direct participation in evolution

in the common purpose of serving life, humanity and sustainability

Public Domain Plant Breeding

or

Why not take the genes in your own hands?

We come from a long history of change.
It comes from the environment
and is inscribed in our chromosomes.
It comes from the genomes
and transforms the biosphere.

Alan M. Kapuler Ph.D.
known in the SSE as OR KA A

March 16-20. 2011

Requirements:

1. **Interest**

Its easy to make some crosses, especially in wind pollinates like corn and beets. The issue is which crosses to make.

That means enough growouts to get in touch with the plants you wish to cross, their parents and near relatives. Its okay to cross corns but there are a lot of kinds of corns.

2. **Willingness to learn**

Plant genomes like the diminuitive thale cress (Arabidopsis thaliana), perhaps the most thoroughly investigated flowering plant (in the Brassicaceae) has about 23,000 single copy genes. That is more than people have, by about a thousand. Genomes of both people and plants are profoundly complex, remarkably different, uniquely similar and worthy of investigating. From the atoms to the solar system, life has
domain as our local and world societies stumble further into the unknown.

3. **Perseverance**

No matter what you read, see or figure out, there is always more that is unknown, unfamiliar, inscrutable or inexplicable at one's current level of understanding. So
in engaging crossing plants, looking at progeny and selecting lines, it usually takes a while to learn the background (the species and their primary crosses and hybrids), the current level of development (new, recent, breakthrough crosses and developing plant characteristics) and the ones you make, select and develop which come from the preceding and which lead to originality, insight and adaptive new cultivars.

4. **Devotion**

Sometimes it takes planting and replanting, overcoming vagaries of the weather, denying populations of herbivores your crops, overcoming intransigent weeds, struggling with too many slugs and snails. Then there is inconvenient timing, poorly chosen cover crops, new crops that escape, the endless selection under the forces of environmental change and internal genetic selection.

5. **Gardening Skill**

No matter how much one grows and has grown, there is always more to grow,

There are many gardening techniques, many fall prey to poisons yet hand weeding, good tools, moving into springtime with good head and heart and lots of kinds of old and new seeds to plant are healthier aspects. Organic systems are an advance towards microbiologically based fertility systems. Improving soils on site from the cycles of growing and composting are essential endeavors. Watering systems matter and merit thoughtful consideration. Minimize amendments.

Fields of Activity

1. Biodiversity

We live in a crucible of the creativity of/in life. It is an ongoing marvel. We now see the perspective of the diminishing horizon of extincting and the emerging, surviving organisms that extends unbroken in essence for billions of years if not older than the solar system.

A. The Earth's Organisms

Myriad, diverse, persistent, adaptive, a multigenome encoded in DNA, RNA and protein. In our chromosomes are the genes for building ribosomes. They are billions of years old as is the making of proteins from translating messenger RNA.

These core discoveries are central to a unified biology. This is how life is able to remember the events of the environment, and adapt to circumstances clearly seen in the structure and behavior of our immune systems.

B. Viruses, Microbes and Eukarytic Cells

The viruses inhabit most of the cellular creatures that live on this planet. Their structures, taxonomy are deep, diverse and remarkable. They are the holders of the collective storehouse of genetic information of and about life. There are many, many more of them then most of us reckon. Immense beyond huge. Awesome and particular. The cells they live in and on are either microbial (bacteria and archaea) or eukaryotic. All the plants, fungi and animals, insects are eukaryotes. And we all have microbes living in most of our cells. Our cells are multigenomic. So are those of a maple tree.

C. The Planetary Flora

In Mabberley's The Plant Book, there are some 270, 000 or so species in almost 14,000 genera. But in the world's herbaria, there are some 30,000 undescribed species. We call most green organisms plants. Some are blue-green bacteria. Some are seaweeds or mosses or ferns and then we get to conifers and the flowering plants. Most of what we garden is in the flowering plants. And for temperate zone gardeners about a quarter to a third of the world flora is temperate or temperate adaptable. With a greenhouse, one can engage a much larger subset of diversity.

D. The Gardener's Handful

Of the hundreds of plant families, we garden in less a dozen. These are the daisies, legumes, umbels, chenopods, grasses, cucurbits, alliums, solanums, brassicas and morning glory.

E. Kinship Gardening

If one chooses to explore the planetary flora , organizing the plants in a phytogenetic or evolutionary array means looking into the diversity with more than a passing glance. One can do this within a single genus. One with 20-50 species is a good size to try. For a larger subset, one can do the monocots, or the Old Trees, or the Rosales, or the Legumes. All are interesting and if one is formulating survival of diversity, the more kinds we plant together who are related together the more chances there are of encouraging interbreeding and adaptation in the current times of erratic weather and consequences of environmental degradation.

F. Common Garden Foodplants and Flowers

Adapting plants that are vigorous, productive, with nutritious and delicious attractive leaves and fruits to our own gardens has been my primary objective in developing new cultivars. So sweet corn and tomatoes have been constant favorites. While my first crosses in the late 1970's were with corn, making new kinds of tomatoes began twenty years later. It is easy to purchase some F1 seed and then select out a stable open pollinated line. This is a good way to begin. There are many F1 hybrids available commercially and some are wide crosses that yield diverse and interesting F2's. Others show very little variation in the F2. After our family grew hundreds of kinds of tomatoes for several decades, my daughter Kusra and I made crosses of *Lycopersicon (Solanum) habrochaites* to *Lycopersion (Solanum) humboldtii*. It was an opportunistic cross, not by plan but circumstance.

In the progeny were tomato plants whose inflorescences had tresses of more than 100 flowers. Some folks growing these hypertress tomatoes have had hundreds of flowers on a spike with huge clusters of cherry sized fruits. These are public domain cultivars. They have several unique traits that can be introduced into many other of the popular tomato subgroups: paste, rainbow colors, slicing, huge, determinate, semi-determinate, indeterminate, drying, long storage, resistance to blights and so on.

By good fortune a comparable thing happened with vine peas. Almost twenty years ago we began breeding peas, reading Mendel to find out how to cross them, and making a public domain green snap pea wherein most of that category were patented. In our pea growouts from seeds obtained from the SSE we had some Carnouby de Mausanne which has purple pods on bushes. So we crossed Sugaree with the purple podded bush shell cultivar and several years later had a mostly snap pea line with purple pods. The snap pods were bitter. At that time in the field, there were Parsley peas. They are bushes with shell pods and tendrils modified into parsley-like leafy structures. An obscure garnish. We crossed the purple snap vine with a bitter flavor with a bush shell with no tendrils and several years later had lines of vine peas with hypertendrils. This hypertendril trait in the public domain makes it possible to reinvigorate pea breeding as the hypertendrils of the pea vines are distinctively beautiful. We like bicolor purple flowers, in snow and snap cultivars as well.

In both of these examples with tomatoes and peas, the results were unexpected. It was pure discovery. What a thing to be able to do with most all the plants we garden.

Insert: As I grew up, service was not high in the goals of the society. Success was more important. Now as we encounter ecological catastrophe in the era of cyber communication, our disastrous ignorance about discovery and invention makes greed and profit the leading values.

As an anodyne to these problems, a virtuous, difficult endeavor like organic gardening is a good beginning.

Public domain plant breeding and kinship gardening are two of the next steps. The first develops new, original and adaptive gene combinations for our local ecosystems, their gardens and for sustainability. Plants that cross pollinate yield populations of F1's that give evolving grexes that can optimize adaptation and survival in these times of radical weather. Kinship gardening is an exploration and conservation matrix for getting direct experience within the 300,000 plant species and their manifold hybrids.

In the garden, our ten standard deviation units beyond the norm ideas can be tested out, explored for veracity and transformed into better soil, fertility, home grown seeds and new kinds for every season.

As pre-human biodiversity continues to decline, there has been an increase in patenting, ownership and MTAs (Material Transfer Agreements) for plants and other living systems. While the genetic systems of almost all life pre-exist humans, one can manipulate one or a few genes,

or insert a gene from a distantly related organism and obtain ownership rights. This tends to close down innovative and more broadly useful work with these organisms. The basic framework of life, the wild species, are common to all, like the air we breathe. With decreasing wild diversity, more and more becomes property. To counter this, and indeed the original intent of agricultural universities with public domain plant breeding programs was to provide locally adapted cultivars so the growing of food was diversified to provide stability for the society at large.

This ongoing travesty of treating life as intellectual property is quite unlike the patenting of a computer or its parts. We did not invent the cell.

Public Domain Plant Breeding has for generations established improved plants. Primary foci are plant architecture, flowering, fruits, fertility, resistance to fungi, bacterial and viral diseases, ecological adaptation, nutrition, and beauty. By making crosses, growing them out, selecting in a wide variety of aspects, one engages the genetic system of life, a place of immense activity and potential. So as plant breeders who work for the common good in the public domain, we are allied with the genetic systems to provide changes that have benefits to humanity, local and planetary ecosystems. In this sense, the genetic systems and their codes are like common source computer code for which a system has been developed which allows one to use it, to change it, to add to it, but not to own it. Janet Hope's recent book Biobazaar, the Open Source Revolution and Biotechnology explores the analogy of the genetic code with the computer code in terms of open source and public domain.

2. Genetics

The 64 codon triplet genetic code of life is the basis of a universal biology. Embodied in DNA and RNA, triplets of the nucleic acid bases A=adenine, G=guanine, C=cytosine, T(U)=thymine (uracil) specify each of the 20 amino acids that make up proteins. The strings of nucleic acid bases code for genes, a few in most viruses, low thousands in bacteria/archaea, high thousands in fungi and tens of thousands in plants and animals.

A. Cells

The tiny free living cells whose ancestors have lived and inhabited the earth for several thousand million years have given rise to blue-green bacteria that have become chloroplasts in the leaves of trees, and all green plants. A common ancestor of a common soil bacterium became the mitochondria that burn sugar to make ATP, the common energy source of most eukaryotic cells. Our bodies, the plants we grow and the foods they provide are cellular in origin. One makes many. And from many comes one. This riddle is a core axiom of genetics. Seymour Benzer studied a bacterial virus called T4, the rII region of two genes connected by a spacer that he genetically surgically removed. It was called 1589. It was the 1589th genetic variation within the gene among many more hundreds of thousands he mapped in revealing the complexity of the genetic fine structure in an obscure virus found in urban garbage that lives in a common human intestinal bacterium. And his work and discoveries impacted our understanding of the common genetical system that is central to all life. His life has been devoted to public domain breeding with bacteria and their viruses, fruit flies and (read Time Love Memory by Jonathan Weiner} The internal core process of change is in our genomes, in the nucleic acids in our cells, in the collaborative network of cells that coordinate the growth, repair, adaptation and wellbeing of our bodies,

B. Adaptation and Selection

Change is inexorable. Now matter what we think, do or figure out, it is always in process. Genomes and organisms are not frozen. Heirlooms change. Gardeners and seed collectors are part of the evolutionary mix. And whether change or not, selection is inexorable. Adaptation is the result. Sometimes large populations give more opportunity for seeing changes. Sometimes one can jump ahead with just a few plants.

C. Number and Variation

By getting a full set of chromosomes from each parent, most of us and most plants are diploids. Occasional doubling of the chromosome number gives tetraploids. Crosses diploids with tetraploids gives triploids, Some plants like the Andean root daisy Yacon are polyploids with 6 or 8 sets of chromosome. Sweet potatoes are hexaploids but the species they come from are diploids.

3. Sweet Corn

In the mid 1970's after collecting sw Amerind starch corns, I wondered why all the sweet corns we liked to eat were monocolors, all yellow or all white seeded. Rainbow Inca Sweet Corn was the first of our multicolored sweet corns. A later one was Painted Hill Sweet Corn. Every once in a while a sweet corn would have some purple, high anthocyanin seeds. We picked out a few and began selecting so that now we have Double Red Sweet Corn with intensely dark purple seeds from a genetic trait that inherits in the female. Some years ago, Rosemarie LaCherez sent us a popcorn (Chires) that tillers and makes 3-5 little ears per stalk. Some plants will have several dozen ears. Crosses with Double Red Sweet Corn have given a remarkable diversity of new corns. Selection is difficult. The direction still inscrutable.

4. Brassicas, Solanums and Daisies

Marigolds and sunflowers have always been a part of our gardens. Years ago an neighbor gave us a few plants of a *Tagetes patula* marigold that was in a 1790's gardening book called Striped Marvel or Pinwheel. In 200 plants there was one with attractive double flowers. It seeds have given rise to China Cat Mix and to several new 3-5' tall beautifully flowered cultivars called Frances's Choice, Sparkler, Red Metamorph and Golden Star.

In 1997 we grew a kinship garden for the Daisy family, some 16 tribes of which we had reps (representatives) of fourteen. In the sunflower tribe, the Heliantheae, there are many genera and particularly in one, Helianthus, a genus of 50 species endemic to the mainland USA we had many species and cultivars. The GRIN (Germplasm Resources Information Network) of the USDA kindly provided seeds of more than a dozen species plus some collections of *Helianthus annuus* from different countries around the world. We planted them together. Several years later it was clear from the volunteers that crosses between *H. annuu*s and the Texas Silverleaf Sunflower *Helianthus argophyllus* had taken place. The plants flower for several weeks to months longer in our cool wet fall weather. The finches prefer the seeds. The flowers are smaller, with dark centers and in many flowered racemes. Now 13 years later we are once again introducing *Helianthus argophyllus* into the field to introgress with our reseeding volunteer population of sunflowers to develop some new architecture and flower structure and arrangement.

Living in the Pacific Northwest in the remnants of the magnificent forests of a giant coniferous rainforest and working in the rain, the overwintering foodplants are very interesting. Most interesting to us have been the brassicas.

Kale thrives here. There are many kales with many kinds of leaves, from soft to hard, from ruffled to plain and smooth, from crimped and crumpled to dark purple to pink striped held on plants from a foot or two to 10' tall. They intercross easily, generally outbreeders. We have had good crosses involving 2 plants (Romanesco Broccoli x Eco Brussel Sprouts). With seven plants, a central one became the female and the other six were males. We work towards perennials that make broccoli, cauliflower, brussel sprouts and small cabbages. One cabbage had 8 heads but the polyheaded trait was not inherited in 40 next generation plants.

The Solanaceae is a favorite temperate zone gardening family. With capsicum peppers, eggplants, tomatoes, tomatillos, ground cherries, potatoes, tree tomatoes, there are good reasons for adapting/selecting for our own favorite kinds. If one prefers growouts to favorites then there are hundreds to thousands to grow up. After decades of *Capsicum annuum* hot pepper cultivars we have been growing *Capsicum baccatum*, Aji Colorado which have many subspecies/cultivars to adapt and diversity in our local temperature conditions. The Apple Chile, *Capsicum pubescens*, has overwintered in our non-freezing greenhouse and begin to look like *Physalis peruviana*, the Giant Groundcherry, now ten years old.

5. The Future of the Future

The back to the land movement of the 1960's took many urban and suburban kids into the fields and countrysides. Partly in opposition to the endless wars, partly in search of an agrarian life built on healthy soil, clean water, fertile soil and the heirloom seeds of our ancestors, we have continued growing organic gardens, saving seeds of heirlooms and local native species. Impelled by the times that continue to change, we have begun breeding new vegetables and flowers for the public domain to promote a healthy biology unfettered by ownership in support of a path towards world peace and the well being of everyone.

Acknowledgements

To thank there are myriad people and the aeonic lives of all the organisms of the biosphere, all alive in their genes and the genetic systems inherited from times as yet unmeasured for these words and the discussion of the common open threads of life. We continue to learn more about life and existence with every moment and every day that passes. These are extraordinary times. Genomics is developing a reality map of the process of evolution throughout billions of years. And we carry it around in our hundred trillion cells. The environment leaves its marks in our chromosomes and genetic systems exist to promote adaptation, to facilitate change, to correct excess damage and radical poisoning, to make survival more likely, to give us a chance for cooperation in the conservation of diversity and ecosanity in our times.

Particular thanks to Linda Kapuler of Peace Seeds, Dylana Kapuler and Mario Dibenedetto of Peace Seedlings and Kusra Kapuler.