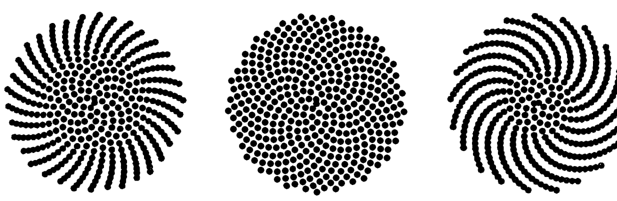

1 2 3

"Depiction of the critical role of the divergence angle in packing efficiency; the three patterns differ only by a slight value of the divergence angle d. In (**1**) it is equal to 137.3°, in (**2**) to 137.507764 . . . ° (the Fibonacci angle corresponding to the noble number τ^{-2}), and in (**3**) to 137.6°. Notice that in the case of the Fibonacci angle a parastichy pair is visible (not just one family of spirals), and the points are evenly distributed in the disk. In the other two cases, η . . . falls to zero while moving outward, although the area per point is still the same." [Reproduced in *Phyllotaxis* from P. Prusinkiewicz and A. Lindenmayer, *The Algorithmic Beauty of Plants* (Springer-Verlag, 1990)]

the first adequate space on the shoot apex by a new primordium; on contact pressures developed by adjacent primordia; and on mechanical stresses in the developing shoot apex that lead to the formation of new primordia. Jean notes that similar kinds of packing constraints arise in a wide range of contexts outside the purely botanical (for example, snake skins, pangolin scales, jellyfish tentacles, virus coats, α-polypeptide chains), including some that are non-biological (for example, flux lines in superconductors, cloud fields in hurricanes). Presumably, the geometry that arises in each of these cases results from maximizing the efficiency of packing of "soft" objects on a spiral lattice, and not from some infinitely precise internal protractor; that is, the golden angle is generated by efficient packing, not vice versa. While Jean recognizes this underlying isomorphism in a few instances, in others he ignores it and incorrectly criticizes various chemical or physical morphogenetic hypotheses; more careful and critical analyses of these ideas are given by Schwabe in *Positional Control in Plant Development* (P. W. Barlow and D. J. Carr, Eds.; Cambridge University Press, 1984) and Steeves and Sussex in *Patterns in Plant Development* (Cambridge University Press, 1989).

Jean's concluding discussion of why plants display geometrically regular patterns of phyllotaxis is, unfortunately, not very compelling. He raises no adaptive explanation for phyllotactic patterns other than the minimization of self-shading, ignores potential relationships of the latter to primordial packing, and fails to cite relevant papers on the adaptive value of specific leaf arrangements, such as orthotropy versus plagiotropy, distichy versus polystichy, and isophylly versus anisophylly. Worse, the author espouses Lima-de-Faria's bizarre concept of autoevolution, arguing that phyllotaxis is nonadaptive and reflects a pattern of self-assembly based on prebiotic evolution of chemical and physical matter, "the tip of an iceberg resulting from the Big Bang" (!). In seeking explanations for phyllotaxis based solely on patterns of growth while denigrating the role of Darwinian fitness, Jean comes nearly full circle, recapitulating the natural philosophy of D'Arcy Thompson that led many biologists to abandon phyllotaxis as a subject of study. The golden phyllotactic spiral remains one of the most striking phenomena in biology but, as Dobzhansky noted, nothing in biology makes sense except in the light of evolution.

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Metal Ions at Work

Principles of Bioinorganic Chemistry. STEPHEN J. LIPPARD and JEREMY M. BERG. University Science Books, Sausalito, CA, 1994. xx, 411 pp., illus. $40; paper, $30.

Although most of the molecules in living things contain only a few common elements (C, H, N, O, P, S, Cl, Br), a wide range of "inorganic" elements are also required in small amounts for normal growth in one or more species (among them Na, K, Mg, Ca, V, Mn, Cr, Fe, Co, Ni, Cu, Zn, Mo, W, and Se). Many of these elements are found in the active sites of metalloproteins, where they take part in processes that are difficult to achieve with the common elements, such as, electron transfer, O_2 binding and utilization, N_2 reduction, water oxidation, and H_2 binding and oxidation. Another interesting issue is the uptake and storage of essential metal ions, which is best understood in the case of iron, where the proteins involved in its transport and storage have been studied in detail, including the way their expression is regulated.

In addition, a number of nonessential elements are also important in biology. Some bacteria have developed an interesting detoxification mechanism to protect themselves against organomercury compounds. Mercury binding to a protein-DNA complex initiates transcription, which in turn leads to the production of proteins that hydrolyze the mercury-carbon bond and reduce the resulting Hg^{2+} ion to metallic mercury, which evaporates from the cell. Among drug applications, platinum is the key element in a widely used antitumor drug, which can bind irreversibly to DNA and so interfere with replication and tumor cell division. In medical diagnostics, gadolinium reagents can improve contrast in magnetic resonance images and the technetium-99*m* isotope is used in trace quantities for imaging body organs via its gamma-ray emission. The chemical form in which the isotope is supplied determines where it goes and therefore what is imaged (blood, bone, or brain).

Bioinorganic chemistry is therefore a very broad field because it involves the study of the role of all these and other inorganic elements in biology. It includes both the biochemistry of these elements and the study of synthetic model compounds designed to answer structural or mechanistic questions about the natural system. Although biochemists had for decades been studying systems we would now call bioinorganic, bioinorganic chemistry first emerged as a recognized discipline in the late 1960s and early '70s, when a number of inorganic chemists and biochemists became interested in such problems as oxygen uptake, CO_2 hydration, electron-transfer, nitrogen fixation, and coenzyme–B-12–dependent reactions, all of which are carried out by metalloproteins. Today a typical meeting on bioinorganic chemistry is likely to have as many biochemists and biophysical chemist participants as inorganic chemists, and the presentations usually cover a breathtaking array of problems.

A bioinorganic chemistry course, often part of the senior undergraduate and graduate student curriculum, poses difficult problems for the college teacher because basic ideas from coordination chemistry, biophysical chemistry, and biochemistry are all needed to understand most topics, and there are a very large number of topics from which to choose. This means that the instructor must be very selective. A severe problem has been the lack of suitable textbooks, and only in the last few years have the first useful ones been published. Lippard and Berg, well-known figures in the field, have now written what is probably the best textbook to date. In it, they present the field in a way that emphasizes important organizing principles. The first four chapters serve to introduce the essence of coordination chemistry, biochemistry, and biophysical chemistry. This is followed by a discussion of uptake of metal ions by cells, the typical cofactor structures in which metals are found, and the effect on proteins and nucleic acids of metal binding. Electron transfer is given close attention, together with mechanistic ideas on how metal ions catalyze chemical transformations in metalloproteins. Platinum antitumor drugs, technetium radiopharmaceuticals, and magnetic resonance imaging agents are also discussed.

In an important chapter, the authors point out that inorganic cofactors having very similar or even identical chemical structures can take part in widely differing chemical processes, depending on the particular protein environment. This implies that the protein environment is able to tune the chemistry of the cofactor. Especially useful is the extensive citation of recent primary literature and the presence of numerous study problems for students. The limitations of the book are the ones posed by the nature of the field itself: a wide variety of areas and concepts must be covered without making the book too long to be useful for students.

The book will also find a place on the bookshelves of both biochemists and inorganic chemists interested in bioinorganic chemistry. In short, it is essential reading for anyone interested in learning more about this fascinating area.

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