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ROSE, NY 14542-0149

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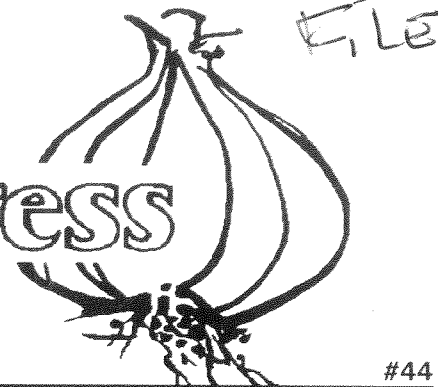
*Garlic Collection of the USDA  
How Many Garlics Are There?  
Hands, Wrists, and Tools  
Vinegar Herbicide - Continued*

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THE REGULAR, AND NOT SO  
REGULAR, NEWSLETTER OF THE  
GARLIC SEED FOUNDATION

The Garlic Press



FALL 2004

[www.garlicseedfoundation.info](http://www.garlicseedfoundation.info)

#44

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*Initial membership in the GSF is \$15/4 issues. Renewals are 8 issues for \$20. All submissions for The Garlic Press should be sent to GSF, Rose, NY 14542-0149 or [rijdunkel@yahoo.com](mailto:rijdunkel@yahoo.com). All medical references should be taken for educational purposes and any recommendations should not preclude consulting with a health practitioner. Please, no reprinting any material herein without written permission.*

## The Garlic Collection of the USDA, ARS National Plant Germplasm System

*Barbara Hellier, Curator*

The USDA, ARS National Plant Germplasm System (NPGS) is a composite of plant germplasm conservation sites that are run by the Federal government to help preserve the genetic diversity of plant species that are either currently of economic importance or have potential as future crops. Although there are 29 sites across the country in the NPGS, the four major Regional Plant Introduction Stations are located in Pullman, WA, Ames, IA, Griffin, GA, and Geneva, NY. Additional significant components of the NPGS include a database management unit in Beltsville, MD that oversees the Germplasm Resource Information Network (GRIN) (located at URL <http://www.ars-grin.gov/npgs/>), and the long term seed and clonal backup repository, the National Center for Genetic Resource Preservation (NCGRP), in Fort Collins, CO. The NPGS *Allium* collection is divided between the Pullman, WA and Geneva, NY sites. The *Allium cepa* (onion) and *A. fistulosum* (bunching onion) are maintained at the Geneva location, while all of the other *Allium* species, including garlic (*A. sativum*), are maintained in Pullman at the Western Regional Plant Introduction Station (WRPIS) and curated by Barbara Hellier. The combined mission of the NPGS germplasm repositories is to acquire, maintain, regenerate, characterize, evaluate and distribute this germplasm to researchers worldwide. In addition, NPGS curators and scientists conduct research related to the crops maintained in the system.

When Richard Hannan started working with the garlic collection in 1983, there were only 13 accessions. (An accession is seed and/or propagules of a species considered to be genetically unique, e.g. a cultivar). The collection grew to nearly 300, but now numbers around two hundred accessions. In the early nineteen-nineties there was a concerted effort made to remove duplicate clones. This was done based on country of origin and plant and bulb characteristics. The many different garlic clones in the collection have come from donors across the United States, as well as gardeners and researchers from all over the world, including a couple accessions from Turkmenistan that were collected from wild habitat. Currently, there are accessions from over 30 countries in the garlic collection.

Within the NPGS, the garlic collection is quite unique. At the WRPIS most of the more than 71,000 accessions of plant germplasm are maintained as true seed. Garlic accessions, however, are maintained as clones; 30 cloves of each accession are planted every fall in our field plots and harvested the following summer. Distributions of the garlic, therefore, occur each fall. What is not used for planting or distributed in the fall is stored under controlled conditions of 55-58 F and 55-60% RH with constant air circulation. Accessions that store well are distributed throughout the winter and into the following spring. WRPIS and NRGCP are working on protocols for cryogenic storage, which will be part of our back-up security/storage approach.

Evaluating our collections are a very important aspect of what is done at Pullman. We take plant, bulb, and fertility characteristic data and collect soluble solids content, storage longevity of the intact bulbs and digital images for all of our garlic accessions. Until recently, we used this data in addition to country of origin to choose which varieties to keep or remove from the collection. Now, with DNA fingerprinting becoming more common and less expensive, we can also use DNA information to determine which accessions might best represent the genetic diversity within the species. While many of our accessions have turned out to be very popular with market gardeners, most are not garlic types that suit the US buying public. However, our mission is to help preserve the valuable genetic diversity in garlic for future use.



Grading garlic bulbs in the field. Note the open-mesh type of bag in general use.

# Director's Notes



I turned to face a large woman, a bit lumpy and disheveled, with a broad and welcoming smile. She thrust out her hand and I could feel the muscles in her grip. She thanked me for my presentation, confessed her love for garlic, and I remember her asking me about growing garlic in a window box. Her voice was a unique, cracking falsetto, but I did not recognize her (since I don't live with television), but she was soon surrounded by people wanting her autograph or asking questions. I was a dirt farmer, brought to the Brooklyn Botanical Gardens to lecture about the garlic, and this was Julia Child. I remember her warmth, openness and sincerity, in contrast to the food editor of the *New York Times*, with whom I shared the lectern and who reminded me of a dead carp. She was annoyed that she would have to share anything with a person with dirt and grease under his fingernails! I connected with Ms. Child later that day out in the herb garden, where she painted a picture for me of the fresh garlic markets of Provence, France, and we talked about the changes in the American diet. I had forgotten about this encounter until I learned of her recent death. She was a true alliophile.

## Garlic Granting

Armed with the new DNA work you'll read about in this *Press*, and the fact that the California garlic industry is in decline, a small group of GSF folks thought it a good time to try to go after some grant money to field trial the results of this varietal research. Now that we know which garlics are truly different from others, we can research which specific cultivars will be better suited to grow in a geographic region. The idea was to take each garlic to different regions/soil/altitudes, etc, grow them out, and have the samples analyzed. What looks good, what doesn't? Correlations in the soil and garlic? How do the cultivars express themselves? Does irrigation/fertilization make a difference? Questions ... questions. We went after a USDA National SARE Grant because we felt that the national diversity would give us more variables to consider. We were warned that the national grants were hard to come by and we were turned down, but the NE SARE folks gave us a call and said they were interested. We submitted a pre-proposal to conduct this same research in the NE. They accepted it and invited us to

submit a full proposal, which we are currently working on! This is the first time we've attempted procuring research funds and it takes a lot of time and work. We'll keep you posted.

## Garlic Drying

During the late summer and fall of 2003, many garlic growers experienced a variety of problems with their harvests. We all have our ways of post-harvest handling, but considering the year and incidents of problems, we began asking some questions to folks who have the knowledge and expertise to help us understand some of what we are doing and not doing. In particular, we've talked with Carol MacNeil and Jan van der Heide, both with Cornell Cooperative Extension here in New York. Carol's working with many growers in the drying/curing/storage business, and Jan comes from Holland with experience and contacts in the tulip industry. What was started last winter will be shared in *Press* #45, and we'll be reading/researching more this winter. I know how resistant to change we all are, and I also know how much garlic was lost. Maybe we'll come up with some new/different ideas and maybe some system prototypes. If you have thoughts on this, please send to GSF/Rose.

We're very pleased to get this *Press* issue finished and out to everyone. Thanks to everyone who contributed! Gayle Volk's enclosed work will surely change the world of garlic. We are also including a very special piece on one of our most important tools, our hands. I read this article many years ago and continue to find it helpful. We work hard and need to keep our bodies in good condition.

I hope that your season went well and your bulbs are full and pungent. I shall again remind you that if you wish to contact me, please use the mail or telephone (after dark). I don't have or use electronic communication. I also ask that you have some patience. This farm is working me 13-14 hour days, and I have little extra time or energy. I look forward to meeting with some of you at festivals and winter gatherings.

Bon appétit! (D.S.)

## Newest Bioterrorism Threat

Matthew L. Wald, *New York Times* 7/23/04

**GARLIC POWDER FORCES EVALUATION AT KERRY HEADQUARTERS.** A suspicious substance that turned out to be garlic powder prompted a two-and-a-half-hour evacuation of part of Senator John Kerry's national campaign headquarters in Washington. The hazardous materials squad of the District of Columbia Fire Department was called to the headquarters at 5 p.m., after a mailroom worker opened an envelope and white powder spilled out. The authorities closed the street in front of the building, which is about three blocks from the White House, quarantined the three people who were in the mailroom and tested the substance. Neither Mr. Kerry nor his running mate, Senator John Edwards, were in the building at the time.



Press #44: September 2004

## GSF ORDER FORM



MEMBERSHIP IN GARLIC SEED FOUNDATION (4 issues of <i>GARLIC PRESS</i> , #387, other swell stuff)	_____	X \$15.00	_____
RENEWALS	_____	X \$20.00	_____
8 Issues	_____	X \$30.00	_____
13 Issues	_____	X \$3.00 =	_____
<i>GSF/CORNELL REPORT #387</i> (10 pgs.) (Comes with membership)	_____	X \$12.00 =	_____
<i>GROWING GREAT GARLIC</i> (Engeland, 213 pgs.) Grower's Guide for Collectors	_____	X \$10.00 =	_____
<i>MAD FOR GARLIC</i> (Pat Reppart, 157 pgs.) Cookbook	_____	X \$3.50 =	_____
<i>HOW TO MAKE A GARLIC BRAID</i> , Clove n' Vine	_____	X \$16.00 =	_____
<i>GARLIC, GARLIC, GARLIC</i> (Griffith, 432 pgs.) Cookbook	_____	X \$7.00 =	_____
<i>THE COMPLETE GUIDE TO MAKING GARLIC POWDER</i> (Kimball, 40 pgs.)	_____	X \$25.00 =	_____
<i>STRINGBRAID YOUR TOPSET - VIDEO</i> (Yerina)	_____	X \$8.00 =	_____
GARLIC PRESS SETS	_____	X \$8.00 =	_____
Set #1 (Issues #1-#8)	_____	X \$8.00 =	_____
Set #2 (Issues #9-#14)	_____	X \$8.00 =	_____
Set #3 (Issues #15-#20)	_____	X \$8.00 =	_____
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Any 2 Sets or more \$7.50 each	_____	X \$50.00 =	_____
All 7 Sets	_____	X \$10.00 =	_____
T-SHIRTS M L XL XXL	_____	X \$ 8.75 =	_____
GARLIC PHOTO CARDS	_____	X \$17.00 =	_____
Beautiful Color from Eastern Exposures	_____	X \$12.75 =	_____
Beautiful B & W from Earth Images	_____	TOTAL	_____
IDEAL CAPE COD WEEDER (perfect hand tool for garlic)	_____		_____

Make Checks Payable to: Garlic Seed Foundation, Rose Valley Farm, Rose, NY 14542-0149

\* Members - all prices include postage and New York State Sales Tax

\* Non-members - please add 15% for shipping and handling

\* PLEASE - U.S. FUNDS ONLY



## WIZARD OF ID



*Effects on the Hand and Arm in Industry*, edited by A. J. Brammer & W. Taylor (New York: Wiley, 1982), with many excellent papers from researchers all over the world.

6. C. W. Suggs, et al., "Vibration of power tool handles," and "Resilient handgrips," both in Brammer & Taylor, *op. cit.* In practice, however, thick gloves can make the situation worse if it forces one to grip too tightly, as explained in J. Teisinger, "Vascular disease disorders resulting from vibrating tools," *Journal of Occupational Medicine*, 1972, 14, 129-133.

7. Ronald Knowlton & Jack Gilber, "Ulnar deviation and short-term strength reductions as affected by a curve-handled ripping hammer and a conventional claw hammer," *Ergonomics*, 1983, 26, 173-179; Brian Sharkey, *Comparing Trail Tool Design Efficiency by Measuring Human Energy Cost* (Missoula, MT: Forest Service, 1981). Bent handles benefit the back too, as I've written about elsewhere, but here we limit ourselves to the benefits for the wrist.

8. C. W. Suggs, "Vibration of manual tool handles," in Brammer & Taylor, *op. cit.*

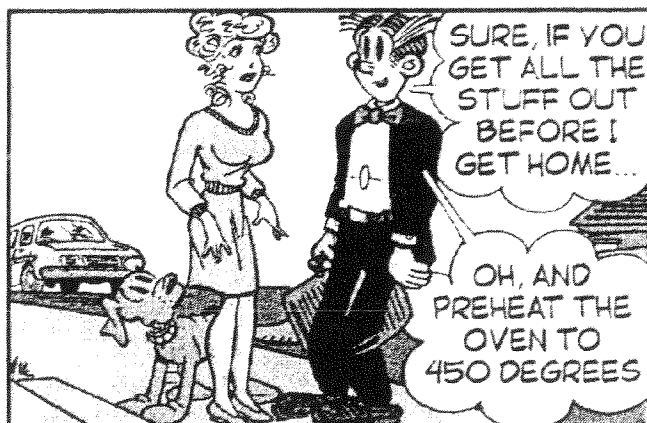
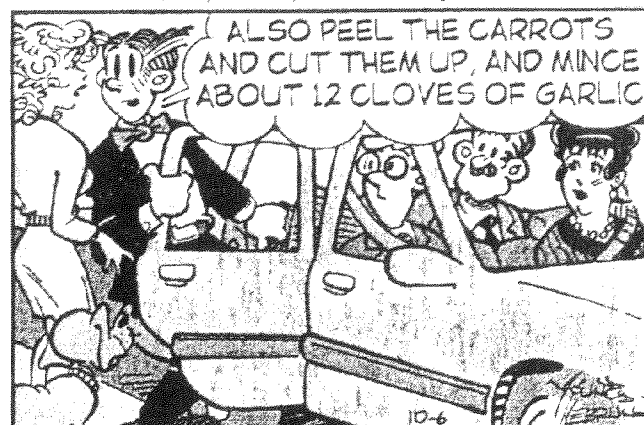
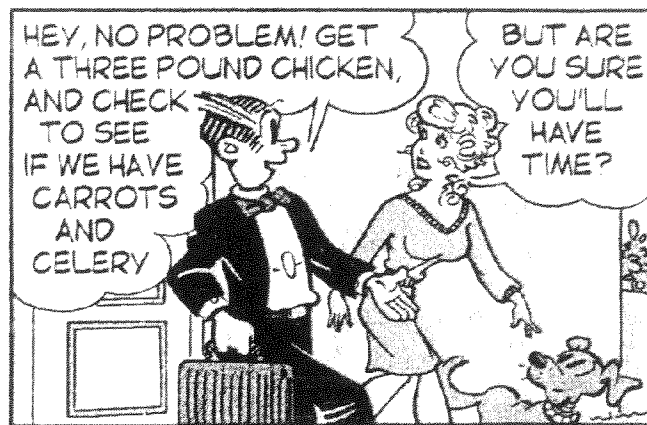
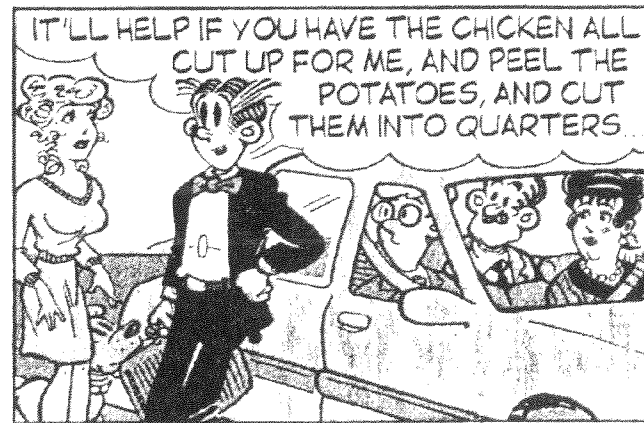
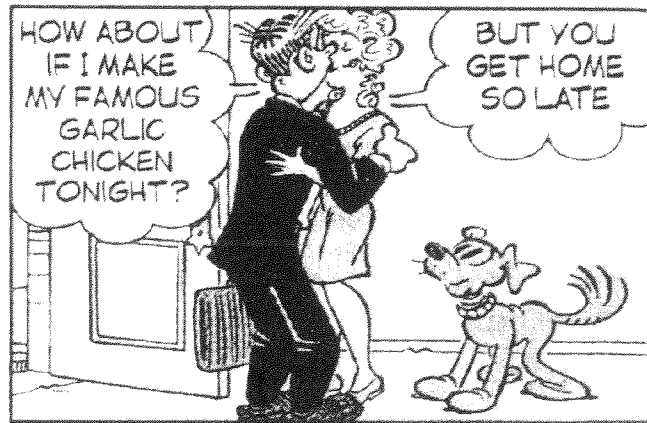
9. I recommend the amazing series of x-rays in William Greulich & S. Pyle, *Radiographic Atlas of Skeletal Development of the Hand and Wrist* (Stanford: Stanford University Press, 1959), which shows what each year of growth does to the hand.

10. Aschoff, Jurgen, "Circadian timing" in John Gibbon & Lorraine Allan (eds.), *Timing and Time Perception* (New York: New York Academy of Sciences, 1984, 442-466).

11. Much more sophisticated exercises are in Daim Batangaris' *Hand Dynamics* (New York: Japan Society, 1984) and Kevin and Barbara Kung, *Hand and Foot Reflexology* (Englewood Cliffs, NJ: Prentice-Hall, 1984).

12. From my article, "Handles," *Horticulture*, spring 1985, pp. 34-36.

[© 1986 GRT. Quotations acceptable with credit given to the Research Department, Green River Tools, P.O. Box 1919, Brattleboro, Vermont 05301]



## ALLIO-PHILE

🕒 **Feeling Better!** Ted Maczka, of the Canadian Fish Lake Garlic Research Station, has a new plastic hip and is going for a plastic knee! Canada's Garlic Ambassador will be taking some time off to heal before he returns to his fields and festivals, bionically.

🕒 **Winter Garlic Meetings:** If you are planning a conference or garlic meeting and want GSF participation, please contact us ASAP. Tentative participation in PA and VA at this time.

🕒 **GSF Brochures:** available for your farm stand, festival, or farmer's market. Contact GSF/Rose.

🕒 **Get Well Soon:** to Fred Sehmeltzer of Sunrise Farm in New Berlin, NY. Fred is part of our team at the Saugerties Fest and we'll miss him this year!

🕒 **Late Notice:** "Scapes to a Good Home. Dakota Garlic is interested in selling bulk fresh garlic scapes mid-late June. Contact Craig at 719-510-9444 or at [sales@dakotagarlic.com](mailto:sales@dakotagarlic.com)" Save this for 2005!

🕒 **Gayle Volk's National Garlic Survey:** If you're one of the brave souls who chose to participate, Gayle awaits their return. Thanks for helping out.

🕒 **Drying/Curing Garlic:** Do you have any special ideas, equipment, or thoughts on this important aspect of garlic production? Please contact GSF/Rose for a future article.

🕒 **Many Thanks:** to everyone who helped put this issue together! (D.S.)

## GSF BUSINESS



Membership means 4 *Press* issues (not calendar year), with the number on your mailing label indicating the issue your membership expires. Issue #42 (Best of *Press*) is on hold until Winter, when time allows us to put it together. We'll send you a postcard when it's your time to renew. Renewals are \$20 for 8 issues and \$30 for 13 issues.

The *Press* is for all to use, and we request and appreciate

your ideas and submissions. Our web site contains information on upcoming festivals and garlic for sale. We continue to collect photos and slides of your garlic, braids, fields, kids, equipment, and to share our collection and knowledge. We urge you to attend Winter workshops, conferences and round tables for farmers/gardeners/consumers, and let us know what is new. (D.S.)

## - GARLIC MEETING -

Wednesday • September 29 • Geneva, NY

3 PM • Jordan Hall

An afternoon lecture/discussion with our Special Guest

**Dr. Gayle Volk, USDA-ARS, Ft. Collins, CO**

Author and primary researcher of our story on her DNA research and what it means for us as producers and the future of our industry.

Followed by:

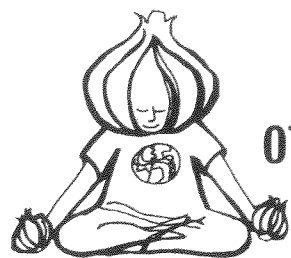
**Garlic Pot Luck Supper**

Bring your favorite dish to share and table service, drinks provided.

Jordan Hall is located on North Street, 150 yards East of the Pre-emption Road intersection, in the Cornell Agricultural Experiment Station. If you are not familiar with the Station, stop and ask when you get to Geneva. (Hint: Hospital Signs will lead you to North Street.)

**Everyone Invited and Welcome**

Sponsored by the GSF - Donations Accepted.



## OUT OF MY HEAD

Bob Dunkel

Garlic in the gully  
Garlic in the grass  
Garlic in the bushes  
They all come on so fast.....

I watch the long and slightly winding rows of garlic filling in now and the push of the continentals to oversee the field, and yet I watch those volunteers that seem so prolific! They come on early and take off like rockets...something about that uninterrupted cycle is telling me things like:

Thickening stalk of grasshopper green  
Before the outline of rows is seen  
Filling the byways and hedgerows about  
Their endurance and vigor is without doubt....

The adaptive ability of a perennial stand of garlic is a good place to examine and select seed stock. Amidst taller clumps of grasslike stands there appear thumb sized garlics here and there that one can immediately recognize as viable and strong. Of course one may not be able to identify the type of garlic but when looking for other characteristics this is an often overlooked means of resurrecting some fine garlics around the farm.

There seems no end to the amount of measurement and study that we intend to input into our built in spread sheets. We analyze, dissect, count, determine degrees of leaf architecture, try various concoctions for seed treatment, fertilization schedules and constantly rethink and retool for weed control under the guise of cultivation. We love names that imbue our characters into this garlic. We associate fire and a range of near ultraviolet colors like burgundy, magenta, purple, red, pink etc into these named accessions. We use terms like marbled or striped to embellish the trace mineral response seen in garlics who've originated in high mineral content mountain areas and we try to duplicate this in flat land farming by cover cropping and using rock powders, granite dusts or seaweeds...exotic arguments for having kidnapped and ransomed these garlics long taken from other climes. What is it though we are really seeking? An edge? A marketing niche—a unique sense of production, variety? From such humble beginnings and having retreated to warmer areas we smuggle our survival and compartmentalize our lives. Garlic is garlic, people are people, brown, red, yellow or white its all just the spreading of light!

This rainbow universe is aswirl in mussel shell and abalone, in the palette of wildflowers, layers of cut rock and in the depths of soils. From Arctic to equator skin tones adjust to electromagnetic rays and land masses long mingled with salt water wrestle in dreams of motion unending. We are displaced and disconnected somehow...A star disappears from the horizon and round we spin, but too often our thought is stationary—frozen like fossils in time and we believe in values that are in our best interest. Heritage is what we have taken in our backpacks and piled on beasts of burden. So we try to

take it with us where we go. We transplant, relocate and still believe we change things and that we are the zeitgeist of the planet! Nay, though, we are the bane, the polluter, the usurer and despoiler of all we pretend is natural but which now is long been altered. So slow at learning that the bounty is everywhere, that the cure is everywhere, everywhere we left alone....In the berries and roots and barks and leaves, of wetlands and forest and bogs and deserts and mountains- but then we remember fear, we see scarcity and become its hostage, we seek to capitalize and profit and yet still pretend that we need not sacrifice and share to maintain a balance to things.

So we chase the sun, spinning backwards as the magnets of commerce beach us like whales and the migratory patterns disappear. We become the manicured rows of kindling for the fires of war. We house ourselves in temporary time and borrow and too often abuse this earth, this land that gives us value rather than the opposite. So we long for booty, pirate treasure, gold and diamonds, gems and pelts and ivory...We substitute their memory with plastic and wood chips and inorganic chemicals, poison brews with no magic, just the intent of control, ethnic cleansing and the pristine look of nutritionless grain that covers the earth whose true mystery has retreated to where we can not so easily reach. 'Tis the bitter herb and sour grass that heals. The pungent bite of wild garlic that cleanses, and yet what does it take to reach out our heads, ear to ear, that lifts the veil of dream memory and salt, of dragons and silicone, carbon and ley lines. Wall street is no pendulum, we forget to dowse for self worth or for the vitality of water. We develop tools and find that we have disabled our own spirits ability to function and in so doing have lost the recognition of purpose...We are the volunteers! We watch the noble energies of a George Washington Carver arise from the ghetto, the brilliance of far eastern science that remembers the lessons of millennia and the madness of overpopulation as if it is different from the cancers that we manifest in imbalance....What is it we want and why?

May you bless your fields with your feet and hands, breathe the solace of Mother Earth and rejoice with the bird and bee that soon the harvest of garlic will be nigh! Try to make new friends and share you harvest and gather together and be joyful...

\* \* \* \* \*

A mighty scape's a waitin'  
For the last leaves to fill in  
Eyeing the sky, it is dreaming  
When that enigmatic curl will begin...  
It is a critical time for us then,  
Like the groundhog of fabled lore  
It marks six weeks to harvest  
And urges us on to be readied.  
Time to think of storage, drying racks et al.  
Time to once again empty out the stall  
Mark the scapes that won't be cut  
Measure heights and ask just what  
Determines satisfaction, what now requires deeds  
To cultivate, initiate the forcing back of weeds.  
Many seasons come and gone  
The years of growing carry on  
We know not what the future brings  
Nor very many other things....

— B.D.

ergonomic problems, since they often diminish the usefulness of the tool to nothing, but this addition does not mar the versatility of the tool. An agricultural consultant told me he now recommends the five-tine cultivator (with center tine removed) with handle assist for weed control in up to two acres of herbicide-free carrots because the handle assist removes the strain from the task, and increases exactness of control as well.

Other tools which turn the wrist out of ulnar deviation to better handle a strong resistance deserve special mention because they can make such a difference: (1) a log hook for picking up wood, similar types used to move bales of hay or cotton; (2) a watering can with handles directly above the weight of the water, whether the water is being transported or poured out; (3) a two-handled thistle puller for pulling out brambles and thistles to substitute for gloved hands in a wrenched position yanking out the plants by the roots; (4) a screwdriver with ball-shaped handle which can be grasped in a number of ways rather than the typical handle which extends the shaft of the tool.

3. Bent handle: Grasp a short-handled tool with the blade coming up from the thumb side of your hand, and set your fist down on a table. The tool will not rise straight up but at about 12 degrees from vertical. John Bennett of East Peoria, Illinois, patented any bend of 19 degrees in a tool, which would make a tool tilt over 31 degrees from the vertical. He and others have applied the bent handles in many situations including kitchen knives, brooms, and golf clubs. The most widespread use was in hammers, which in fact were tested in an ergonomics laboratory; the bent-handle hammer was found to be on average 42% less tiring.<sup>7</sup> Other tests were run on forestry tools from axes to brush-clearing tools. Despite this experimental support and a large marketing effort for the hammer, production has been discontinued because people will not buy them.

Bent handles, however, appear already in axes, bowsaws, pruning saws, carpenter's saws, hedge shears, some trowels, dibbles, wheel hoes, etc.—places we don't think are strange because they've already been that way. There is nothing magic about 19 degrees or 31 degrees; any bend can reduce ulnar deviation. Many tools from around the world—from the crude machetes of African tribesmen to the jewelled daggers of India—have these bends to take the strain off the wrist.

4. Light handles: For striking tools, it is important to concentrate as much of the tool's weight as possible in the head of the tool, to reduce excess energy coming up the handle to your hands and wrist, a consequence known as "handle sting." Wood is better than steel for tolerance of vibration<sup>8</sup>, though sometimes steel is preferable since it can be bent into a better shape (e.g., handles of the wheel hoe). Some people shave their handles even further to decrease the handle weight and increase the handle resilience. The wheel hoe sets the tool and the resistances encountered onto the ground so that the wrist does not meet impacts directly.

5. Handle grip: To avoid slipping, a handle should

have a textured finish with rounded edges and no finger recesses (because fingers vary so much in the population). A textured, non-slippery finish permits one to loosen the grip lightly at impact to reduce vibration—as in the strike of an ax or a digging hoe—without losing the tool. Excellent handle wraps have been developed recently to cover handles which have become splintery, cracked, or slippery. They substitute for gloves, but are better for situations when the sensitivity of the fingers is needed, as in cultivating ground flowers with a handweeder, and setting down the tool occasionally to deadhead old blooms or scoop up cut weeds.

6. sharp Edges: Dull tools stress the body. Dull pruning shears, for example, are quite hard on the wrist. The time to sharpen them is quickly regained in more efficient work. The same is true of a long-handled wooding hoe in the sense that it substitutes for pulling out weeds with a wrenched hand (the clothes-wringing position where ulnar deviation predominates).

### Wrist Care

There are several things you can do to maintain the health of your wrists. The experts recommend for hard work and vibrating tools to structure rest breaks when the work is heavy, to wear gloves and hearing protectors, to grip loosely, and to take vitamin E. In general, do not use your hand as a hammer. Especially, do not hit your wrist against anything. Take special care for children's hands, whose bones are not fully formed until the age of 16.<sup>9</sup>

The flexibility and strength through the wrist will vary over 10% depending on the time of day.<sup>10</sup> Take time to get going in the morning. Simple exercises to help are shaking out your hand as if you were shaking out a dust rag. Let all the tension of your hand be shaken out through the tips of your fingers. Shake each hand for thirty seconds or so.<sup>11</sup> It gets the blood and synovial (joint) fluids moving and removes any stiffness, readying your hand to articulate in the most versatile way.

### Notes

1. From p. 67 of Henri Focillon's "In Praise of Hands," in *The Life of Forms in Art* (New York: George Wittenborn, 1948, second ed., 65-78). See also John Napier's *Hands* (New York: Pantheon, 1980).
2. An excellent anatomy relating structure to function is David Gorman's *The Body Moveable* (Ampersand Press, 123 Woolwich St., Guelph, Ontario N1H 3V1 Canada, 1981). Figure 1 comes from Volume 2, page 96, with permission.
3. Culled from many sources, principally T. M. Fraser, *Ergonomic Principles in the Design of Hand Tools* (Geneva: International Labour Office, 1980); Leo Greenberg & Don Chaffin, *Workers and Their Tools* (Midland, MI: Pendell, 1977) from which Figure 3 is taken; E. R. Tichauer, *The Biomechanical Basis of Ergonomics* (New York: Wiley, 1978); Kathryn Luttgens & Katharine Wells, *Kinesiology* (Philadelphia: Saunders, 1982); and James Hunter et. al. (Eds.) *Rehabilitation of the Hand* (2nd ed.) (St. Louis: C. V. Mosby Co., 1984).
4. Thomas Price, "Lateral epicondylitis presenting as jailer's elbow," *British Medical Journal*, 1982, 285, 1775; William Plavan, "Carpal Tunnel Syndrome," *International Society of Bassists*, 1983, 9, 3-4; B. Falck et al., "Left-sided carpal tunnel syndrome in butchers," *Scandinavian Journal of Work, Environment, and Health*, 1983, 9, 291-297.
5. The most comprehensive reference is the conference, *Vibration*

[continued]

Second, when in doubt, and especially for difficult tasks (like holding your head up for a long bout of reading), keep your wrist straight as in the handshake position.

Thus, when holding a pair of pruning shears, it is up to you to prevent ulnar deviation by bringing the jaws up to a branch rather than straight toward a branch. Pruning shears with angled jaws, meant to prevent ulnar deviation, do not in and of themselves solve this problem—you must think about holding your hand correctly with these too (see Figure 4).

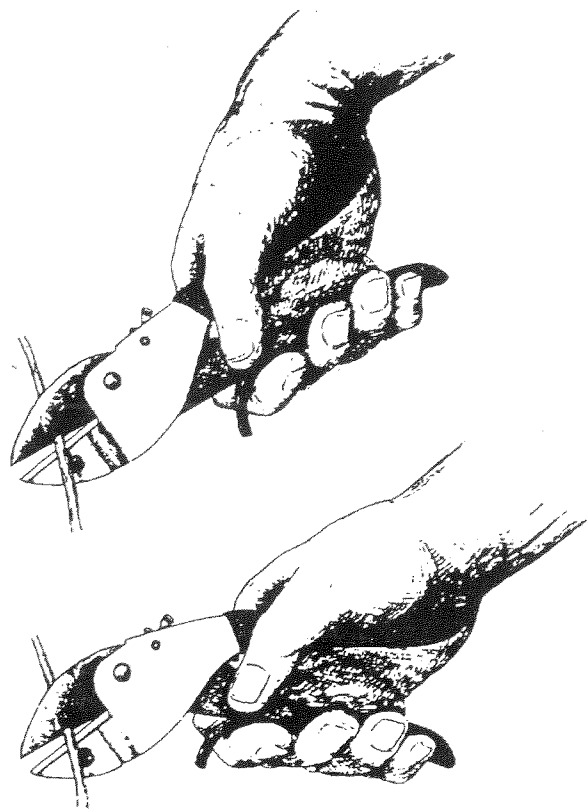


Fig. 4. Bent hands on pruning shears can help prevent ulnar deviation, but knowing how your wrist works helps more.<sup>12</sup>

Another common example: When using a digging fork or spade with a D- or T-handle, take care to hold the wrist straight when thrusting the tool into the soil. Many people rest the handle between the first and second joints of their fingers rather than against the thenar eminence (fleshy pad of the thumb in the palm); the hand goes into extreme extension when they thrust the tool down. Better to use the foot to push the tool head down rather than an extended hand.

Another common example: When using a trowel to dig, the hand is forced into ulnar deviation, often with flexion mixed in. Try instead to use the tool as is done in Europe, with the blade coming from the bottom of your hand next to the little finger, rather than from the top. The digging motion is thus up and down, and the hand is not in ulnar deviation.

Similarly, we ask children to hold eating utensils in the first three fingers rather than in their clenched fist, thus

reducing flexion and ulnar deviation and allowing them to sit up straight!

#### B. Special Tools

Examples of tools designed to solve wrist problems are:

1. Gloves: An ideal glove is like a second epidermis—a pad which fits snugly but is not too thick. Although it is easier to make gloves with seams along the insides of the fingers, this pressure against the digital nerves supplies incorrect information about the tightness of grip. Professor Tichauer<sup>3</sup> once told me, “The digital nerves run along the surfaces between the fingers. Seams along the inside edges of the gloves lead to broken metatarsals!” Responding to my bewildered look—tarsals are foot bones—he smiled, “Broken toes! Poorly made gloves cause you to drop things on your toes!”

Gloves should be long at their entry, enough to cover the wrist area. Some gloves have extra pads here. This is especially important when picking up very heavy and large things like chunks of wood which press against the wrist area. For strongly vibrating tools, the gloves should be very thick—one study found a half-inch thickness advisable when using tools like chainsaws.<sup>6</sup>

I have found gloves which meet these specifications available to electrical linemen but not in retail hardware stores.

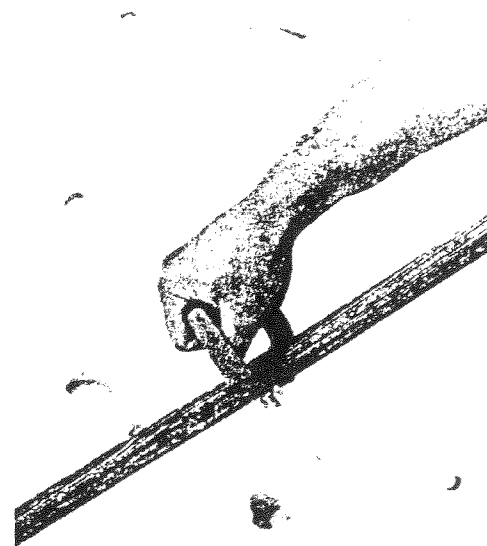


Fig. 5. The handle assist straightens the wrist.

2. Handle assist: Pulling tools such as rakes require you to conform with the lines of resistance to the pull, namely along the handle of the tool. This forces the lower hand into an extreme position of ulnar deviation and the upper hand into a moderate position of radial deviation. In hard pulling, this can create problems. My favorite remedy is the handle assist which turns the lower hand into a straight-wrist power grip (Figure 5). I am usually leery of attachments to tools to cure

[continued]

## How many Garlics are there?

Gayle Volk, Adam Henk and Christopher Richards

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We have recently finished a genetic analysis of 211 *Allium sativum* and *Allium longicuspis* accessions from commercial and USDA sources. We know that garlic, in general, tends to be very responsive to the environment and cultivars that thrive in some locations can do very poorly at others. We suspect that these different responses are dependent upon soil type, moisture, latitude, altitude, and cultural practices. We also know that garlic varieties have been renamed multiple times as they have been passed between growers and gardeners. As a result, many varieties may be identical genetically, yet have unique names. We used a fingerprinting method called AFLP (Amplified Fragment Length Polymorphism) to compare the DNA of different garlic cultivars. A general description of this method can be found at the website: [http://ravel.zoology.wisc.edu/sgaap/AFLP\\_html/fAFLP\\_Introduction.htm](http://ravel.zoology.wisc.edu/sgaap/AFLP_html/fAFLP_Introduction.htm). Using the AFLP method, we have identified many identical as well as numerous unique garlic accessions in federal and commercial collections. The studies presented in this summary will soon be published in the Journal of the American Society for Horticultural Science.

Garlic is botanically known as *Allium sativum*. Another described species, *A. longicuspis*, can be found in the wild in Central Asia and was once thought to be the progenitor of *A. sativum*. USDA's National Plant Germplasm System (NPGS) maintains 193 main accessions of garlic at the Western Regional Plant Introduction Station (WRPISD) in Pullman, WA. One hundred eighteen of these accessions were provided by Barbara Hellier (collection curator) and included in our current study. There are many additional named garlic varieties that are available through growers nationwide. We included 75 commercially available varieties that were generously provided by Walt Lyons ([www.thegarlicstore.com](http://www.thegarlicstore.com)) and Tom Cloud ([www.filareefarms.com](http://www.filareefarms.com)).

In our dataset we included some accessions that had the same names but were obtained from different sources. Accessions duplicated in this manner were identified in tables and figures with an appended number on the name, for example 'Siberian-1' and Siberian-2.' We included these duplications to test if clones bearing the same name from two sources were genetically similar.

#### Genetic Methods

A description of our methods is detailed in our full-length publication. We briefly describe our methods and techniques in this summary. We extracted DNA from two tissue samples from garlic shoot tips within cloves from each of the 211 accessions, which gave us 422 samples. We then followed the standard AFLP protocol as described by Vos et al. (1995). After a series of treatments and digesting the DNA with

enzymes that cut it into pieces, we had DNA fragments that we could separate by size on a large, thin gel.

In Figure 1, DNA fingerprints of several garlic accessions are shown. One accession is represented by a column of bands. Banding patterns differed among samples. The rows of bands in this gel are all the same length. For some pairs of accessions, the band might be absent (white space), and in

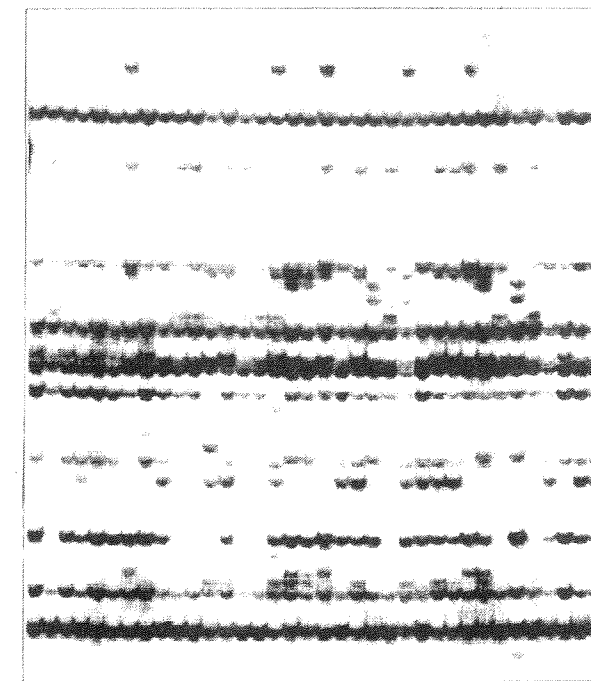


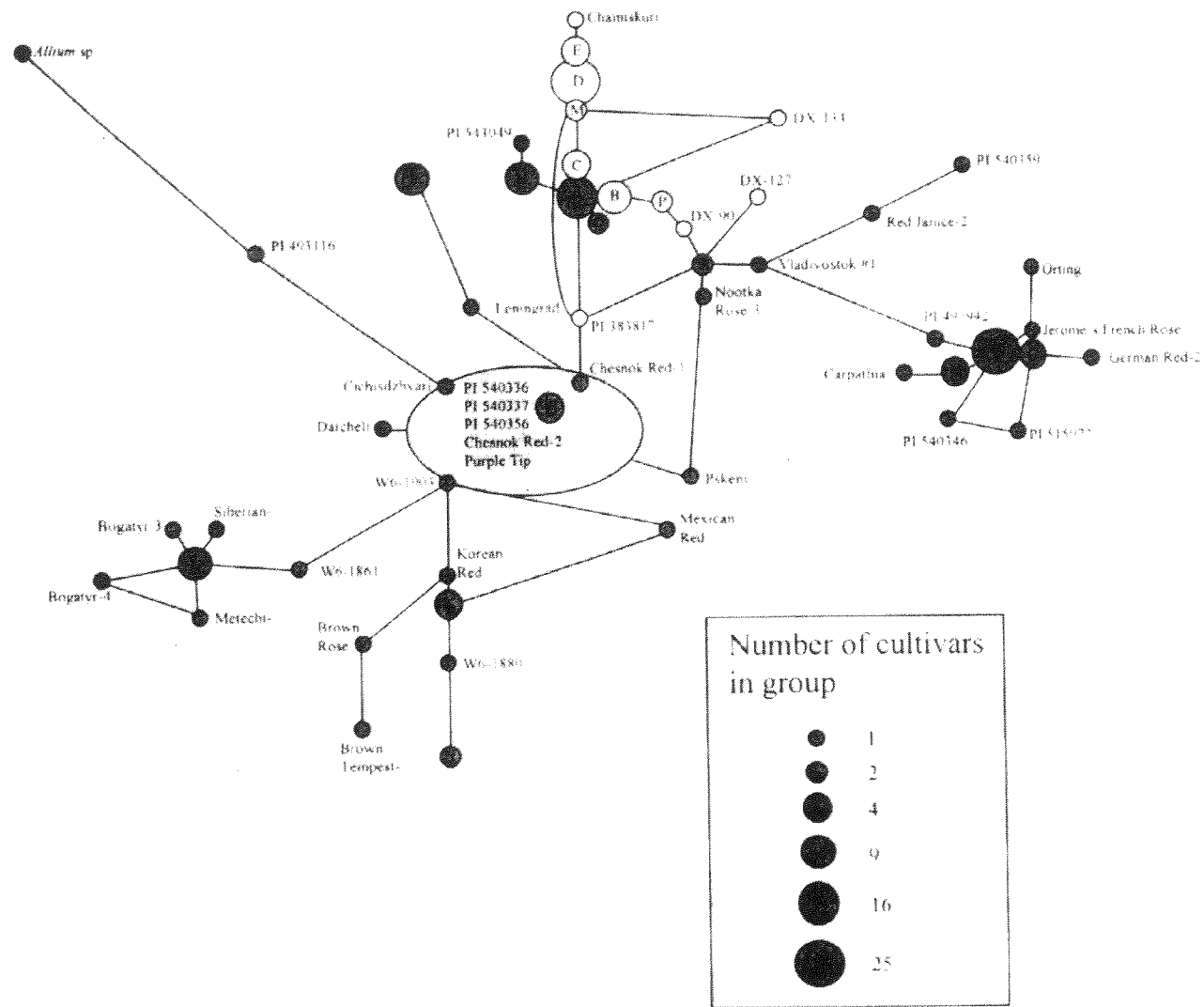
Figure 1. DNA fingerprint pattern for garlic accessions.

others, it may be present (black band). We selected 27 rows of bands (each row is called a locus—a position in the garlic genome) that we scored for all 422 samples. We felt confident scoring 27 rows of bands that were variable between samples, yet unambiguously black or white for all the samples. We then made sure that the fingerprint assigned was identical for both of the two replicate DNA samples for a given garlic cultivar. For 158 samples, the scores were identical between the replicate samples for each cultivar. For the remaining 53 of the 211 cultivars, 26 of the 27 loci scores were in agreement between the two replicates. We considered that one locus to be a “missing data point.” We performed a number of statistical analyses on these data to determine differences and similarities across cultivars in our dataset. These results will be presented in a detailed manner in our published paper. Here we concentrate on the results revealed by one of our figures.

**Results**

We used the technique called a minimum spanning network that uses genetic distance to graphically illustrate genetic diversity among the complete set of 211 accessions (Figure 2). Genetic distance measures how closely related one individual clone is to another. This diagram shows similarity among the 211 accessions in our study. The length of the lines between nodes in Figure 2 reflects genetic distance. In some cases, connections among nodes create loops in the network where there are several "closest" relatives. In fact, the network is better thought of as a mobile in three dimensions that has been laid flat. This would explain why lines connecting nodes that appear far apart are linked in the two-

dimensional representation. The large ellipse in the center of the network represents accessions with many connections and appears to be the basal or most primitive group of accessions because of its similarity with an unrelated *Allium* species. The diameter of each node is proportional to the number of accessions in that group. We were able to identify garlic accessions that were unique, and the names of those accessions are written directly on Figure 2. Many of the clones, however, were clustered into genetically identical groups listed as lettered nodes in the network. The names of the clones that were assigned to a lettered node are listed in Table 1 [not included here].



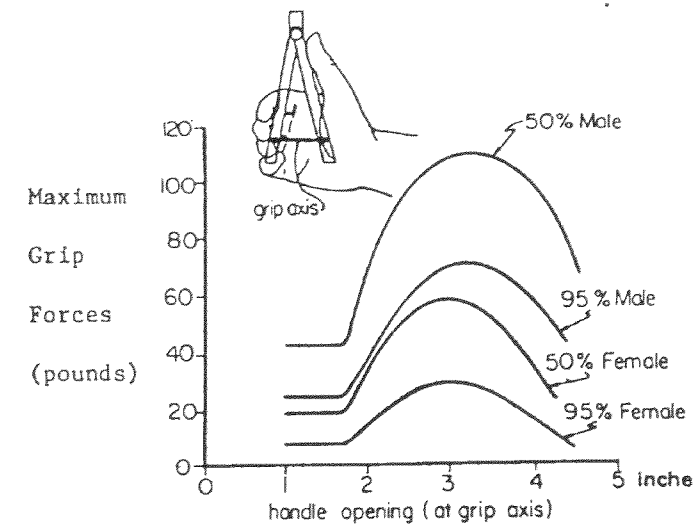
**Figure 2.** Minimum spanning distance diagram illustrates the genetic relatedness among 211 garlic clones. Node size (circles) represents the number of genetically identical accessions. There are several samples in a lettered node (key to letters is provided in Table 2 [not included here]). Accessions and nodes that are primarily softneck (white circle) or primarily hardneck (dark gray circle) are identified. The central region is shaded (light gray) since it was difficult to show the many interconnected lines among the listed varieties.

leading to "tennis elbow" (technically, lateral epicondylitis). The person need not play tennis to contract "tennis elbow"; indeed, it is known as an occupational hazard among jailers (from turning keys), bass viol players, and butchers.<sup>4</sup> Referred pain can be experienced also in the shoulder.

A more common example than the jailer or bass player is the chainsawyer, where Precision is required in the control of the throttle and emergency stop switch, Power in the grip of the handles, Vibration tolerance from the engine, and Bending of both wrists as in flexion of the left hand and ulnar deviation of the right hand when cutting downward.

Though several studies have confirmed that it takes 5000 hours of chainsawing to develop Vibratory White Finger, it has been found to be cumulative, sometimes irreversible, and widely varying, some people developing symptoms after a very short time handling chainsaws. Also, small homeowners' chainsaws have been found to have more handle vibration than large commercial chainsaws. Other power tools have been found to be troublesome: jackhammers, handheld grinders, chipping hammers, motorcycles, lawn mowers, sabre saws, and pad sanders. The ads titled "torture" which show a person wrestling with a rototiller, stress lines emanating from his body, may be truer than the advertising department realized.<sup>5</sup>

As the stress situation grows worse, further symptoms that have been observed are tingling of the extremities, profuse sweating of the hands, extreme sensitivity to cold, pain in the hands and arms, dull headaches, general anxiety, sleep disturbance, injury of bones and joints, weakness of muscles, numbness spreading to the legs, death of a finger, nausea and dizziness, and neurosis. The symptoms can appear singly or together, and not always in this order.



**Fig. 3.** Maximum grip strengths for various handle sizes.

Another combination which does not work is Range of grasp and Strength, as is shown in Figure 3. Shown there are the maximum grip strengths for the strongest half of American working men, the strongest half of American working women, the strongest 95%—that is, nearly all—of the men, and the

strongest 95% of the women. The conclusion is that the objects which one can manipulate with strength must be of a certain size (and, as we shall mention later, shape and texture). The strength figures can all be reduced by 30% when the wrist is moderately bent, up to 50% or more when extremely bent.

I could go on with special pairings, but I shall skip to the point: Every one of the five capabilities cannot really mix with any of the others.

Researchers have discovered that there are three other factors which don't combine with the five capabilities of the wrist. Physical strain on the wrist can turn into a serious malady more readily in the presence of *noise*, *cold*, and *emotional stress*. We know that tendons are more susceptible to the effects of cold than are muscles, and perhaps that is an explanation for this factor. But noise and emotional stress can only be explained as inputs to the nervous system. Wrist problems are thus a two-way street—they can cause nervous problems which spread to the rest of the body as the symptoms noted above, and they can also be precipitated by nervous problems which already exist.

Not only power tools create problems. Poor design and/or poor use of many hand tools can lead to trouble. Strength, Vibration tolerance, and Bending are often combined in striking tools like hammers and digging hoes. Strength, Bending, Range of grasp, and sometimes Precision are called upon by twisting-and-cutting tools as in pliers and pruning shears. These effects are not as serious as with power tools, but also not to be neglected.

**Tools to Solve the Problem**

**A. Technique**

I emphasize the seriousness of these problems because I have known the sufferers and have experienced some of the symptoms myself during my work with tools of different sorts.

When I taught an anthropology class about the hand, we all went around for two days with our fingers taped together: One learns to appreciate what one has lost.

You can learn an important fact about the wrist right now. While you read, prop your head up on your palm supported by its elbow on a table, the hand thus in extension. After an hour, your wrist may be quite sore, an irritation which takes some time to dissipate. Now you know why Rodin's "Thinker" props his head on the knuckles of his fist, and thus you've learned the two most important principles one can deduce about how to handle tools safely.

First, better than any design feature or accessory to a tool is your own knowledge of your capabilities and their limitations. Aristotle said, "A tool that would explain its own use would be invaluable," meaning even cleverly designed tools can be used improperly. You must watch *how* you use your hands with different tools for different jobs, and make corrections based on what you learn.

[continued]

should know: (a) ulnar deviation when the little finger bends toward the ulna bone in the forearm (sometimes called adduction, meaning in the anatomist's palms-forward stance, the hand is coming closer to the center of the body); (b) radial deviation (or sometimes abduction) when the hand moves out from the body, the thumb going toward the radius in the forearm; (c) extension (or sometimes dorsiflexion), the back of the hand coming back toward the forearm; and (d) flexion (or sometimes palmar flexion), the palm coming forward to the forearm. I am astounded at the disagreement between studies of human movement as to the maximum angles than can be achieved in these movements. The average of the averages (from which many individuals would deviate with greater or lesser flexibility) are as follows: ulnar deviation, 45 degrees from a straight arm (the handshake position); radial deviation, 20 degrees; extension, 70 degrees; and flexion, 80 degrees.

Fig. 2 Extreme positions of the wrist



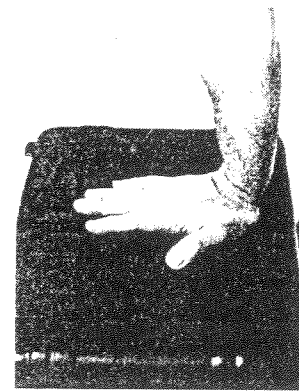
flexion



ulnar deviation



radial deviation



extension

3. Precision: The many tendons and nerve endings in the fingers permit a sensitive and delicate grasp by the fingertips which is firm but not strong.

4. Vibration tolerance: the hands can soak up the excess energy of another object, such as a chainsaw, ax, or rambunctious child, which if connected directly to the torso, would quickly exhaust it and damage internal organs.

5. Range of grasp: The fingers can spread to great distances to handle objects of many different sizes.

#### Combinations

Many of the capabilities can be combined. A "twist of the wrist" (strength plus bending) makes for the winning finesse of the best baseball pitchers and expert weeders, the finest dancers and the swiftest axmen.

For average people who don't practice as much as the professionals, and/or for poorly designed tools and work situations, the limits of combining can be exceeded, leading to serious difficulties.

The most frequent example is the combination of Strength and Bending, as in a tool handle that is grasped tightly for hard work and yet is used in a wrist position of ulnar deviation. The worse example of this sort is the wrenched hand, the hand that twists off firm jar lids or which wrings wet clothes—observe how frequently you use this position with tools. In these cases, the tendons, especially the ones turning corners through the carpal tunnel and around the metacarpal bones, become chafed. The tendons, sheaths, and bursae (cushions) become inflamed and swollen, making the passage more cramped. Nerves and blood vessels passing through the carpal tunnel can be impaired in their function or they can swell also; there is pain whenever a tendon moves through the irritated area, a situation diagnosed as carpal tunnel syndrome (CTS) or tenosynovitis. CTS can lead to numbness, tingling, and/or pain in the wrist and parts of the hand.

CTS can contribute to Vibratory White Finger or Secondary Raynaud's Phenomenon.

Strain on a tendon can cause its other end also to swell, at the attachment at the lateral epicondyle of the elbow, thus

[continued]

Overall, 64% of the WRPIS and 41% of the commercial accessions had some degree of duplication according to this method. Cultivars may differ at loci that we did not examine. Therefore, cultivars that we identified as belonging to the same group are genetically very similar (but statistically identical). We certainly **DO NOT** promote the renaming of known accessions since there could be genetic differences among cultivars that were not identified using our method.

Growers looking to maximize the diversity of accessions they are growing should select a clone from among nodes in the networks. Alternatively, if some growers know that accessions listed under group "F" and "G" grew and sell particularly well in their region, they may want to try other accessions that are assigned to those nodes. Finally, if planting stock for an accession listed under group "I" is unavailable, a grower could try to grow a differently named, yet genetically similar accession listed in the same group.

Our genetic analysis confirms previous observations of Pooler and Simon (1993), Ipek et al. (2003), and Al-Zahim et al. (1997) that *A. longicuspis* is indistinguishable from *A. sativum* and may not be an appropriate taxonomic entity. These data also provide some indication of the diversity of garlic lineages. There is substantial structure in the network that indicates the genetic origins of certain plant morphologies. An example of this is the split between hardneck (dark nodes) and softneck (white nodes) clones.

\* \* \* \* \*



## Alice Asks . . .

**Why do you use the tip of a clove to look at the garlic's DNA?** We used the very young shoot tip within the clove. Most garlic varieties are infected with viruses. These viruses are most prevalent in elongated leaves. We used shoot tips for our studies since it would lower the likelihood of having viral DNA contamination in our DNA samples.

**Why did you choose the 27 bands to compare, how many loci are there and why?** There are hundreds of loci that we could have included in our studies. We picked 27 loci to score that showed some variance between samples and were unambiguously black or white on our printouts of the gels. For many loci, faint bands could be seen. It was difficult to tell if these very faint bands were background marks or were bands that didn't amplify well in some samples.

**I don't understand. If all garlic comes from the same place, why is DNA different?** At one time, garlic propagated itself by seeds, like onions. Crossing between varieties brought about new genotypes of garlic. In recent years, garlic has been propagated primarily as clones (using cloves or bulbils). This garlic is much less likely to change genetically from one generation to the next. However, random DNA mutations can occur.

**Since you've done all this work, and now that we know we're growing duplicates, why not just use the groupings you've shown us and get rid of the rest?** Our DNA studies only compared 27 loci in the genome, out of its total of 30 billion base pair length DNA (most of which base pairs that

These data suggest that the softneck neck type may have arisen out of a much broader hardneck pool of diversity. These kinds of analyses provide a framework for further studies on the domestication process but also for the development of forensic tools that can be used to provide the genetic identify of garlic clones.

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don't actually encode for genes). Statistically, we can say that we could identify groups of varieties that were identical. When we increased the number of loci to more than 100, these groups were still identical. Our approach has identified groups of garlic that are very similar to one another genetically. However, differences could exist in regions of the genome that we did not examine.

**So, if I count correctly, the table that goes with the spanning tree tells me there are (A-R) 19 garlies, is that right?** No, there are 19 groups of garlic that we identified. There are also a number of unique varieties whose names are shown directly on Figure 1.

**What's the difference between a variety and a cultivar?** According to the International Society for Horticultural Science, a cultivar is a "group of individual plants which collectively is distinct from any other, which is uniform in its overall appearance and which remains stable in its attributes." There are lots of garlies that appear similar to one another, so 'cultivar' may not be a good term to refer to various garlies. According to the American Society for Horticultural Science, the term "variety" is synonymous with the term "cultivar." It has been suggested that garlic accessions could be referred to as "clones" since they are clonally propagated.

**If you did the same DNA tests on the cousins, onions, leeks, or elephant garlic, would they look similar?** The banding patterns on our gels would be very different than those we

## Alice Asks (continued)

observed for garlic. AFLP technique has been used to study diversity in other *Allium* species.

**Is there any place GSF members could send their garlic to have someone test it and tell them its variety? Cost? Location?** Unfortunately, I'm not aware of anywhere that garlic varieties can be genotyped. There are no uniform standards developed to define each garlic variety. Genetic technologies are always improving, so hopefully there will be some new techniques available in the future that will prove to be reliable and cost-effective for genotyping this crop.

**How long did it take to do all these DNA tests and why did you do it?** A technician worked full time on this project for 2 years. The project ended up being much more

difficult than we had originally anticipated. We did it so that we would have a better understanding of the genetic diversity of garlic that is available commercially and at USDA's Western Regional Plant Introduction Station in Pullman, Washington. Prior to our work, there were no studies that demonstrated the correlation between the genotypes and phenotypes of US garlic varieties. Ultimately, we plan to back up this garlic collection using cryopreservation techniques. It's a lot of work to cryopreserve garlic and we'd like to focus our efforts on accessions that represent each genetic group of accessions as well as genetically unique accessions.

**Now for the last and most important ... would you like to share your favorite garlic delight or recipe with us?** I like to add garlic to pasta sauces and, of course, we make a lot of garlic butter for bread.

## Vinegar Herbicide, Continued

Shortly after the *Press* #43 published Fred Forsburg's article on his SARE grant, we had many telephone calls. The first was from Fred pointing out our printing errors: Fred's electronic address is [honeyhillfarm@excite.com](mailto:honeyhillfarm@excite.com) and the SARE web site where you can find the entire report is [www.sare.org](http://www.sare.org) (Fred will send you a copy).

Fred and I wanted to expand and clarify some additional points as well. The 10% Acetic Acid is corrosive to certain gadgets - and your eyes. Caution must be taken. Check with the manufacturing representative for your particular sprayer and ask about the use of acetic acid. Solo Sprayers from Germany use a vixton material which is O.K. a CF Valve is a constant flow adapter for pressurized backpack sprayers which allows you to deliver a constant pressure no matter what's going on with your arm stroke. They are made for many different sprayers (different sizes and threads). Their web site is [www.cfvalve.com/cfvalve\\_ag004.htm](http://www.cfvalve.com/cfvalve_ag004.htm) and cost about \$15.

Now that several producers have been using vinegar, we can report their observations: Spray when it's hot and sunny for best results. Works well on broadleaf weeds but not on vines or grasses. You can give a double dose, but it's seldom needed. Choose a nozzle that won't "overapply." Don't waste

material and experiment with height and speed as you go for most efficient application. It appears to work equally well for the softneck, hardneck, elephant garlic and for onions, but the big question was: "Where can I purchase 100 grain (10% or 200 grain (20%) vinegar? Well, it just so happens that there is a vinegar plant between Rose and North Rose (New York) and the GSF has:

### 200 GRAIN (20% Acetic Acid) VINEGAR FOR SALE

1 gallon and 5 gallon sizes available  
Cut 1:1 with water for 10% usable solution.  
\$3.00/gallon + S&H

Great for burning weeds or kickass pickles!  
Shipping is expensive, so call/write  
GSF/Rose if you want to buy some to use.

It doesn't freeze. MSDS provided. (D.S.)



## Hands, Wrists, and Tools

by David Tresemer, Research Department, Green River Tools, 5 Cotton Mill Hill, P.O. Box 1919, Brattleboro, VT 05301

Flexible relations between the 27 bones of hand and wrist permit a cooperation in subtlety and power greater than in any other creature. Physiologists call these positions "articulations," and this is not the only sense in which the hand is articulate. Hands speak; they show vigor, surprise, sadness, a thousand expressions. Hands also listen; "my hands," said the centaur, "have felt rocks, waters, plants without number, and the subtlest impressions of atmosphere, for I lift up my hands on dark, still nights to detect the breezes and so discover signs to make sure of my way."<sup>1</sup> A moment's experience of one's own hand shows that the origin of this range of capabilities is the wrist, refining the general direction of the long arm bones into a specific application, the fingers sensitively completing the task.

But things can go wrong. Abuse of the wrist can contribute to "white finger," where blood supply of one finger is diminished sometimes to the point of death of the finger. Abuse can also lead to "tennis elbows," where pain is felt in the elbow to the extent that any movement for the forearm is excruciating. Abuse can also lead to headaches and behavior disorders. How can this be? We need to look at how the wrist works—the "ergonomics" of the wrist—in order to find out.

### How the Wrist Works

I am easily lost in the fascination of the many structures in the wrist and hand which permit me to move in so many orientations—the muscles, tendons, sheaths, with their nerve and blood supplies, all wending through and attaching to the eight odd-shaped bones of the wrist, and the nineteen bones of the palm and fingers. The names devised by anatomist are also fascinating; e.g., the *flexor digitorum profundus* and *flexor digitorum superficialis* function to bring the digits (fingers) down into the palm. How can something so seemingly simple as my hand, so taken for granted, be so complicated?

We don't need to understand the details to use our hands but we do need to know the general principles in order to avoid problems. Simply put, there are many more muscles and tendons than there are bones; the combinations of their actions give an infinite range of possibilities. But there are very few muscles in the hand and wrist. Most of the movements are powered by muscles in the forearm. You can test this yourself: When you cut with scissors or pruning shears, feel your forearm with your other hand to see how much activity is going on. Cut with them in many different wrist positions to get an idea of how many different sets of muscles are involved.

Many of the muscles which create movements in the hand are attached to the condyle (knuckle-shaped base) of the humerus (upper arm bone) and to the upper ends of the radius and ulna (forearm bones) at the elbow. The pulling power of the muscles is translated to the many destinations in the hand by strong thin tendons, originating about half way up the forearm at the end of the muscle and traveling through a set of fibrous ligamentous sheaths at the wrist to keep them in place. The sheaths at the wrist are particularly strong and form a passageway called the carpal tunnel. Were the sheaths not there and the tendons thus connected like a bowstring in a

straight line, the wrist would be 7½ inches wide (vs. the average of 2½ inches) and 10 inches thick (vs. the average of less than 2 inches). Thus, in many positions, the tendons must turn a corner, sliding within the sheaths which are throughout the wrist (and hand). Also through the carpal tunnel run many of the nerves and blood vessels of the hand.<sup>2</sup>

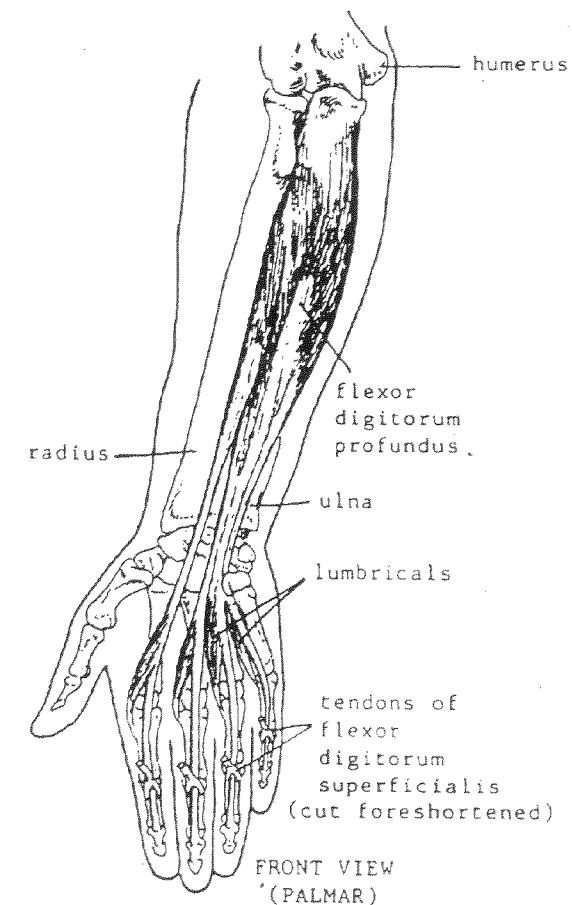


Fig. 1. Muscles and tendons of the *flexor digitorum profundus* and *superficialis* (Gorman, modified from Kapandji).

### Capabilities

Each capability of the hand makes it special in relation to other organisms. Yet there are limits within each capability, and especially limits when they are combined.<sup>3</sup>

1. **Strength:** The average strength of the adult human hand in the palmar power grip is 110 pounds for men and 77 pounds for women, with a good deal of overlap between groups; some individuals show much greater strength. Continuous holding is more difficult than repetitive grasping as muscles tire unless massaged by movement.

2. **Bending:** The hand can approach from different angles. The four extreme positions (Figure 2) have names which one

[continued]