Book REVIEW

Boris Rozin. 2020. **Double Helix of Phyllotaxis.** (ISBN-13: 978-1-62734-748-8, pbk). Brown Walker Press / Universal Publishers, Inc., 200 Spectrum Center Drive #300, Irvine, California 92618-5004, U.S.A. (**Orders:** www.BrownWalkerPress.com). $39.95 US, 186 pp., color figures throughout, appendices, references, index, 6" × 9".

It's easy to admire the beauty and morphological significance of a sunflower head or inflorescence. Casual admirers can appreciate the three-dimensional structure of the head and its components. The petal-like ray florets around the periphery of the head, and the green bracts or phyllaries subtending the florets (flowers) add interesting variation in color, shape, and texture. Integrating form and function, taxonomists can appreciate the dense aggregation of florets on the head as an evolutionary structure adapted for maximizing pollination and reproductive success. Careful observers of phyllotaxy—the pattern of arrangement of plant parts—will also recognize a spiral arrangement of the symmetrically-shaped disc florets found in the center of the head.

While revealing floristic beauty and functional advantage, observations of external structures of plants fail to appreciate a deeper beauty that can only be revealed by mathematics. The purpose of this book is to lead the reader on a journey through the mathematical study of phyllotaxis. In the synopsis to the book, the author describes phyllotaxis as "the most beautiful phenomenon of nature." Phyllotaxis—as traditionally defined in botanical texts—is the study of the arrangement of leaves and axillary buds on a stem. The author extends this definition to include other plant organs and structures, including the inflorescence and seeds. These plant structures exhibit a complex ordered structure and a consistency of form.

As mentioned earlier, we can visibly see a spiral arrangement of the disc florets in the center of a sunflower head. Looking closer, one might notice that there are left-handed and right-handed spirals. The author takes this observation to a deeper level with a mathematical approach to reveal that the number of left-handed and right-handed spirals is equal to a pair of the Fibonacci numbers, which are a sequence of numbers and their corresponding ratio. A Fibonacci sequence of numbers often reflects patterns found in nature. The ratio between the numbers of a Fibonacci sequence is called the Golden Ratio, which is a mathematical constant that appears in some patterns in nature, from the center of a sunflower head to the eye of a hurricane.

For those wanting to pursue this book, the author opens with a chapter on mathematical foundations, including a discussion of the Golden Ratio, recursion and recursive sequences, the Fibonacci sequences, and the geometric properties of spirals. This is followed immediately by a chapter which employs this foundation to explore the phyllotactic patterns of a sunflower inflorescence, a spruce cone, a pinecone, pineapple, artichoke, and the arrangements of leaves. These examples are illustrated with color photographs.

The heart of the book presents a mathematical discussion of various models and concepts applicable to a mathematical analysis of phyllotaxis. The author states that the mathematical calculations used in the book do not go beyond the "advanced high school course of mathematics," with the main tool being integer analysis, which is applicable to the discrete elements of phyllotaxis. Such discrete elements include the central disc florets in the spiral arrangement of a sunflower's head.

The central focus of the book involves a detailed mathematical exposition of the double-helix (DH) model of phyllotaxis. As just noted, a reader need not be trained in advanced mathematics to follow the author's discussion of the several variations of the DH-model but should be comfortable with a discussion that is replete with mathematical symbols and equations. The book is at heart a mathematical treatise and will appeal to mathematicians and mathematically inclined biologists with an interest in understanding plant morphogenesis from a geometrically-modeled perspective.

I applaud the author's desire to connect the mathematical rigor and analysis to the "search of beauty in mathematics, and mathematics in the beauty around us" as stated in the synopsis. I asked the author for his advice to a casual observer of nature for appreciating phyllotactic patterns:

> "I would advise the casual observer of nature to forget about civilization for a while, go out into the wild for the fresh air, stop, relax, take a deep breath, and look at the trees and flowers. Take a flower and start looking at it slowly and carefully. Perhaps, the observer will be able to see the spirals that form the seed buds. On closer inspection, the observer can see that there are left- and right-handed spirals. Then the observer can sit down and count the number of these spirals. And the observer will be surprised to find that the number of left- and right-sided spirals are adjacent members of the Fibonacci series, which I heard about once in middle school."

The book has video illustrations and images (referenced throughout the text) available to supplement the main discussion and these can be found on the author's *Double Helix of Phyllotaxis* YouTube channel.

—Rick L. Hammer, Research Associate, Botanical Research Institute of Texas, Fort Worth, Texas, U.S.A.