowers with molecules, and shells of foramininifers with Roman pottery, seems either senseless or improper (or both). The overcoming of this psychological barrier, and the spreading of the application of system laws to structural investigations, will be a revolution in biology comparable to the introduction into biology of statistical thought" (Meyen, 1973, p.248). The phenomenon of morphogenetical parallelism is certainly an important key in the arsenal to extend the frontiers of our knowledge on phyllotaxis. The aim of comparative morphology is the discovery of homologies in the organic world, and more often only in a specific part of it. We are interested here in isomorphisms with phyllotactic patterns, and these do not stop at the artificial frontier between inanimate and animate worlds. Beyond genes there are fundamental mechanisms, such as branching processes, and gnomonic growth, which reveal deeper isofunctionalisms with phyllotactic pattern generation. The paper will give many examples of structural parallelism, and examples will be given where the methods in one field can be used to strudy structures in other fields. In particular predictions will be made regarding the symmetry of amino-acid residues in polypeptide chains as a result of the application of phyllotactic methods. The reader is reported to some of the author's publications for an access to the literature.

References

Jean, R. V. (1981) An L-System Approach to Nonnegative Matrices for the Spectral Analysis of Discrete Growth Functions of Populations, *The Mathematical Biosciences*, *55*, 155-168.

Jean, R. V. (1982) The Hierarchical Control of Phyllotaxis, *Annals of Botany* (London), *49*, 747-760.

Jean, R. V. (1983) Allometric Relations in Plant Growth, *Journal of Mathematical Biology*, *18*, 189-200.

Jean, R. V. (1984) *Mathematical Approach to Pattern and Form in Plant Growth*, Wiley-Interscience, New York (published in Chinese by Chinese Acad. Periodicals Pub. House, Beijing, 1990).

Jean, R. V. (1985) A Geometric Representation of α-Polypeptide Chains Revisited, *Journal of Theoretical Biology*, *112*, 819-825.

Jean, R. V. (1986): A Basic Theorem on and a Fundamental Approach to Pattern Formation on Plants, *The Mathematical Biosciences*, *79*, 127-154.

Jean, R. V. (1987) A Mathematical Model and a Method for the Practical Assessment of the Phyllotactic Patterns, *Journal of Theoretical Biology*, *129*, 69-90.

Jean, R. V. (1988): Number-Theoretic Properties of Two-Dimensional Lattices, *Journal of Number Theory*, *29*, 206-223.

Jean, R. V. (1988): Phyllotactic Pattern Generation: a Conceptual Model, *Annals of Botany* (London), *61*, 293-303.

Jean, R. V. (1989): Phyllotaxis: a Reappraisal, *Canadian Journal of Botany*, *67*, 3103-3107.

Jean, R. V. (1990) A Synergic Approach to Plant Pattern Generation, *Mathematical Biosciences*, *98*, 13-47.

Jean, R. V. (1991) Hierarchy and Autoevolutionism in a General System Approach to Plant Pattern Morphogenesis, *International Journal of General Systems*, *18*, 201-212.

Jean, R. V. (1992) Nomothetical Modelling of spiral symmetry in Biology, *Symmetry*, *1*(1), 81-91, and In *Fivefold Symmetry*, I. Hargittai (ed.), World Scientific Pub., Singapore, pp. .

Jean, R. V. (1992) On the Origins of Spiral Symmetry in Botany, In *Spiral Symmetry*, I. Hargittai and C. A. Pickover (eds), World Scientific Pub., Singapore, pp. .

Jean, R. V. (1992) *Phyllotaxis: A Systemic Study of Plant Morphogenesis*, Cambridge University Press, Cambridge, U. K..

Lima de Faria, A. (1988) *Evolution without Selection*, Elsevier, New York.

Meyen, S. V. (1973) Plant Morphology in its Nomothetical Aspects, *Botanical Review*, *39*(3), 205-260.