Phyllotaxis in *Magnolia* Fruits

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The term *phyllotaxis* normally refers to the regularity of placement of leaves around an axis (stem). Since parts of flowers, such as stamens and carpels, are actually derived from leaves, the term is applicable to them as well. For example, in fruits of *Magnolia tripetala* it is relatively easy to see that the carpels are arranged in two sets of spirals, one set oriented in clockwise fashion, the other set counter-clockwise. With a marking pen, lines can be drawn along the mid-points of the carpel faces to reflect this *phyllotactic* arrangement (see Figure 1). Notice that one set of lines, or *parastichies*, is oriented in a more vertical spiral than the other set. For simplicity, I will refer to the more vertical parastichies as columns, and the more horizontal ones as rows. If we then count the number of rows and columns on the fruit, we normally find 8 rows and 13 columns in fruits of *M. tripetala*. The same is usually true in fruits of *M. obovata, M. grandiflora,* and in fruits of many other subgenus *Magnolia* species. On the other hand, if we do the same with fruits of subgenus *Yulania* species we normally find five rows and eight columns. It turns out that these phyllotactic carpel patterns in magnolia fruits are parts of the mathematical sequence known as the Fibonacci series, such that each number in the series is the sum of the preceding two numbers:

1, 1, 2, 3, 5, 8,13, 21, 34....

The Italian mathematician, Leonard Fibonacci, discovered this famous sequence during the twelfth century.

Just as some magnolia flowers don't always produce the expected number of tepals, sometimes nature adds or subtracts a row or column in a particular fruit. Studies have shown that most magnolia fruits show the Fibonacci pattern in their carpel arrangements about 75% of the time (Zagorska-Marek, 1994).

One interesting finding is that particular types of Fibonacci carpel patterns seem to correlate to taxonomic affinities in *Magnolia*. In fruits of subgenus *Yulania*, the average pattern is 5:8 regardless of the

number of carpels. In fruits of subgenus *Michelia* the pattern is either 3:5 or 5:8. Here, too, in species with large numbers of carpels the pattern never shifts to the higher order 8:13 pattern.

On the other hand, in the lineages that comprise subgenus *Magnolia* (including the former genera *Talauma* and *Manglietia*, but excluding section *Maingola*), species with approximately less than 30 carpels per fruit, such as *M. virginiana*, are usually patterned at 5:8, while species with more than 30 carpels, such as *M. tripetala* and *M. grandiflora* are patterned at 8:13, and a few species with considerable

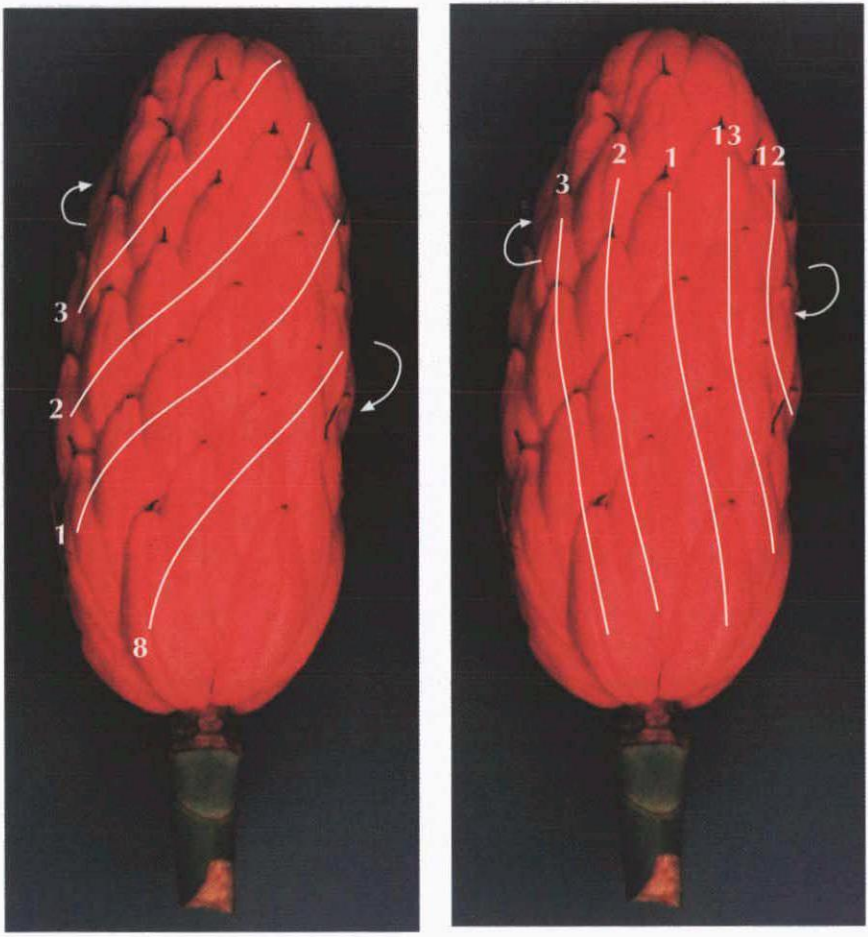

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Figure 1
Phyllotactic carpel pattern (8:13) for *M. tripetala* showing eight counterclockwise "rows" (left) and 13 clockwise "columns" (right).

numbers of carpels (approximately more than 150) are arranged in an even higher order of Fibonacci pattern, 13:21. This 13:21 carpel pattern can be seen in fruits of *Magnolia hernandezii* (South America) and *M. hodgsonii* (SE Asia).

These generally higher order Fibonacci patterns, which increase in proportion to the number of carpels, probably account for the ovoid or ellipsoid fruit shapes that we normally find in fruits of subgenus *Magnolia*~~*Maingola*~~ (as defined above) since the fruits must expand outward to accommodate the larger number of carpel positions brought about by the higher order pattern. On the other hand, the lower order patterns, which do not vary with respect to the number of carpels, seem to account for the mainly cylindrical shapes of the fruits of the *Yulania*, *Michelia*, and *Maingola* groups. Interestingly, these affinities support those found in recent molecular (DNA) studies.

Fibonacci phyllotactic patterns are found in leaf and fruit arrangements throughout the plant kingdom, including the patterns of spines in pinecones and seed arrangements on the flower heads of Echinacea spp. As fascinating as phyllotactic patterns are, scientists are still not sure how this regularity of arrangement is accomplished.

Reference

Zagorska-Marek B., 1994. Phyllotaxic Diversity in *Magnolia* Flowers. *Acta Soc. Bot. Poloniae* 63(2): 117-137.