

## **AN ARK FOR THE PLANTS**

### **A Practical Tale of Kinship Gardening**

Organizing, Constructing and Growing a Phylogenetic Garden Using Dahlgren's Coevolutionary Layout.

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In the early 1980's after a decade of organic gardening and seed growing, I was faced with two problems. The first concerning criteria for selecting among the variety of cultivars for a particular vegetable. For example, there are hundreds of types of tomatoes. Which ones should I grow and maintain for seeds? In addition to structural aspects such as color, size, use (salad, slicing, paste, salsa), I wanted and needed nutritional characteristics useful for choosing perhaps a dozen that were optimal. Vitamins were one clear characteristic and high Vitamin C and high Vitamin A varieties soon became standard in the growouts and seed production. However, a broader range of nutrition was imperative and hence I began looking at the amino acids that are used to build proteins. This has led to the series of papers by Dr. Gurusiddiah and myself on free amino acids in our fruits and vegetables, which can be found in the journal.

The second issue of prime importance involved the conservation of plant diversity. Given that native habitats are disappearing and that soon there will be very few undisturbed ecosystems left on earth, then those of us who garden in our homes and backyards need to grow and care for as many different types of plants as possible. The question was how to optimize diversity in terms of available space and energy. The question also was how to learn about actual diversity and to implement this knowledge in our gardens.

Between 1975 and 1982, Rolf Dahlgren, an eminent Danish botanist proposed a bubble mapping system, which organized the kinship relationships of the flowering plants into a single layout. Using a multitude of traits, he developed the system while studying the monocotyledons. He then used it for displaying a variety of traits and extending it to include the flowering plants just before his untimely death in 1989. During these years, Olaf Brentmar and I amended and extended his format to include all of the plant kingdom including the mosses, liverworts, equisetums, ferns, treeferns, cycads, conifers and their allies.

The concept of kinship is the core notion for optimizing the conservation of diversity. The bubble mapping system is a treasure in the rough. By providing a basic working model of the plant kingdom, Dahlgren's layout gives impetus to the development of myriad gardens based on relationship. It also provides a bed diagram layout for organizing gardens based on kinship and diversity.

The immensity of diversity is one of the most difficult things to comprehend. The mapping systems extends from individuals grouping, into species that cluster to make genera. The genera fit together to make tribes, which then lead to sub-families and families. The families group to make orders. The orders organize to

make superorders. For the flowering plants, the 280,000 species lead to 13,500 genera, 540 families, 106 orders, and 32 superorders.

After 9 years of studying and writing about this working model system of the plant kingdom and 15 years of collecting plants, in collaboration with several friends and assistants, and with the help of many volunteers and the support of my family and Seeds of Change, the layout and planting of a kinship garden as a representative subset of the world flora was begun in the spring of 1994 using a 30' x 70' area in a 30' x 96' x 15' greenhouse just east of Corvallis, Oregon.

### **The Initial Concept**

I have been interested in the fabric of diversity. This includes not only the plants that mark the progress and highlights of evolution but also the basic aspects of plant life. This includes the ecology and adaptation to diverse environments, the variations in form of stem, leaf, flower, fragrance and fruit and the growing together of kinds that have existed on earth for millions of years but never been in the same neighborhood and lived in the same home. While habitats and diversity are presently under assault, access to diversity and to the world flora has never been as great as it is now. Thus we are at a cusp in the development of life on earth. By putting inside a greenhouse a modest version of the world flora based on kinship, we have been looking at and working with the concept of conservation based on optimizing diversity. In the process we have discovered again and again that the mapping system is a working model and the actual plants in the garden have important ecological needs and requirements that lead to hands-on adaptation of the layout, rearrangement and discovery.

### **Simplification of the Layout**

There are an infinite number of possible gardens based on the extraordinary wealth of plants on earth. To build a kinship garden based on Dahlgren's layout, limitations arise from two directions. The first is our access to diversity; namely, what plants and seeds are available. The second are the constraints of the environment. As well, these are the core issues in the development of life through evolution.

Our environment is inside a metal-framed greenhouse covered with a double layer of 6 mil polyethylene plastic and inflated with 2 small squirrel cage blowers. A minimum night temperature of 45 degrees F is provided by a 225,000 BTU natural gas fired heater. There are two internal circulating fans. During the summer, circulation and cooling is provided by opening the doors at both ends and by opening the endwall plastic to the very top.

We began planting in unamended soil. Prior to the greenhouse, the ground had been planted in marionberries, black cap raspberries and boysenberries. These had been removed before building the greenhouse. There is more than 15 feet of clay loam topsoil of moderate fertility. A central expanse of 30' x 70' was rototilled to garden consistent on April 1994 and we began planting.

Using the layout illustrated in Figure 1, we put a wooden stake labeled with the name of each of the 32 superorders of flowering plants in the appropriate location in the rototilled plot. Then we put the diverse set of plants we had collected

for each superorder near the appropriate stake to give us a rough idea of where they would be planted. The more specific relationships of each of the plants comprising an order or superorder, generally representative of families followed the layout that is found on the cover of *Peace Seeds Resource Journal* #6, 1991. To accommodate aquatic groups, we purchased three 150 gallon plastic feed containers and set them into the garden in the right location to accommodate the aquatic monocots and aquatic dicots. As I discuss subsequently, the relationships of the families to the orders and superorders that they build are not well established. Furthermore, the orientations of superorders to one another is an unexplored part of this gardening puzzle. It is interesting, challenging, and daunting to find out that notwithstanding the immense amount of work that has gone into studying plants and establishing their kinship relationships, when it comes to making a garden representative of these studies, virtually nothing is known. Kinship gardening is a new area of biological research.

Choice of representative plants for the initial planting was historical as well as conceptual. For more than a decade, we had been collecting plants. The collection was based on knowledge, curiosity, utility, rarity, fragrance and happenstance. Survival and success of the plants we collected reflected our skill at horticulture which in turn depended on the conditions in our other greenhouses and gardens.

The first selection was for perennial plants that optimized diversity and already liked our growing conditions. These plants were to be totem plants or representatives for the major groups. Thus a 6' shrub of lemon verbena (*Aloysia triphylla*), a longtime denizen of our orchid greenhouse was transplanted to the kinship garden as a representative of the verbena family (*Verbenaceae*). Dr. Don Emehiser had given us several 5' papayas (*Carica papaya*, *Caricaceae*) and two were planted to represent the violet order (*Violales*) since the species is monocious and has male and female plants. Fortunately we got a male and a female and had later hand pollinated them to get fruits. We had been collecting the forgotten crops of the Incas and decided to use these plants as one of the aspects of the initial plantings. From Ecuador, Ruth-Marie Moore of *Semillas Solanus* had sent us seeds of a cold hardy custard apple (*Annona* sp *Annonaceae*), basil (*Erythrina edulis*, *Fabaceae*, *Phaseolus* Tribe), ice cream bean tree (*Inga feuillei*, *Mimosaceae*, *Inga* Tribe) and a crown for the Andean carrot (*Arracacia xanthorrhiza*, *Apiaceae*). These were planted as representatives of their respective orders in the Magnolia, Citrus and Carrot-Ginseng superorders. One day while wandering through the garden part of Fred Meyer's department store, I saw an unlabeled pot of a sad sale plant of the elegant aralia (*Dizygotheca elegantissima*, *Araliaceae*). I purchased it and planted it as the first rep of the ginseng family. It is now 8' tall, in good health and quite beautiful. Australian Paul Gardner had sent us seeds of the blue lillipili (*Syzygium austral*, *Myrtaceae*), which germinated and grew into nice shrubs. A seed of the rose apple (*Eugenia jambosa*) collected in the Quail Botanical Gardens had germinated and in two years also had become a lovely potted shrub. Both species were transferred from pots into the ground as reps of the myrtle family, order and superorder. One of the nicest early features of the kinship garden was the liberation of many potted plants from their tight and overgrown containers into the direct connection with planetary topsoil. During the month of the initial planting, I had

several nighttime dreams in which the plants thanked me for facilitating their escape from pots.

### **Watering**

I love the magic of watering. On a sunny morning, the water with a soft yet abundant flow casts a dispersion of rainbows and fills the garden with fertility. Nothing replaces the daily journey through the greenhouse, hose and fog nozzle in hand, checking the progress of regrowth, the development of flower spikes, the opening of flowers, the setting of seeds and maturing of fruits. In another greenhouse that now houses an orchid and rare plant collection, I set up a solid set system for automatic watering. After a few months, I stopped using it and a then a year later removed it. Many times I am asked about problems with insects, other pests or about how to successfully grow certain plants. Rarely has there been an insuperable difficulty since the daily inspection of the plants during watering leads to simple and quickly effected remedies for most problems. During our many years of greenhouse maintenance here in Oregon, the most significant plant destruction has come from molluscs. The snails and slugs cherish young seedlings, new growths of most plants and line up for the buds of *Cattleya* orchids. Nightly with a flashlight is the cure. Pick 'em and remove'em.

### **Volunteers and Annuals**

After the kinship garden was planted with totem reps for many of the major groups of plants, we decided to plant several annuals to fill out the space. In the cucurbits, we planted a single plant of the white flowered gourd of the kind that makes dinosaur long handled dippers (*Lagenaria siceraria*, Cucurbitaceae). Since we needed seeds of the red-seeded citron melon, we planted 2 plants of this watermelon used for making pickles (*Citrullis vulgaris*, Cucurbitaceae). Among the daisies, we planted several marigolds. In the legumes, we planted several bush and pole beans. In locale dedicated to the potato-tomato family, we planted several kinds of peppers, a large fruited ground cherry, a giant solanum and a tree datura. Next to these, in the related morning glory family (Convolvulaceae), we planted some heirloom morning glories. And since part of the garden was rather empty and unplanted we transplanted several kinds of castor beans, knowingly putting them 'in the wrong' place. I had reckoned that it would take several years to grow the basic kinship framework of the garden and that consistent with my other work of producing seeds crops, it would be okay to use the space as needed while the longer term goal was to establish everything in its appropriate kinship location. Thus, every once in a while an interesting seedling would arise and rather than move it or remove it, we would leave it alone, to grow, to flower, seed out and finish the cycle. Several times, I planted plants entirely in the wrong place. For example, I thought that *Debregeasia edulis* was in the myrtle family while actually it belongs to the nettle order (Urticales, Urticaceae). Two years later, it was transplanted to the appropriate place. There is a certain patience essential for enjoying the process of watching the kinship garden evolve, develop and thrive. Some of the errors have been very instructive.

During the first year, several plants 'got away'. Most notable in this regard were the cucurbits. By early August of the first season, the gourd plant had made 20-30' runners and was threatening to overtake the whole garden. So we hung several 20' x 20' pieces of 65% plastic netted shade cloth 8' off the ground over the area where the gourd was growing and encouraged the runners to climb onto the netting. We did the same for the citron melon runners. By the end of September, both plants had made a second tier, an actual second story for the garden and more than 50 fruits matured during the next two months. We learned not to plant rapacious annual cucurbits in the kinship garden.

In the part of the area destined to house reps of the 31 tribes of fabaceous legumes, we planted castor beans (*Euphorbiaceae*). They became immense and although we let them mature seeds, we took all but one out during the next winter. During the second year, the sole individual that remained grew a 6" wide trunk and branches up to 15' tall occupying more than 10% of the garden. We let it mature hundreds of seeds before taking it out and replanting with legumes that belonged in that location.

To establish an intensely diverse, phylogenetically accurate and taxonomically interesting kinship garden where the plants thrive and growth is balanced is a demanding process. Initial planting had depended on the plants available to us, both from our own collection, from local nurseries, from starts grown from seeds available by mail order and from botanical gardens, the United States Germplasm collection and from wild collections. As the more common families, orders and superorders become represented, locating the reps for rarer families, orders and superorders becomes more difficult. Then too, plants that initially do well for one year don't necessarily survive the overwintering transition and some of the ecological vicissitudes that happen during the cycle of the seasons.

### **Weeding**

Locating plants within a family, order and superorder combines botanical scientific knowledge, ecological insight, horticultural skill and an intuitive savvy of location that Asian people call 'feng-shui'. Each plant needs to be sited in the correct orientation relative to its neighbors. The aspects of shade and sun, soil quality and water requirement all contribute to the growth and long-term success of the planting. Some vines need to be pruned back routinely to keep them from outgrowing their neighborhood. Appropriate choice of species in a genus can overcome this problem. Some plants seed prolifically and they can sponsor a weed problem.

Weeding and cultivating are important parts of maintaining the health, appearance and utility of the garden. Well-located and well-maintained paths through the garden make it possible for gardeners and visitors to take care of and enjoy the relationships held by the plants. Cultivating the plants into beds comprising orders and/or superorders works very well. With a pathway around the superorder and weeded, cultivated plots for each plant, there develops an aesthetic beauty for each location and a greater appreciation of the science that has led to the kinship structure. This is botanical horticulture in action. It is also conservation in practice. Botany students from the local university have remarked that a few hours

in the kinship garden did more for their understanding of botany than several years worth of academic coursework.

### **The Second Year**

Several aspects contributed to major increases in the depth and diversity of the garden during the second year. Larry Bushman who had collected cacti for many years and grown hundreds of kinds from seed gave us his collection for a very modest amount of money. In a similar manner, Lorne 'Red' Hanna, a kindly octogenarian and generous soul had skillfully grown a fine succulent collection including members, euphorbias, cacti, gesneriads, daisies, diverse crassulaceous, apocynaceous, portulacaceous and liliaceous stock. He ended his era in the mail order plant business by selling us specimen plants covering a wide spectrum of families, genera and species. Finally, and also with great generosity, Bob Smith of Orlando Florida who has an extensive collection of gingers and their relatives sent us reps for the tribes of the ginger family and for several unrepresented families in the ginger superorder. This conjunction of accessions gave us the basis for expanding and deepening several parts of the kinship garden. Other nice contributions came our way as well. Thelma and Bus Nance gave us a dwarf Cavendish banana and a beautiful China rose (*Hibiscus rosa-sinensis*). Several small plants from mail order nurseries had grown into nice sized plants. They had been chosen to fill out the garden and exemplified one of the nicest parts of the kinship garden. There was always a place for an unusual, rare or unrepresented group. Many times in the collecting of plants, a pot gets stuck away in a corner or on a bench receiving little attention and fitting in poorly within the larger groups that comprise the major collections. Since the kinship garden optimizes diversity, additions that bring more diversity find a home much more readily than more common kinds, easy to obtain and which are already well represented.

Our expanded access to cacti, euphorbias, pachypodiums and members of the asparagus order which includes aloes, amaryllids, agaves, dracaenas, scillas and kin led us to make roughly circular beds 5-15' across of sand, sand plus pumice, rock gravel, rock gravel mixed with pumice with a little peat moss and similar well draining combinations of low fertility materials. These have provided good circumstances for the growth of each of the botanically well isolated yet ecologically similar groups of desert, xerophytic plants.

Although we have worked to make the kinship garden represent a broad spectrum of the diversity of major plant groups that grow on earth, for several of these groups such as the cacti, we had many specimens thus allowing us to make a more in depth layout. Thus not only were the cacti represented as part of the carnation superorder, but the family, subfamily and tribal structure could also be represented. We are repeating this process of doing tribal layouts for the daisy alliance, the euphorbias, the ginger alliance, the milkweeds and their allies and the legumes. I find this a very educational process. Not only does it require collecting reps for the different tribes and genera, but means studying the recent cladistics analyses of kinship appearing in scientific literature. Summaries and insights from such scholarship appear in the Peace Seeds Resource Journals giving bed diagrams for kinship layouts for many of the best-known plant groups. For others, our

synthesis of current botanical taxonomic science gives rise to new beds in the kinship garden.

### **The Third Year**

Eco-catastrophe has an upside and a downside. During January of 1996 the rain just kept on falling. By the beginning of the second week of February, the Willamette River was raging and the Mary's river was at flood stage. Soon what was a wet season became one of the major floods of the century. And without planning or expectation, the kinship garden was under 3 feet of water for several days. Just towards the end of the second year, small mounds of soft soil began to appear inside the greenhouse, signs of the diligent activity of moles. I had dreaded the consequences of their activity in our carefully planted beds of cacti, euphorbias, roseaceous succulents and amaryllids. Their activity had been increasing markedly during the seven years that we had been growing seed and gardening organically on 2 acres of Hal and Alice Brown's bottomland Willamette Valley soil. After the flood waters receded, the underground rodents retreated to the higher margins of the land, away from most of our agricultural activities.

The plants that suffered the most from the flood were the papayas. Their roots totted and one day we found them lying horizontal. We cut off the rotten roots, put the tops in pots and are hoping the new roots will grow. The perennial peppers also fared poorly with only a few new growths showing on large shrubby plants. Some mints and daisies also rotted away. And so the process continues. Each year seeds a new spring for the kinship garden. We study the scientific literature to see the progress of molecular biology in fathoming kinship relationships. For several centuries, discoveries of plants have led to large increases of our knowledge of the families, genera and species that live on the earth. Now the destruction of the tropical forests, our major resource for new kinds, is reducing plant discovery. At the same time, the fabric of relationships is under ever more intense scrutiny. Using tools and concepts that analyze the genetic material such as order and sequence in the DNA of the chloroplast, old concepts of kinship based on apparencies are being replaced by ones closer to the actual. Thus Dahlgren's legacy of formulating relationships extending from families to orders and superorders continues to be increasingly fruitful.

Since the greenhouse and heater make the garden semi-tropical, some groups that thrive in the temperate zone are noticeably absent. This includes the Bellflower Order (Campanulales), Ranunculus Superorder (Ranunculaceae) and the major portions of the Rose Superorder (the stone fruits, the pome fruits, the brambles, roses, walnuts, chestnuts and oaks). As appropriate reps are found, they too will be included.

Entry into our kinship garden is through the monocots into the dicots. The major pathway first encounters the pineapple family (Bromeliaceae) on the left and the ginger alliance (Zingiberanae) on the right. To accommodate the epiphytic character of the bromeliads, we left most of the plants in pots and surrounded them with coarse grade orchid bark thus allowing them to outgrow their pots and make a densely grown array of several genera and numerous species. To the left of

bromeliads is a two tiered bench of the kind used to grow orchids. During the spring, summer and fall we fill this bench with 100-150 potted orchids.

We envisage a journey through the kinship garden that can be an unforgettable experience of the wonder and beauty of the plant kingdom. During the years to come, the kinship garden needs to grow in many ways. We see that arching trellises will make it possible to create second and third levels and that upon entering the garden, one is surrounded at every turn by marvelous diversity and kinship strategy. As the trees and shrubs representative of the major groups become established perennials, they become the home for epiphytes and sites for clusters of pots housing interesting relatives. As our collections permit wider and deeper diversity to be developed, so do our skills at horticulture and plant care. For some groups, like the asparagus order, which thrive so well under our conditions, we are considering an entire greenhouse for a kinship garden which focuses on the 30 families and 270 genera that make up the order.

The interactive network of all the kingdoms of organisms, from bacteria to algae, fungi and animals living within the shelter and ecos of the plants is another horizon for the future development of the kinship garden. Tanks of tropical fish, frogs and lizards, birds and small mammals can be woven into the garden, extending the kinship concept, expanding the diversity of life and increasing the attraction and complexity of the environment. Rebuilding the ecosystems we as a species have destroyed planetwide is also a task we surely face. Experience with gardens such as the one described herein grows in us the ability to face the needs and challenges of organizing, sustaining, and developing life-promoting activities. The current environments we inhabit routinely take us away from life. Yet, as organisms we yearn for more involvement with life.

### **Conclusion**

The kinship garden came from the need to make gardens that increase our conservation of diversity. Rolf Dahlgren's bubble mapping system provided the impetus to organizing our plant collection in kinship format. Now we have planted a kinship garden, which represents 24 of the 32 flowering plant superorders and 50 of the 106 orders. It contains more than 500 plants including more than 450 species. To maintain and develop it are dynamic processes. It is only a beginning, one that has taken 14 years. A temperate zone kinship garden is in the planning stage. Hopefully, the concept of kinship gardening will 'take' and diversity based conservation gardens will germinate all over the world.