LEARNING SCIENCE FROM THE KITCHEN GARDEN

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In this article, the author shares his experience of learning about plants by looking around with childlike curiosity in the kitchen garden. Using the common garden variety of chilli, tomato, eggplant, etc., as examples, he illustrates how they are classified as belonging to the Solanaceae family, based on their floral structure. They share a lot at the genomic level and flowers with five-fold symmetry of some of the other members of the same family go back in time by several million years. Following the splitting of the Gondwana land nearly 200 million years ago, some of the flora must have survived the tectonic movement and evolved differently depending upon the geophysical conditions. It is not necessary that all flowers with five-fold symmetry belong to the Solanaceae family. Flowers of some of the other members of the plant kingdom exhibit four-fold and six-fold symmetry too. Practically all the flowers that we see around us have two-fold symmetry, perhaps because of the bilateral vision of the pollinators.

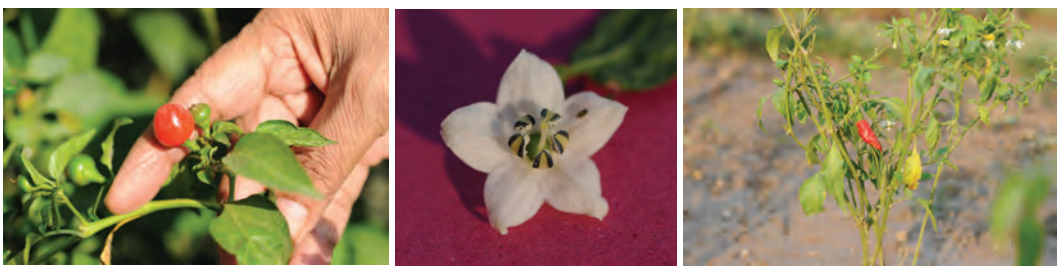
Keywords: chilli, tomato, eggplant, Solanaceae family, fossil flowers

Introduction

From the time we are born till we die; we are driven by curiosity. The children, soon after birth start looking around and sense what is happening around them. Soon, they start probing through other senses and try to figure things out. As we grow older, the curiosity continues, and we learn as we go along. Although we learn a lot from the teachers and textbooks in a classroom environment, we learn much more outside the classroom. This article illustrates how one could learn a lot by looking around in a kitchen garden.

Curiosity About a Plant

I was looking at a plant with cherry-like fruits in our garden (See Fig. 1). I knew it was not a cherry. Therefore, I asked the *mali* (gardener) what it was. He told me that it was a *mirchi* (chilli). I asked him how; he said that as it looked different from the common garden variety. He told me that it was a particular



(a) (b) (c)

Fig. 1: (a) Cherry like chilli; (b) the characteristic white flower of a chilli plant, with five petals and a stigma surrounded by five anthers; (c) a common garden variety chilli with characteristic leaves and flowers. (Credit: N G Prasad)

kind of hot chilli. When I asked him how hot it was, he told me that it was VERY hot. Therefore, I asked a colleague (Professor N. G. Prasad) who was trained as a botanist what the plant was. He responded by saying that it looked like it was a chilli plant. When I asked him how he could identify it, he told me that the leaves had a characteristic shape, and the white flower with five-fold symmetry was characteristic of a chilli plant. Then he showed me the more common types of chilli plants in the garden, which had similar leaves and flowers like the one I saw.

Once I knew that it was a chilli, I wanted to know how hot (pungent) it was! Another colleague (Professor T. R. Rao) took a bite of the chilli and confirmed that it was indeed extremely hot. He told me that the hotness of a chilli is measured by the amount of capsaicin present in it and is measured in Scoville Heat Units (SHU). He also told me that the hottest chilli on earth is Naga *Bhut Jolokia*, from Nagaland. It is hot by 1.6 M (million) SHU. In comparison, pure capsaicin, responsible for the pungency of a chilli is hot by 16 M SHU. The common garden variety of chilli, in comparison, has a pungency of 0.001 M SHU. The hottest chilli powder could, in principle, be used as a weapon in the form of a spray. The enemy would run for his life. When attempts were made to grow Naga *Bhut Jolokia* in some other parts of India, it became clear that the pungency of the chilli declined dramatically. The soil and the climate conditions in Nagaland clearly contribute to the pungency of its chilli.

Plants of the Same Family

My colleague told me that chilli belongs to the Solanaceae family and that potato,

(a) (b)

Fig. 2: The flowers of (a) eggplant and (b) tomato have a characteristic five-fold symmetry. (Credit: N G Prasad)

(a) (b)

Fig. 3: The fruits of (a) eggplant and (b) tomato have a characteristic crown and a stock. (Credit: N G Prasad)

tomato, eggplant and tobacco also belonged to the same family. One thing they all have in common is that their flowers have a five-fold symmetry (and similar floral diagrams) as can be seen from Figure 2, the fruits have a crown and a stock as illustrated in Figure 3.

I learned that some of the other members of the Solanaceae family are *Datura alba*

Fig. 4: The top panel has the image of a flower and fruit of ***Datura alba***; the middle panel has the image of the flower and fruit of ***Physalis***; the bottom panel has the image of the flower and fruits of ***Solanum torvum***. (Credit: N. Sathyamurthy)

(Oomathai in Tamil), *Physalis* (Chinese lantern), *Solanum Torvum* (Turkey berry, Sundaikkai in Tamil). All of them have their characteristic five-fold symmetric flowers and fruits having a crown and a stock as illustrated in Figure 4.

Molecular Basis

I learned that the Solanaceae family is one of the largest in the plant kingdom. While the members of the family could be identified on the basis of their floral diagrams and the characteristic fruits, I wanted to know if they had common characteristics at the molecular level. It turned out that genomic studies confirmed that potato, tomato, eggplant and chilli have a lot in common at the genomic level. It is worth adding that (the late) Professor J. P. Khurana of Delhi University was part of the international consortium for sequencing the tomato genome.

Do all plants having flowers of five-fold symmetry belong to the Solanaceae family?

While the flowers of all members of the Solanaceae family have a five-fold symmetry, all plants with five-fold symmetric flowers DO NOT necessarily belong to the same family. Some of them are shown in Figure 5.

Why do many flowers have part of their names reflecting the name of places from different parts of the world?

When I asked my friend geologist and a paleontologist, Professor Ashok Sahni, if there was any geological connection between different plants, he told me that in the beginning, there was one united land mass called *Gondwana* (incidentally, *Gond* refers

Fig. 5: Some of the flowers with five-fold symmetry belong to different families. Top panel left: cucumber (Cucurbetaceae), top middle: Plumeria alba, Top right: *Nerium*, middle right: Rangoon Creeper (*Quisqualis indica L.*); bottom left: Madagaskar periwinkle (*Vinca rosea*) and bottom right: Egyptian star (*Pentas lanceolata*). (Credit: N. Sathyamurthy)

to an ancient tribe and *vana* refers to forest). When the *Gondwana* split about 200 million years ago, part of the land mass started moving up north and a part of it split into Africa, Madagascar, the Indian subcontinent, Australia, etc. They all moved away from each other due to tectonic movements and the Indian subcontinent moved up north until it hit against the Eurasian plate. A close examination of the geological maps would reveal that the east coast of Africa matches with the west coast of Madagascar and the east coast of Madagascar matches with the west coast of India. During these tectonic movements, there were several volcanic eruptions. Some of the flora and fauna of yesteryears disappeared while some survived and fluorished in different landmasses and evolved differently. Sahni pointed out that there were fossils of flowers uncovered in the Himalayan foothills and date back by several millions of years. Some of them belong to the Solanaceae family and exhibit five-fold symmetry as illustrated in Figure 6.

Fig. 6: Microscopic image of a fossil flower, *Kasaulipushpam sahnii*, uncovered by Sahni and collaborators. This flower belonging to the Solanaceae family dates back by about 18 million years. (Credit: Ashok Sahni)

Fig. 7: Flowers of mustard (left) and cabbage (right) exhibiting a four-fold symmetry. (Credit: N. Sathyamurthy)

Is the five-fold symmetry in flowers exclusive?

The answer is, NO! There are plants of different symmetry. Flowers of mustard, radish, cabbage, etc., belonging to Cruciferaceae family exhibit four-fold symmetry as illustrated in Figure 7.

Flowers of plants like onion and *Argemone mexicana* exhibit a six-fold symmetry as is evident from their images in Figure 8. In other words, flowers of different plants can have different symmetry. Interestingly, they all exhibit bilateral symmetry. That means that if each flower is to be divided vertically, the left side and the right side would be found to be (approximately) mirror images of each other as shown in Figure 9. Could this be due to the fact that most of the animal species have bilateral vision? Why do the flowers blooming


Fig. 8: Flowers of onion (left) and ***Argemone mexicana*** (right) exhibit six-fold symmetry. (Credit: N. Sathyamurthy)



Fig. 9: Bilateral symmetry of flowers of pancy (left) and snowtop (middle). To drive home the point of bilateral vision, the author's face is included along with the images of the flowers in the right. (Credit: N. Sathyamurthy)

Fig. 10: Five-fold symmetry of the flower of ***Mirabalis jalapa*** (***Andhi mantharai*** in Tamil) that blooms in the night.

in the night, like the one illustrated in Figure 10, have bilateral or higher symmetry? Maybe to attract nocturnal pollinators? Do they need to be symmetric to attract the pollinators? Do they need to emit fragrance to attract them? If wind can do the pollination, flowers need not be symmetric and they do not have to be fragrant either.

Summary and Conclusion

Based on the characteristics of the flowers (floral diagram), flower-bearing plants (angiosperms) are classified into different families. Despite chilli, eggplant and tomato looking so different and tasting so different,

their floral characteristics are similar. Their fruits have similar crowns and stocks. They are identified as members of the Solanaceae family. At the genomic level also, they have a lot in common. Some of the available fossils of flowers that are several million years old, reveal five-fold symmetry suggesting that some of the florae have survived the tectonic movements and volcanic eruptions over the eons and evolved as per the available weather and soil conditions. While all members of the Solanaceae family have flowers with five-fold symmetry, not all flowers with five-fold symmetry belong to the same family. Flowers of some families have four-fold and six-fold symmetry too. On closer examination, we realise that regardless of the order of symmetry of the flowers of different families, they exhibit bilateral symmetry. This is presumably linked to the bilateral vision of most of the pollinators.

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