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The nearest thing to come along before sliced bread was, of course, the bread. But before there was bread, there was a neat thing known as flour. And before flour there was cultured grain. And before cultured grain was a wild little grass that about 10,000 years ago dropped the first seeds of agriculture and began feeding the neat thing known as the civilized world.

Wheat helped establish humankind’s first farmers and today remains the primary source of food eaten around the world. Americans consume about three bushels per person annually in the form of daily bread, cereal and pasta.

Wheat is a grain so readily available and in such abundant supply that it is often taken for granted by most U.S. consumers. While bread can be made from other grains, wheat is the only grain that can be made into dough that rises and produces light, fluffy baked items.

That’s good and bad, as far USU wheat breeder and Plants, Soils and Biometeorology professor David Hole is concerned. Ubiquitous wheat and its products aren’t here by happenstance, he says. Nor will wheat continue to be without the continual arrival of new pest- and disease-resistant strains that also use less fertilizer and require less water.

“As far as we know, wheat was the first agriculture,” Hole says. “We need to make sure that science does what it can to sustain the plant that sustains us.”

The clearest evidence yet that wheat was indeed the first domesticated grain was cited in the journal, Science, this past November. A team of European scientists reported that today’s cultivated einkorn wheat is similar genetically and in appearance to their ancestral wild varieties that were first domesticated about 8000 BC in the so-called Fertile Crescent of the Middle East.

The scientists analyzed 68 lines of Triticum monococcum and 261 wild einkorn lines, T.m. boeoticum, still growing in the Middle East. Because that wild group grows today near the Karacadag Mountains, near the modern city of Diyarbakir, and was presumably there in antiquity, it is “very probably the site of einkorn domestication,” the scientists conclude in the article.
Dr. Hole says many of the ancient wheats are diploids, meaning they have two sets of chromosomes. Modern wheat, a hexaploid, has six sets. He says that is likely a result of a diploid wheat progenitor naturally hybridizing with tetraploid (four sets of chromosomes) wheat.

Ancient humans weren’t concerned with chromosomes of wheat, but were driven by the same motivations scientists such as Dr. Hole have today: to find the highest quality, highest producing source of food. And although the ensuing years have brought a more high-tech method of enhancing the quality and yield of wheat, the goal of scientists today is the same as the ancestors who improved their crop by accident using a stone sickle.

Ancient man, in the process of reaping wild einkorn grain over a few centuries, without knowing it caused small alterations in a couple of genes. The new DNA analysis cited in Science shows that an alteration of only a couple of genes could have transformed the wild einkorn into a cultivated crop. Ancient harvesters would have selected stalks more laden with grain to be stored for the following year’s seed stock. The resulting mutations, such as plumper, more clustered and more nutritious grains that cling to the stem until ripe, were the result.

Biogeographer Dr. Jared Diamond said in The New York Times recently that the DNA analysis helps explain why densely populated agricultural societies arose so much earlier and developed so much more rapidly in Southwest Turkey than in the New World. Diamond said maize (corn) didn’t become a cultivated crop in central Mexico until several thousand years later.

Spaniard explorers are said to have brought wheat to the New World in 1500s, and American settlers planted it as early as 1602 in Cuttyhunk Island, near Martha’s Vineyard. It was being planted heavily in the Colonies about 100 years later.

The country’s main genetic “library” of wheat is in Aberdeen, Idaho, at the USDA’s Agricultural

The Fertile Crescent

The Harvester Vase, from Hagia Triada on the island of Crete, c. 1500 B.C, late Minoan period, approx. 5” wide.
Research Service National Small Grains Collection. It holds more than 110,000 accessions of some 130 species and subspecies of wheat, barley, rye, rice, oat, and triticale and related wild species.

Tetraploid wheats found in northern Israel, Iran, Iraq and Turkey are considered possible sources of genes to produce higher protein levels in modern-day wheat.

Dr. Hole says key improvements in wheat quality probably lie in enhancing protein because wheat's most important components for dough are its gluten proteins, which enable wheat flours to produce strong yet pliable doughs.

Gluten has some 100 to 200 different subunits joined in an incredible number of combinations that may affect the proteins' nutritional and physical qualities.

During the past 30 years, better ways to isolate gluten's two main constituents—gliadins and glutenins—have been discovered. That is important, he says, because protein content in hard red winter wheat has shown signs of decline.

Complicating glutenin studies is the fact that all glutenins aren't equal, Dr. Hole says. Some scientists speculate that glutenins with high molecular weights give dough added strength and elasticity, and thereby

FOR SOME, DAILY BREAD CANNOT BE WHEAT

Even though wheat is considered a staff of life, the millions of people who have celiac disease must avoid it like a plague.

A person with celiac disease who eats wheat can experience a long list of minor to severe symptoms such as paleness, sore throat, diarrhea, bone disease, tetany, anemia, neurologic disorders, blistering skin rashes, and even death.

Celiac disease, also called celiac sprue, occurs in people whose bodies cannot tolerate gluten, a mixture of the two main groups of storage proteins in wheat.

The actual number of people worldwide with the disease is unknown, although estimates range from 1 in 250 to 1 in 2,000. The disease usually only affects Caucasians and appears to be hereditary.

The number of Americans with the disease can only be estimated, primarily because the disease hasn't been the focus of much research. Scott Adams, who has celiac sprue and provides a celiac support page on the Internet, says during the past 30 years, 6,276 scientific research papers have been published on celiac disease; only 10 were from the United States.

In an effort to deepen the pool of knowledge about the disease as well as increase public awareness of the disease, a nationwide survey is scheduled to begin in May.

Also, the University of Utah is recruiting participants for a study to detect genes that may predispose individuals to celiac disease. Study organizers are most interested in sibling pairs and extended family members. Contact Jeff Black at 800-444-8638, ext. 15075 or jeff@episun5.med.utah.edu for more information.

Gluten, which gives bread its texture and dough its elasticity, when eaten by celiacs will inflame and flatten, sometimes dramatically, the nutrient-absorbing surface area in the small intestine. The result is a decrease in the amount of surface area available for nutrient, fluid and electrolyte absorption.

There is no cure, although celiacs can lead normal, healthy lives by following a diet that contains no gluten. Extra vitamins can be taken, but the only way for a celiac to avoid
damage to their intestinal villi and the associated symptoms is by maintaining a gluten-free diet.

Dr. David Hole, a USU grain geneticist, says celiac sprue might appear as a minor affliction to most people who don’t have it and who usually eat between 10–40 grams of gluten per day.

“But stop and think about the practically infinite ways that you eat wheat in all its forms; all the cereal, breads and pasta. Now stop and think what your diet would be like if you had to constantly avoid those things.”

Sources: Dr. David Hole, Michael Jones, Bill Elkus, Jim Lyles, Lisa Lewis, Evan Hunt

HOW BREAD RISES

Gliadin and glutenin, two proteins found in flour, give bread its texture. When flour is added to water and kneaded, the proteins swell up like sponges and form gluten, which traps the bubbles of gas and makes dough rise. The gas is a result of the leavening action of a tiny one-celled fungi call yeast. When yeast is combined with flour and water, a sticky white dough is formed and fermentation is taking place. (The fermentation has caused some people to call leavened bread "a loaf of beer" because bread and beer making processes are similar.) In bread, enzymes from the yeast cells attack starch, breaking it down into glucose. Other enzymes transform glucose molecules into carbon dioxide and ethanol. The CO2 then bubbles up through the mixture, causing the dough to rise. Breads that are leavened by baking powder instead of yeast lack the flavor of fermented bread because when baking powder gets wet, a chemical reaction occurs that releases only CO2, salt and water. In breads leavened with yeast, however, the yeast cells grow under anaerobic conditions and cannot convert glucose molecules completely to gas. Some sugar molecules get sidetracked and are converted into alcohols, acids and esters.

Source: American Institute of Baking

better bread. Enhanced resilience enables doughs to remain strong throughout the kneading process involved in baking.

Genetic engineering should make it possible to modify the natural proteins, which might yield superior glutenins capable of outperforming those in wheat today.

Glutenin’s disulfide bonds might hold clues to engineering ideal proteins for baking. The bonds can link one part of a glutenin chain to another part of that same chain. And perhaps even more important, the bonds make it possible for one glutenin protein to crosslink with another. JT

MORE INFO

David Hole
dhole@mendel.usu.edu
(435) 797-2235

UTAH WHEAT FACTS

- New Utah wheat cultivar releases since 1979:
  - Powell Wheat
  - Wynne Wheat
  - Rick Wheat
  - Sylvan Wheat
  - Manning Wheat
  - Ute Wheat
  - Promontory Wheat
  - Garland Wheat

- About 160,000 acres in Utah were farmed as winter wheat in 1996.

- Winter wheat in Utah yielded 31 bushels per acre in 1980. Through research efforts by USU and Utah Agricultural Experiment Station scientists, yield in 1997 was 49 bushels per acre.
Conjugated linoleic acid is a mouthful of a name for a compound that used to be easy to swallow. That was before the advent of the modern low-fat diet. Now science is indicating that one side-effect of people cutting out fat is cutting out CLA, a component of fat that has been shown to slow the progress of some types of cancer and heart disease, and appears to actually help reduce body fat and increase lean muscle mass.

"We have a tendency to get a little information and think that all fat is bad," says Dr. Tilak Dhiman, a USU animal scientist who is examining ways to increase the CLA content of the milk, cheese and meat. "We must distinguish between types of fats. We tend to think all fat is bad for us, but nutrition is very complex and we don't know everything about it."

CLA is a fatty acid that occurs naturally in many foods and is especially high in milk and meat from ruminant animals such as cows, sheep and goats. The acid is produced by bacteria in the rumen.

While the relationship between diet and cancer is extremely complex, CLA has been found to inhibit the growth of chemically-induced skin and stomach cancers in mice, as well as cancer in the mammary glands of rats. Studies in other animals have produced similar results.

Synthetic CLA similarly changed the body composition of laboratory animals; they developed more muscle and had less body fat.

In following the food chain down to the molecular level, Dr. Dhiman has found that the amount of CLA has everything to do with what the ruminants consume.

Dr. Dhiman and others have found that the CLA content of milk is as much as five times higher when cows graze green, predominantly ryegrass or on natural pastures than when they eat diets consisting of 50 percent conserved forage, such as alfalfa and corn silage and 50 percent grain.

Regular cows' milk available at the grocery store contains an average of 4.5 milligrams of CLA per gram of fat. The lower the fat content of the milk, the less CLA.
Researchers have also found that feeding higher amounts of conserved forage in the diet increases CLA content of milk. However, the CLA level is still not as high as in milk from cows grazing pasture.

Dr. Dhiman says it is possible that something in green grass enhances the growth of the particular bacteria in the rumen that is responsible for producing CLA. Or it may be that grazing cows have different microbes in the rumen than cows fed inside the barn.

“We cut our consumption of CLA when we changed the ways we feed our animals,” Dr. Dhiman says, noting that 30 or 40 years ago animals mostly grazed on pasture. Now their feed is controlled, which might be having a negative impact on human health, he adds.

“Today we are producing milk more efficiently,” Dr. Dhiman says. “However, we need to couple this efficiency with milk quality. CLA could be considered a value-added product of grass-fed cows depending on how much people come to value it.”

In ongoing research in cooperation with USU Animal, Dairy and Veterinary Science Associate Professor Kenneth C. Olson, Dr. Dhiman is working toward understanding exactly what the mechanism is that produces CLA in the rumen and how to enhance its production.

At this point, Dr. Dhiman has determined that CLA levels can be boosted by supplementing the cows’ diet. Roasted cracked soybeans added to a diet of alfalfa and corn silage resulted in increases of CLA content of milk. When soybean oil and linseed oil
forage, many Americans have also made CLA intake a casualty of their war on fat. Milk is a good source of CLA, but the beneficial fatty acid comes along with the fat grams.

Information from the International Dairy Foods Association indicates that American milk consumption has dropped to about 24 gallons per person annually in 1996 from 31 gallons annually per person in 1970. A portion of the decline may be due to concern about fat in foods because sales of nonfat and reduced-fat milk have doubled since 1970 while consumption of whole milk has dropped to less than half its 1970 level.

In the billion-dollar business that accompanies the American quest for leaner bodies, some manufacturers of health supplements are selling capsules containing CLA synthesized from sunflower oil.

Dr. Dhiman, who says a new brand of CLA capsules seems to appear nearly every month, is about to begin a study in which he will feed this form of CLA to laboratory mice and monitor changes in the muscle and fat composition of their bodies.

Similar studies in other laboratories have found rats, mice and chickens fed a CLA-rich diet reduced body fat and increased lean body mass. Studies in other areas are tracking long-term changes in human subjects, he says.

Until the results are in, dietary moderation is still the best advice for humans, he says, cautioning that people might want to think about the milligrams of CLA they are passing up in their efforts to cut out all the dairy and meat fats from their menus.

— Lynnette Harris
UAES Information Office

In addition to cutting our CLA intake by taking cows off pasture and feeding them conserved...
The posterity of pests and problems that have at times plagued mankind since agriculture was first established are with us today. Research by the Utah Agricultural Experiment Station in conjunction with its local and national affiliates ensures that our food supply is the safest, most plentiful and diverse in human history. Below are a few examples of how state and federal funding for the UAES has helped. They were included in a package of information provided to state legislators in February. The names and phone numbers of lead scientists are included.

Deer/Car Collisions Reduced
A newly designed fencing network that funnels game across the road near Heber City saved 130 deer and $150,000 in vehicle repairs the past year. Prior to installing the new crossings, 280 deer were killed there. The crossings were built for $25,000 each, a fraction of the $500,000 to $1 million each for road over/underpasses that have not eliminated deer/car collisions as predicted.

John Bissonette, 435-797-2511

More Water For A Lot Less
Computer-assisted management is saving the Delta Canal Company 55 percent more water and has more than tripled the number of irrigator requests the canals can handle per day. The value of the water saved was twice the $42,000 cost of the project in the first two months, and instead of routing two to four requests for water per day, the automated system handled 10 to 12 during peak demand.

Wynn Walker, 435-797-2788

Salt of the Earth
A new, more salt-tolerant alfalfa is worth $2 billion a year in areas of the country with unusually salty soil. Not only does the new hay grow better in saline soil, it also breaks a vicious cycle in crop production by producing fertilizer nitrogen. Nitrogen, a chemical element necessary in all living things, is in extremely short supply in salt-affected soils and is usually supplemented with petroleum-based fertilizers, which in turn increases soil salinity.

William Campbell, 435-797-2246

Cheese With Less Fat, More Flavor
Flavor enhancers developed at USU and elsewhere have improved the quality of reduced-fat cheese and increased its share of the $1.1 billion cheese market to nearly 25 percent. Pilot research also generated more than $1.5 million in federal grants that will help dairy processors in Utah and elsewhere improve flavor in both lower-fat and full-fat cheese.

Jeff Broadbent, 435-797-2113

Bread in Space
After 12 years of research, a short variety of wheat that stands 18 inches high and produces the equivalent of 1,000 bushels an acre under constant light has been bred specifically to grow in space. The grain is to be tested aboard the Russian space station, Mir, later this year.

William Campbell, 435-797-2246,
Bruce Bugbee, 435-797-2765

The Utah Agricultural Experiment Station
Cloning For Greater Yields
A U.S. Patent is pending on a cloning procedure that would increase yield as much as 30 percent in inbred crops such as wheat, barley and rice. The seeds of these so-called apomictic hybrids will produce abundant, uniform yields year after year, and would permit impoverished nations to use hybrids for the first time.
John Carman, 435-797-2238

Crops that Control Pests
An important step toward reducing pesticide use and reducing crop disease at the same time was taken this year when several strains of new wheat were found to inhibit fungi in roots. The research is still in the field-test phase, but grains that can help protect themselves from root disease will save farmers millions of dollars by reducing pesticide use and plant loss.
Bradley Kropp, 435-797-3738

Beans Conserve Natural, Human Resources
A fast-cooking bean developed by a regional research group is saving thousands of hours in preparation time, as well as scarce fuel sources in foreign markets. Families are saving $550 (U.S. equivalent) each year and using thousands of metric tons less of fuel wood each year.
James R. Steadman, 402-472-3163

Airing Out the Orchard Floor
Grass sods in apple and sour cherry orchards can reduce soil compaction caused by sprayer and harvesting equipment traffic. A study by the Department of Plants, Soils and Biometeorology shows the more extensive a grass sod cover crop, the more it competes with the fruit trees for water and nutrients. A sod extending from tree trunk to tree trunk is more competitive than a sod with a vegetation-free strip down the tree row, Anderson’s study shows. He offers area orchardists several alternatives to perennial grass sods.
J.L. Anderson, 435-797-2236

A Guideline for Wetlands
Many wetlands in Utah and other states have been created by irrigation return flows, reservoirs and as mitigation measures to replace wetlands destroyed by housing, industrial or other development. Research has resulted in guidelines to determine the water supply required to maintain plant communities in wetland areas that must be considered in ground water and water basin studies, and in land-use planning. The guidelines can be used to reflect any wetland area and include elements of season, size and location of the wetland, and nearby land use.
Richard G. Allen, 435-797-2798

Shopping The Range
Most Utah livestock producers rely on federally administered rangelands for grazing. Many people perceive grazing as a threat to natural areas, and poor management can result in overuse of vegetation along streambanks and meadows that damages aquatic and rangeland ecosystems. Research has found that sheep choose among various plants and maintain a balance of energy to protein in their diet by selectively eating plants with the nutrients they need. This research has increased understanding of controls of animal behavior, how to alter where livestock graze and how to prevent consumption of some poisonous plants.
Fred Provenza, 435-797-1604

Looking at Needs of “Human” Crops
The housing needs of people in rural/nonmetropolitan Utah as they age is the focus of a research project in the College of Family Life, Department of Human Environments. About two-thirds of the Utahns report that they prefer to age at home, while a third planned to move when they retire. Local, state and national presentations and publications have resulted from the research.
Joan McFadden, 435-797-1570
**Recent Grants and Contracts**

**Jeffery Hall,** Animal, Dairy and Veterinary Sciences, studies the effects of lasalocid on production in elk supported by the Utah Department of Agriculture.

Zions First National Bank supports economist **Tyler Bowles’** research of macroeconomic agricultural trends.

**Eugene Schupp,** Rangeland Resources, has received a grant from USDA/CSREES to study competition from native grasses in restoring cheatgrass infested rangeland.

The U.S. Department of Energy supports regional biomass energy programs including research conducted by **Conly Hansen,** Nutrition and Food Sciences.

**Daren Cornforth,** Nutrition and Food Sciences, studies cooked beef patty color with support from McDonald’s Corporation.

**Gary Straquadine,** department head, Agricultural Systems Technology and Education, is involved in studying a young professional placement program funded by the Utah Office of Education.

The USDA/CSREES funds research by **David Vagoni,** Animal, Dairy and Veterinary Sciences, on the effect of enhanced protein efficiency of dairy cows on manural nitrogen excretion.

**Lawrence Hipps,** Plants, Soils and Biometeorology, studies the response of canopy photosynthesis to turbulence-induced light fluctuations with funding from the USDA/CSREES.

**Dale Blahna,** Forest Resources, is conducting an assessment of back country visitor management needs for the U.S. Department of Interior/National Park Service.

Sustainable Agriculture Training Programs are a continued focus of work by **Philip Rasmussen,** department head, Plant, Soils and Biometeorology, funded by USDA/Extension.

**Dani Or,** Plant, Soils and Biometeorology, studies how evolution of soil pore space and transport properties are affected by post-tillage soil fragmentation and rejoining with support from USDA/CSREES.

Effects of tree root stocks and plant growth regulators on fruit bud hardness is the focus of research by **Lamar Anderson,** Plant, Soils and Biometeorology, who is supported by USDA/CSREES.

**Martyn Caldwell,** Rangeland Resources, studies carbon dioxide fluxes on sagebrush-steppe rangelands and evaluates forage germplasm from central Asia with grants from the USDA/ARS.

**Shiquan Wang,** Animal, Dairy and Veterinary Sciences, conducts analysis of frozen and fresh semen to predict fertility and to assess embryo survivability with funding from the USDA/ARS.

**Sherman Thomoson,** Extension Specialist and Biologist, studies control of dyers woad with support from the Utah Department of Transportation. He also studies the host range of dyers woad rust with funding from the U.S. Forest Service.

**Fred Provenza,** Rangeland Resources, studies the effects of plants’ physical and chemical characteristics on food preferences of herbivores with funding from USDA/CSREES.

**John Workman,** Rangeland Resources, studies the development of deer ranching technology in the United States with funding from USDA/ARS.

USDA/CSREES supports research by **Roger Coulombe,** Animal, Dairy and Veterinary Sciences, to prevent mycotoxin disease in poultry by dietary induction of glutathione.
Rapid development isn’t only feeding on gobs of land along the Wasatch Front, it also has an insatiable appetite for the countryside.

On the fringes of the new, tightly bunched houses in the cities along the I-15 corridor is the other form of urban sprawl known as small-acreage ranches.

Not since the pioneers were dispatched to settle early townships has there been so much interest in living on a patch of land in the country, say pasture use experts at USU and elsewhere. And never before have there been so many people who want to—and who can afford to—commute into the cities from ranchettes in places such as Ogden Valley and Morgan County.

That particular type of development creates a particular type of land use question that a special committee of scientists and landowners from Utah, Montana, Nevada and Oklahoma is trying to answer.

You can’t blame people for wanting to live out of town on five acres and have a horse or two, says Ralph Whitesides, USU Extension Agronomist and Professor in the Plants, Soils & Biometrology Department and committee member. However, because so many are doing it, a unique set of effects on the land is developing.

Resource management is the fundamental principle that must underlie efforts to promote prudent use of improved pastures in small acreage parcels, Whitesides says. “Successful management must address the joint needs of pastures, animals and humans.”

The 11-member committee, which spent several days this past summer looking at small-acreage ranches in Northern Utah, recently finished a report on the current status of pasture issues related to small acreage ranches. It stressed the importance of cooperation among developers, communities and government agencies.

The first step in beginning to address the needs of the small acreage owner is to identify communities with the greatest concentration of small acreage properties and the greatest likelihood of future development, the report states.

There is a need for research to develop management materials for small-acreage owners that are specific to Utah:

- animal health, including nutrition, respiratory and parasites
- plant materials, including dryland and irrigated grass species
- waste management
- water quality leaving the ranch
- water management, including irrigation water and stock water

The report also states that the public is generally not aware of pasture management techniques.

“Pasture management practices can be enhanced through education which provides current information targeted to the landowners. Information regarding carrying capacity and plant/soil/water interactions intertwined with residential demands needs to be developed.”

Health issues and basic care and management of the animals needs to be stressed, the report states.

In the near future, zoning and planning may need to include more restrictions or ordinances governing land use.

Dr. Whitesides said such ordinances could include planned unit or cluster developments that incorporate open spaces with common management.

More Info

Ralph Whitesides
ralphw@ext.usu.edu
(435) 797-2259
The landscapes that people in the Intermountain West want around their homes and towns are often in conflict with what nature intended, the nation’s best forester writes in an article for the Journal of Arboriculture.

Michael Kuhns, named Forester of the Year by the Society of American Foresters this past November, states that climate, topography, and geology have an important impact on urban and community forests because people are usually growing their residential, commercial, and institutional landscapes in dry valleys where native trees never existed.

Overriding the aridity of the region is the abiding lack of water, says Kuhns, an associate professor of Forest Resources in the College of Natural Resources and Extension Forester. He notes that while mountainous areas in the Intermountain West can and do receive large amounts of precipitation, it comes mainly as snow.

Valley locations where the climate is warmer and where most people live usually receive very little precipitation, with annual amounts ranging from 16 inches in Salt Lake City and Spokane to 12 inches in Boise and about 7 inches in Reno and Phoenix.

“These extremely dry valley conditions mean that urban populations only exist where large rivers flow nearby or where smaller streams exit mountain ranges at the mouths of canyons. Though the region historically has had a low enough population that water use was fairly unrestricted, supplies are quickly being strained to the limit because of the region’s rapid population growth, and restrictions are becoming more common,” Kuhns writes.

Low precipitation and some aspects of the region’s geology often lead to fairly poor soils in terms of tree growth, especially in low valley sites where most people live, he says. Desert shrubs and grasses are the typical native vegetation, with trees found only along some streams and in the mountains. Only box elder and blue spruce are native to much of the region; several cottonwoods are native but are not commonly planted.

Such lack of adapted plants often leads to a high level of plant maintenance, poor plant health or both, Kuhns says.

Based on a survey of foresters, arborists and educators in the region, Kuhns reports that the main problems with trees caused by people are:

- lack of education, awareness and understanding of tree maintenance
- selecting trees unsuitable for the region
- improper planting (too deep, wire baskets)
- improper pruning (topping)
- improper irrigation
- unprofessional arborists
- construction damage

Residents of the region have been planting the wrong trees for decades, Kuhns says. “Often residents favor the trees that were planted by previous generations, many of which were brought west without regard to their adaptability.”

Many of the popular trees have trouble staying healthy, Kuhns says. Siberian elm and green ash have borer problems. Silver maple will usually develop severe iron chlorosis. Black locust has borer problems and Russian olive is a noxious weed in some locations.
While most people deal with illness-causing bacteria on their food by trying not to think too much about them, Dr. Bart Wiemer always has *E. coli* or Salmonella or Campylobacter or some other microbug on his mind.

And instead of trying to wish them away, he’s coming up with better ways to trap and examine them.

In recent months, for example, Dr. Weimer, Associate professor in Nutrition and Food sciences at USU, has developed a way of collecting Campylobacter, which causes severe diarrhea, and other microbes on glass and ceramic beads. The process is helping reduce the time necessary to test for contamination down to minutes from days.

“The closer we can get to what is called real-time testing of food for contamination, the safer we can make our food supply,” Dr. Weimer says.

Safe is not a term a sizeable portion of the American public associates with food, pointing to numerous hepatitis and *Escherichia coli* outbreaks in recent years. The apparent increase in food-borne illnesses has prompted the U.S. Food and Drug Administration to instigate a program designed to help find and prevent bacteria from infecting food products where they are processed.

The program, Hazard Analysis & Critical Control Point (HAACP), will require certain industries to take preventative measures to control microbial, chemical and physical hazards in the food processing. HAACP programs have become effective in seafood and poultry. During the next three years the program will be phased into the meat industry as well.

Dr. Weimer says a major problem in the spread of food-borne illness has been the length of time required to test foods for harmful bacteria. It now takes a day for the test results on a sample piece of meat or poultry to be completed. Suppliers cannot wait for a day to hear if the product is bad or good so trucks are being shipped to consumers before the analysis results are back, he says, noting that any
tests a restaurant conducts will also take at least a day for the results to be returned. By that time some of the food may have already been consumed by the public.

Dr. Weimer's detection process is in its final stages of development and should be available for industry use by next year. The tester is able to detect campylobacter in liquid at the rate of two liters per minute, or nearly 10 times faster than the existing technology.

Dr. Weimer says there is no completely safe, cost-effective way to make the food we eat completely sanitary. However, as more and more breakthroughs continue in his field, he believes food free of bacteria will be achieved within the next 10 years.

No matter what high technology does to help food producers and suppliers to test their products faster for bacteria, the menial duty of hand washing will always do the most to reduce food-borne illnesses, Dr. Weimer says.

Whether new antibacterial soaps actually reduce illness from bacteria is unknown, he says, adding that most bacteria can be washed from the hands with running water and a paper towel wipe. He suggests washing the hands twice at one time; lather and rinse with hot water, lather and rinse again.

While bacterial pathogens are indeed becoming stronger and more virulent and are infecting more people, the No. 1 cause of the spread of disease is poor hand sanitation, he says. Therefore, as viruses become able to live longer and in different types of foods, restaurant workers and consumers who handle food need to take more precautions by washing their hands more often and better.

Dr. Weimer says that orange juice and tomatoes, once thought to be too acidic for bacterial infection, are now susceptible to being infected by *E. coli*, vibrio and other new strains of bacteria. *E. coli*, for example, can now live in orange juice for up to six weeks because it has mutated into new strains that are more virulent and resistant to anti-bacterial measures.

Although *E. coli* may be the most dangerous bacterial pathogen, it is certainly not the most prolific. There are only about 20,000 cases of *E. coli* per year. However, Salmonella and Campylobacter affect nearly two million people every year. These bacterial diseases have been on the rise the past 20 years. According to the U.S. Department of Agriculture, Salmonella cases have risen from 10 out of 100,000 in 1973 to 20 out of 100,000 in 1997. Campylobacter has risen even faster, from 10 out of 100,000 to 25 out of 100,000.

The USDA also reports that since 1973 more than 30 new bacterial pathogens have been discovered. In other words, a new illness-causing bacteria is being found about every year.

Salmonella cases have increased for several reasons, Dr. Weimer says, noting that food is not being prepared properly, correct sanitation is not being used while handling the food and people who have previously had Salmonella are spreading the disease.

Another major cause of contamination is the modern American lifestyle: Americans tend to eat much more than we did a generation ago, he says. "We are a society always in transit, and we eat on the move as well."
Food handlers who come in contact with Salmonella on chicken and other food products also need to be very careful. If the food handlers do not properly wash and sanitize their hands, they could potentially be cross-contaminating other foods with Salmonella.

Humans cannot only be infected by Salmonella, they are carriers as well. Just as lizards shed Salmonella bacteria from their skin, humans infected with Salmonella will also shed the bacteria.

According to Dr. Weimer, the average human will shed Salmonella for two to three months. However, he says some humans will shed Salmonella for their entire lives.

As with most food-borne illnesses, older and younger people are more susceptible to the disease because their immune systems are weaker.

Campylobacter has become even more of a threat than Salmonella. As more and more Americans increase their consumption of chicken to reduce fat in their diets, the risk of Campylobacter will continue to increase. The bacteria are carried mainly by chickens, but can also live in untreated water and unpasteurized milk.

According to Dr. Weimer, chickens are high bacteria carriers and very susceptible to becoming infected with Campylobacter. Once one chicken has become infected, the entire flock is sure to be infected as well, Dr. Weimer says.

According to a 1997 report by the Centers for Disease Control, Campylobacter is the most frequently identified cause of acute infectious diarrhea, with nearly two million cases a year.

By Ryan Anderson

Pathogens mutate by a process called natural gene exchange in which one bacteria's DNA is sent to another organism. The other organism will then accept the DNA, creating a new strain with abilities from both parents.

A good example of this is the E. coli pathogen. The form it is in today was caused by the mesh of Shigella and E. coli, creating E. coli 0157:H7, the deadly pathogen. Originally, E. coli was not as dangerous an organism. Shigella was a very dangerous pathogen, but could not survive except in a very cold and selective environment. However, when the two meshed, E. coli 0157 resulted. Now E. coli can produce the Shiga toxin and can also live in a variety of climates.

This makes E. coli the most dangerous of all food-borne illness. According to Michael P. Doyle, director of the Center for Food Safety and Quality Enhancement at the University of Georgia, E. coli has caused kidney failure in 10 percent of the people who have become infected with the bacteria. Also, a very small amount of E. coli bacteria can make a person ill.

According to Doyle, less than 10 cells of E. coli can cause illness. During the outbreak of E. coli in the Northwest in 1993, only 15 E. coli cells per gram of meat were on the hamburger.

Dr. Bart Weimer's new test developed at USU is sensitive to one cell which will be useful in detecting microbes in food, such as E. coli 0157:H7, with low infective doses.

This past August the largest recall of red meat in U.S. history—25 million pounds—took place because the meat might have been contaminated with E. coli.

Some states have begun publishing in local newspapers lists of restaurants that do not pass public health inspections. Utah is not one of them.

Whose responsibility is it to make sure food is safe, anyway? Dr. Weimer says it's everyone's because contamination can occur at any point in production, processing, cooking and eating.
This is a time in Utah when asphalt, not alfalfa, seems to be the state’s bumper crop. Flora and fauna go by the way of the bulldozer every day, and the exceptional plants at the Utah Botanical Garden will be no exception.

Since 1954, plants have flourished at the garden just north of Farmington. Ever since Utah State University horticulturists planted the first bulb and established the first shrub test plot, the garden has done nothing but grow in size and scope. It now covers seven acres and showcases hundreds of varieties of plants designed in attractive and unique arrangements.

But even more than enjoy the beauty of the garden, horticulturists throughout the years have had the opportunity to experience hands-on science in this work in progress.

But the garden has to go.

The expansion of U.S. Highway 89 is making a fast track right through the heart of the garden. Rather than let the garden simply be flattened under urban sprawl, garden director Bill Varga and others are going to move it out of the way.

With the help of a key land acquisition from the LDS Church, the garden is being moved to a new location near Kaysville that will be roughly 14 times larger. The new garden, which will be called the Utah Botanical Center, is situated on a long-neglected stretch of land between Kaysville’s Main Street and a hustling Interstate 15. It will allow programs to be expanded and make access to the planned world-class botanical center easier for residents around the state.

Varga knows he’s got a big job ahead of him. Not the least of which is moving history, one root at a time.

“You can’t just pack your bags one day and move,” Varga says. Varga and his crew will move a community of plants that were carefully matched and have lived together a long time.

It’s like breaking up a home, Varga says, noting that taking everything to the new location would be too expensive.

The center’s project manager, David Anderson, and Varga have had the ponderous task of looking over every plant and selecting the most unique materials for relocation.

Plant hardiness has also been a major consideration in the ultimate decision of which plants would stay and which would go.

Some of the chosen ones are plants so rare they are found nowhere else in the state; specimens that could not be bought anywhere, for any price.

Already 80 or 90 shrubs have been uprooted and transferred to the new location. Day lilies, peonies and of course the family of medal-winning Iris Dykes have been moved into temporary holdings.

Some 50 trees will also be moved, a job that’s a little like asking the Lilliputians to move Gulliver. Moving these giants is an extraordinary process that will take several months to complete.
then, he has been monitoring the root pruning process of the specimen plant.

"By golly that's a nice tree," Morris says. "It's also part of history."

In 1941, fossils of a dawn redwood were found in Japan. In 1944, the trees were found growing wild in a canyon in China. Horticulturists collected seeds from the tree and sent them to botanical gardens all over the world.

If given the time, this giant could grow up to 100 feet tall.

Most of the trees will survive, says Morris, if the root pruning process to prepare them for the move is done carefully.

The procedure involves digging a trench around the tree near the drip line. The soil inside the circular trench is then divided into pie shapes, which are excavated two sections at a time in an effort to minimize shock.

Crews dig down about two feet, severing the roots at the edge of the trench. This type of root treatment encourages growth of a new fibrosis network vital to tree nourishment and eliminates extended roots that add little to the vitality of the tree.

"We only want to shock the tree in bits so it can recover and so we can generate new growth where the tree has been severed," Varga explains.

After the roots are cut, new soil is placed back in the hole. After two to three months the other sections are given the same treatment.
When the tree is ready to be moved, crews will dig a hole about 10 feet in diameter. The entire root ball is excavated with a giant mechanical spade, then wrapped in burlap. A crane will wrench the tree from the ground and move it to a waiting truck that will transport it to the new facility.

"Better than 95 percent of trees moved this way will survive," says Morris. "If we do it right we will have trees that will be around longer than we all live."

The giant redwood, technically known as a *Metasequoia*, is scheduled to make the journey in September or October. It and all of the trees have to be moved in the fall when they are under the least amount of stress from the weather.

Transferring plants is just one part of making the Center a reality. The new Utah Botanical Center, in addition to the traditional theme gardens at the present location, will include additional gardens such as a water-conserving garden, a children's garden, a heritage garden, a native wildflower meadow and native plant displays.

A unique feature of the gardens will be the Utah House. Made of recycled and environment-friendly materials, the house will be "a sustainable model home for the 21st century."

Another feature will be the working gardens, which will emphasize vegetables, fruit trees, turf trials, edible landscapes and low water use. A building will be available for informal gatherings, hands-on workshops and cooking and canning demonstrations.

Educational programs currently offered at the Utah Botanical Garden in Farmington will continue at the Utah Botanical Center. These programs will include USU Extension classes, Master Gardener courses, a Children's Discovery Program, 4-H and USU courses.

Anderson says that against fairly steep odds, and more than one bulldozer, the Utah Botanical Center will press forward with its mission to serve as a catalyst—creating awareness of resource conservation and enriching quality of life through education, research, and public service.

Varga adds that although it is hard to say goodbye to some of the plants that won't make the move, the new garden is about the future, about generations to come.

In the immediate future is a presentation before the state Legislature for additional funding that the Center will use to leverage private donations. Rep. Marda Dillrey from Davis County and Sen. John Holmgren from Box Elder County will encourage support for the center among their colleagues on Capitol Hill.

*By Missy Buck*

![MORE INFO](#)

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone</th>
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<tbody>
<tr>
<td>Bill Varga</td>
<td>(435) 797-2252</td>
</tr>
<tr>
<td>Dave Anderson</td>
<td>(435) 797-1984</td>
</tr>
<tr>
<td>Ann Palo</td>
<td>(435) 797-0568</td>
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*The Utah Agricultural Experiment Station 19*
Despite enough food, half the world still going hungry

Most of the people in the world are poor, so if we knew the economics of being poor we would know much of the economics that really matters. Most of the world's poor people earn their living from agriculture, so if we knew the economics of agriculture we would know much of the economics of being poor.


A majority of the world's 5.6 billion people live with a transitorily or chronically unreliable supply of food. A majority of the 220 million people in the United States don't.

Those facts are two among the many dichotomies that feed the rampant complexity of world hunger, says USU economist Dr. Christopher Barrett, who has just completed a manuscript that assesses the threats to food security as well as the effectiveness of various government and private emergency food aid programs.

His 111-page chapter will be part of a first-ever handbook on agricultural economics scheduled to be published in late 1998 by Elsevier Science of Amsterdam.

"The issue of world hunger captures the fact that we Americans are for the most part spoiled," Barrett says. "We really don't identify with people who must struggle for food."

While there has been remarkable and indisputable progress in reducing the prevalence of chronically undernourished people in most of the world the past 50 years, hunger and food insecurity "remain distressingly widespread," Dr. Barrett writes.
The best available estimates indicate that 800 million to 1.3 billion people—about the same number classified as "poor" around the world—suffer from chronic protein energy malnutrition, and about 20 million people die of hunger each year.

Another 2 billion people are affected by micronutrient malnutrition related to insufficient intake of iodine, iron or vitamin A.

The prevalence of this macronutrient and micronutrient deficiency is doubly distressing, Dr. Barrett says, because in any given year there is 20 to 40 percent more food available than is needed to feed every person on earth well.

"This highlights the now widely accepted fact that, at the global level, food availability is not the primary cause of food insecurity," he says. It has more to do with poor or overwhelmed distribution networks and civil strife, he says, noting that crop failure rarely leads to famine without the conjunctural force of accompanying civil unrest.

"There have in fact been famines in bumper crop years because civil unrest literally destroyed the food supply distribution channels of a country and people raised havoc with the social structure."

More sobering still, the above estimates of food-insecurity reflect only head counts of those who are hungry or malnourished and don't include those who are threatened by those prospects, he adds.

The cross-sectional snapshots used to estimate the undernourished population capture only those suffering at any given time, not the potentially much larger group that suffers at some—but not all—times, nor those who are uncertain about their access to food, Dr. Barrett says.

"We can only speculate as to the true numbers, but it seems safe to say that at least one of every three people on earth today—perhaps more than half—suffers from at least transitory food insecurity," he writes. "No nation and very few communities on earth lack food-insecure citizens, and women and children comprise a disproportionately large share of this subpopulation."
Dr. Barrett notes that people shouldn’t have the impression that nothing is being done, nor that government-sponsored food assistance is the only way food security is being promoted.

There are three key elements to a successful food security strategy: stable employment and high labor productivity to provide a regular means of sufficient income to subsist; access to finance, food markets and storage technologies; and safety nets to provide transfers to those who suffer adverse shocks that the economic system cannot allay itself.

“At an aggregate level, there is also a need for continuous technological and institutional progress in food production, processing and distribution,” he says. “In other words, the very work done at land grant universities and at experiment stations like ours and others around the country is vital if we’re to have any hope of reducing food insecurity at home and around the world.”

In the short term, an extensive private emergency food network that has developed in both poor and wealthy countries during the past 25 years will have to strengthen, he says. Bread for the World Institute, a nonprofit, nongovernmental organization, estimates there are more than 150,000 emergency food programs in the United States alone.

That emergency network appears to be a socially efficient mechanism for using food that would otherwise be wasted and for providing necessary transfers to food-insecure people at extraordinarily low unit cost.

Nevertheless, charitable efforts can sometimes simply overwhelm the distribution mechanism in a particular region, as did the huge outpouring of money and food for Ethiopia in 1984. The donations were in large part generated by widespread public awareness of the famine through media attention.

That kind of emergency assistance, as well as government-supported food aid, are not long-term solutions, Dr. Barrett says. For example, the effectiveness of food aid in improving food security has suffered because the quantity and type of food available has historically been driven primarily by the surplus generated by farm support programs, not by the particular need of the recipients.

“In other words, it is the surplus that is available at the time that dictates the giving, not the economic circumstance of those who need it nor the humanitarian criteria of the donors,” Dr. Barrett says.

Literature that Dr. Barrett cites in his chapter shows there is a vital link between nutrition and labor productivity, i.e. a properly fed population exhibits greater productivity thereby contributing more effectively to economic growth and development than does a labor force weakened by inadequate diet.

Dr. Barrett writes, “Protein-energy malnutrition and some forms of micronutrient deficiency (anemia caused by insufficient iron absorption) directly reduce cognitive and physical activity, and hence labor productivity, which is the essence of increased per capita incomes.”

Dr. Barrett compares the forces at work that make food security continually problematic to those that dictate research in the pharmaceutical industry: “Malaria kills more people around the world than several diseases combined. But because the very people the medicines could help can’t pay for better medicine and distribution, there is no
commercial incentive to develop and provide them. It's the same way with food security; there is no immediate commercial incentive, but there is a moral and social imperative.”

But with a world population of 5.6 billion and rising during the next 50 years, “we need to address ideas that don’t appear profitable right now.”

A prime example of the political economy of agricultural policy is the domestic food assistance programs in the United States. They had their origin not so much in meeting the food needs of the vulnerable as in efforts to dispose of agricultural surpluses.

Appeals to basic human dignity, to equity, to charity, to duties of human solidarity and mercy, etc., have all been influential in the development of food assistance programs, Dr. Barrett says, noting that articles 25 of the Universal Declaration of Human Rights of 1948, and 11 of the International Covenant on Economic, Social and Cultural Rights, state that everyone has a right to food.

Most countries are signatories to both of those accords and are thus legally obligated, although they can’t be forced to ensure the food security of all their citizens.

“The persistence of food insecurity in a world of plenty begets a formidable consensus that something must be done,” Dr. Barrett writes, “although there is considerable disagreement as to what, by whom and for whom.”

He suggests that agriculture needs to be intensified, “mainly because if you fail to intensify you extensify; you push out on to an ever more fragile land.” Forests are taken, more erosion occurs, grasslands become deserts.

“We have a huge room for improvement in those developing countries,” he says. “We don’t have any choice, it seems to me.” JT
EDITOR'S FOOTNOTE

Just because there are a lot of movies about nasty bugs feeding on humankind these days is no reason to think it's science fiction. We are indeed prey. Not for the gargantuan cooties arriving suddenly out of Hollywood but for invisible multitudes of infectious bacteria and viruses that mill around us all day long.

These bugs don't have the bone-crushing pincers wielded by their celluloid counterparts, nevertheless size definitely has a lot to do with their formidability: they can get into the food that goes into you and I, and once there get busy multiplying and wreaking havoc with our health.

They not only have a taste for us, we are their housing and transportation. They are insatiable and infinite in number and have the daunting ability to mutate to survive.

The writer Wallace Stegner said in so many words that all living things spend their lives just trying to be. Bacteria are no exception. If you have any doubt about that, spend an afternoon talking to food sciences professor Bart Weimer. You'll leave looking for the nearest washroom and making a promise to yourself to never taste-test grapes in the grocery store again.

Especially with the news that *E. coli* O157:H7, one of the era's nastiest little mutants, cannot only infest meat but can also live on fruits and vegetables. (Please see story on page 16 of this issue.)

Given its and other bacteria's natural ability to endure, why should humans have the audacity to think we can regulate them out of existence? That's what we've been calling for lately in the wake of several food contamination scares. Not that *E. coli* and other manners of food poisoning aren't a serious, even deadly, problem. But where do we get the notion that there is such a thing as a fear-free food supply?

One normally reasoned person said the other day, "It's the old 'If they can put a man on the moon' argument. If they can do that, why can't I have a hamburger that's pink in the middle?"

Such are the immature and paradoxical demands Americans are putting on their food suppliers. Trade-offs are not permitted in our modern scheme of things; we want raspberries in January, tomatoes year-round and our meat rare, and it all better look delicious to boot.

A *New York Times* op-ed writer noted recently that it wasn't long ago that we were accusing farmers of being too free with their pesticides and fungicides. "Now the alarm is that we farmers have been too lax in cleansing nature of its own bacteria and viruses."

This, friends, is impossible, and regulations requiring the complete safety of food won't make it so.

Bacteria are dangerous, and patrolling pathogens from farm to table is vital. But before demanding completely safe food, we should consider whether it is a realistic response to a real danger. We should realize that calls for stricter food-handling protocols have consequences. We should keep in mind that the threat of infection from food by the supplier is for the most part gone already.

When's a good time to mull all this over? How about the next time we're in too big a hurry to wash our hands.

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PHOTOQUIZ

Clue: Used in grass and barley seed harvesting/improvement processing. Answer in next issue.

Above--
Answer to last issue's photoquiz: Leafcutter bee cell extractor. Used to pull out nests made by alfalfa leafcutter bees in drilled wooden and styrofoam boards so researchers can count the number of cells within the nest and track mortality.

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Utah Science is on line. Check out our Web page at: //ext.usu.edu/agx/