In a world that is complex, sometimes to the point of chaotic, it’s little wonder that we humans love to classify, sort, graph, and map in an attempt to understand. Trouble is, new information comes along and our classifications and maps aren’t just outdated, we find out they are just plain wrong. Such is the case with one of the most memorable and prevalent illustrations in biology textbooks: the tongue map.

From the tongue map we learned that humans detect sweetness at the tip of the tongue, bitterness at the back, sourness on the sides, and saltiness at the edges. We should have suspected that part of anything as complicated as human physiology couldn’t possibly be that simple.

“There are areas of the tongue that are slightly more sensitive than others to particular modalities, but it’s just not true that we taste sweetness only at the tip of the tongue and salty at another spot,” says neurobiologist Tim Gilbertson. “The diagrams of the tongue we’ve all seen are just patently untrue. We know from work we’ve done in our lab that even individual taste receptor cells within a single taste bud can respond to up to four different tastes.”

The surface of the tongue is a busy, complicated place. The tiny, velvety bumps most of us assume are taste buds are actually papillae. Some papillae are involved in sensing tactile stimulation, while others contain taste buds. (See diagrams on pages 4-7.) You can find the taste bud-containing fungiform papillae in your mouth by swabbing your tongue with blue food coloring. The spots that remain tiny pink circles are where your taste buds lie. Viewed on its own under a microscope, a taste bud is an onion-shaped structure made up of 50 to 100 individual taste cells. At the top of each taste bud is a pore that allows in chemicals from food that have been dissolved in saliva. What happens next is a series of electrical changes in the cells and chemical signals that alert the brain to what is going on in the mouth and gut.

While the act of eating and the mechanisms of tasting may be similar for most people, the reactions we have to foods are more individual. There are many physiological and chemical reasons we enjoy certain foods and despise others, and just as many psychological and sociological reasons. Our appetites and cravings are conditioned by the foods we eat when we are young, by the foods we see others eat, the climate in which we live, our body’s reaction after we’ve eaten, and a host of other factors. For example, your mouth may long for the taste of a chili dog with cheese and extra onions, but remembering your stomach’s reaction following a previous chili dog encounter may stop you from indulging. We condition our eating habits in other ways too. Gilbertson doubts anyone is born to like the bitter flavors of coffee or beer, or the sensation of drinking extremely sour lemonade, but psychologically we can overcome our initial reactions and learn to like them.

Researchers have also found that some people, about 25 percent, taste things in a way that is different from the general population. They are called super-tasters and they are highly sensitive to bitter and sweet flavors in food. Consequently, Gilbertson says, super-tasters tend to dislike broccoli and other cruciferous vegetables because they taste the bitter molecules much more intensely than most people do. Their tongues are even constructed differently. The fungiform papillae that dot most people’s tongues cover the front of a super-tasters’ tongue from edge to edge.

New information about our sense of taste may lead to new products and discoveries that will change what we eat and help fight disease. Even then, the erroneous tongue map may live on, a myth we can’t quite let go of. After all, even the Flat Earth Society has a Web site.
PUTTING FAT ON THE TASTE MAP
How does your body recognize protein, fat, carbohydrates and nutrients? Part of the answer is right on the tip of your tongue.

GAINING WEIGHT AND LOSING YOUR MIND
An 18-year study finds being overweight puts you at greater risk of developing Alzheimer’s disease.

THINKING LIKE YOUR ANIMALS
Providing good food doesn’t guarantee healthy animals or healthy habitat. An animal's food choices depend on what it's learned, regardless of what's on the menu.

SEEDS - new people, grants and contracts in science

SYNTHESIS - science at Utah State

SEEK - discoveries in science

SEARCH - science on the web

ON THE COVER: Electron micrograph/illustration of the surface of the tongue
Putting Fat on the Taste Map

We've asked or answered the question innumerable times: What do you feel like eating?

Beef or fish? Chinese or Mexican? Pasta or potatoes? Chocolate or vanilla?

Perhaps the more important question is, what does your body need?

Clues to answering those questions are right on the tip of your tongue. Actually, they're all over your tongue, in your stomach, small intestine, and your brain. Taste receptor cells that send and receive signals from the brain allow us to taste our favorite things, help us avoid eating some potentially dangerous ones, trigger searches for certain foods and, neurobiologist Tim Gilbertson believes, prompt us to eat things our bodies need.

Why we like some foods, dislike others, crave certain flavors or textures and sometimes eat more than we should are all extremely complicated questions. Finding answers requires a careful blending of molecular biology, physiology, biochemistry and behavioral studies.

"The primary goals of the research in my lab are to understand how taste receptor cells function," Gilbertson says. "We also want to know how the body recognizes carbohydrates, proteins, fats, and the essential nutrients we need for survival."

People have long believed that the taste system is passive, that it does nothing until a stimulus comes along and then it reacts. By contrast, Gilbertson says he believes the taste system has a very active role in controlling what we choose to eat.

Fat is among the nutrients we need, though it has gotten a bad name as obesity and its accompanying health problems have become more prevalent in the United States. Of course, in the days when people expended more calories doing physically demanding
tasks just to survive—hunting for food, carrying water, walking miles while guiding a plow horse—fat was an especially important part of the diet.

“If you’re an animal foraging in the wild or someone out there trying to find food the best thing you could find is fat,” Gilbertson says. “It is the most energy dense food at nine kilocalories of energy per gram. Protein and carbohydrates have only four.”

Scientists long believed that fat did not have a taste. Gilbertson explains that flavor—the combination of taste, smell and texture—is a complex thing and people have long known that when you add fat to food it enhances the flavor. But most believed that fat contributes only to the texture portion of the flavor equation, enhancing what food scientists and chefs refer to as mouth feel.

Several years ago Gilbertson and his research team set out to challenge the notion that fat has no taste.

“We talk about salty, sweet, sour, bitter and umami (Japanese for “delicious”, describing a unique taste blend of salty, meaty and sweet associated with proteins), but we’ve left out a big one and that’s fat,” Gilbertson says. “You don’t hear people say, ‘That tastes like fat.’ We talk about mouth feel and historically assumed that fat had no taste.”

Researchers in Gilbertson’s lab isolate individual taste receptor cells, primarily from rodents, and attach tiny glass electrodes (1/10 of a micron) and record the electrical activity that results when the cells contact a nutrient or taste stimulus. Taste cells, like many neurons, deal in changes of electrical activity as they signal the brain.

“Most taste stimuli activate the cells and the electrical activity changes according to the concentration and how long the stimulus is on the cell,” Gilbertson explains. “For example, saliva
has about 50 millimoles of sodium chloride, but you don’t taste that as salt because you’ve adapted to it. Whereas, if we rinse your mouth with distilled water and then you drink a solution with 50 millimoles of sodium chloride you find it tastes salty.”

Most fats are in the form of triglycerides. When Gilbertson’s team applied triglycerides to taste receptors the electrodes registered no change. But in most foods that contain fat there are other compounds, including free fatty acids.

“We put fatty acids on taste cells and saw huge increases in activity,” Gilbertson says.

“It was really the first report of anyone being able to show that something in fat activated the taste system. We jumped on the findings and looked to find the parameters of the response, looked to see if all fatty acids activated the system or just specific ones.”

What they found was that the response was limited to polyunsaturated fats, an interesting discovery in light of Gilbertson’s belief that a primary role of the taste system is to detect nutrients that are important for survival.

“"If you’re an animal foraging in the wild or someone out there trying to find food the best thing you could find is fat.”"
**Structure and nerves of a taste bud.**

Water-soluble substances reach the surface of the tongue and diffuse through a pore into a fluid-filled space over the taste bud; here they contact the membranes of the microvilli that form the outer ends of the sensory cells.

Two of fifty afferent fibers which enter and branch within a single taste bud

Extracting a single taste receptor cell.

Individual taste receptor. Even individual taste receptor cells (shown in green) within a single taste bud can respond to up to four different tastes.

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**Would You Like**

Figuring out why people and animals choose certain foods and pass on others is a complicated endeavor. Clearly, people have emotional and economic reasons for some of their food choices. But does biology tip the scale and, consequently, cause us to tip the scale?

Neurobiologist Tim Gilbertson set out to find whether the way individuals sense fat in combination with other tastes might affect their food choices. His research team bred a group of rats that were closely related, but with slight and specifically selected genetic differences. They allowed the rats to choose meals from among food in three dishes—one containing protein, one with sugars or carbohydrates, and one with fat—and measured how much each rat ate every day.

What they found were clear differences between “fat preferers” and “fat avoiders” that soon became visible differences in body composition.

“Fat preferers took fifty percent or more of their calories from fat,” Gilbertson says. “We call this one our ‘typical American’ rat. This is the rat that given the opportunity would run downtown for a burger or pizza every day.”

Their fat avoiding cousins, however, ate mostly carbohydrates and got about 10 percent of their calories from fat. Next, the rats were offered only the high fat food. The fat avoiders
ate the right number of calories to maintain normal weight, but the fat preferring rats ate themselves quickly into a state of morbid obesity and continued eating as long as food was available.

When the researchers isolated taste receptor cells from the rats and measured the response to fatty acids they found dramatic differences. Taste cells from the fat preferers had a much lower response to the fatty acids, while the other rats were very sensitive.

“We know the brain activates some negative feedback pathway that tells you to stop eating,” Gilberson says. “It took a lot longer for the less sensitive rat to get there and know he’d eaten enough. For example, you may love chocolate cake, but if you were given a whole cake and forced to eat it all you wouldn’t like it much by the end. The fat preferer could eat more of the cake before it got the signal to stop.”

It’s a leap to extrapolate findings from rats to humans, but the signal-transporting potassium channels that tell you when you’ve had enough may work in similar ways. Those channels may offer another target for appetite-suppressing drugs. Another interesting twist of the research will be investigating whether feeding very young animals a high fat diet will change the way their taste receptor cells and cells in the small intestine respond to fat and predispose them to being fat preferers as adolescents and adults.

“Fat preferers took fifty percent or more of their calories from fat... This is the rat that given the opportunity would run downtown for a burger or pizza every day.”

Continued from page 5

“We must have polyunsaturated fats in our diet in order to survive,” he explains. “Monounsaturates and saturated fatty acids did not activate the taste receptors. But there are enzymes in the body that can change polyunsaturates in the other forms so we don’t have to have them in our diet to survive.”

Gilbertson says one reason fat substitutes may not have become wildly popular is that they are designed to imitate the texture of fat while ignoring that there is a taste factor as well. The research team further discovered that fatty acids send messages to the brain through a particular ion channel and modulates the taste system’s response to other stimuli. That may be why we like things that combine fat and sweet, like chocolate, or fat and salty, like chips. The fats come in and block the ion channel which extends and heightens our response to the sweet or salty stimuli.

“Ask people about fat-free foods and most of them say, ‘They don’t taste right,’ or ‘They taste like cardboard,’” Gilbertson says. “That is partially texture contributing to the flavor, but we think it also involves the taste. We’re looking at the implications of what we’ve found and how we might be able to trick the body into thinking it’s had fat when it hasn’t. Down the road, knowing which molecules activate our receptor cells may help develop a fat substitute that will satisfy consumers and may help us get our average 40 percent fat diet down to 30 or 20 percent so we might see a decrease in heart disease, diabetes and obesity’s other attendant problems.”

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Gaining Weight and Losing Your Mind
A 18-year study tracking the physical and mental health of older adults has uncovered another important reason to watch your weight even after age 70. Nutrition scientist and UAES researcher Deborah Gustafson, in a collaborative study with researchers at Gothenburg University in Sweden, tracked a group of Swedish seniors from age 70 to age 88 and found being overweight increases the risk of developing dementia, including Alzheimer’s disease.

“We typically think of overweight and obesity as increasing the risk of heart disease, diabetes, hypertension and atherosclerosis, but we hadn’t yet looked at the risk excess weight poses for Alzheimer’s,” says Gustafson.

Overweight and obesity are increasing at epidemic proportions in western societies, and the problem has significant public health and societal implications. More than 50 percent of adults in the United States and Europe are overweight and 22 percent of those are classified as obese. That trend seems headed for a collision with the facts that women over age 50 are the fastest growing age group in western societies and many more people are living well into their 80s, Gustafson says.

The study, which was reported in the American Medical Association’s Archives of Internal Medicine, used an extensive series of physical and psychiatric exams to track the well being of nearly 400 Swedish seniors over a period of 18 years.

They found that women who developed dementia between ages 79 and 88 had a higher average body mass index (BMI, see sidebar) at age 70 than did women who did not develop dementia. Higher mean BMI was also observed in exams at ages 75 and 79 in women who developed dementia. The team noted that even when adjustments for blood pressure and other factors were made there was still a clear association between high BMI and dementia or Alzheimer’s disease.

The team noted that surprisingly few studies have examined possible links between overweight and dementia, and that some short-term studies have found people with clinical signs of dementia tend to have lower BMIs. That finding may be the result of the short time periods those studies have tracked subjects and because people exhibiting signs of dementia and Alzheimer’s have usually been eating less and experienced a decrease in weight.

The team’s findings compliment recent reports that other vascular problems like high blood pressure, heart disease and diabetes likely contribute to the onset of Alzheimer’s disease.

“They typically think of overweight and obesity as increasing the risk of heart disease, diabetes, hypertension and atherosclerosis, but we hadn’t yet looked at the risk excess weight poses for Alzheimer’s,” says Gustafson.

“With more people living until they’re 80 or 90 years old, Alzheimer’s is going to become an increasing burden on society,” Gustafson says.”“Sometimes as people age they think they don’t need to worry about their weight any more. This study shows that maintaining a healthy weight, even to the oldest ages, helps ensure better health.”

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What is your BMI?

<table>
<thead>
<tr>
<th>Height</th>
<th>Severely underweight (BMI &lt;16)</th>
<th>Underweight (BMI 16-19)</th>
<th>Healthy (BMI 19-24)</th>
<th>Overweight (BMI 25-29)</th>
<th>Obese (BMI 30 or more)</th>
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<td>83-96</td>
<td>97-123</td>
<td>128-148</td>
<td>153 or more</td>
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<tr>
<td>5'1&quot;</td>
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<td>132-153</td>
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<td>88-103</td>
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<td>136-158</td>
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<tr>
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<td>141-163</td>
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<td>145-169</td>
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<td>114-144</td>
<td>150-174</td>
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<td>221 or more</td>
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<td>126-147</td>
<td>148-186</td>
<td>194-225</td>
<td>233 or more</td>
</tr>
</tbody>
</table>

Body Mass Index (BMI) is a measurement based on height and weight that helps assess a person's body mass. BMI is just one of many factors that indicate potential risk for diseases like cancer, diabetes and heart disease, and now dementia, but it is a useful tool in evaluating health. It is not accurate for young children, pregnant or breastfeeding women, the frail elderly, or very muscular people.

To calculate your BMI:
1. Divide your weight (in pounds) by your height squared (in inches).
2. Multiply the results of step 1 by 705.

For example, if you weigh 138 pounds and are 5'3" tall (63") the equation looks like this:

\[(138/(63\times63))\times705 = 24.5\]

You can find a BMI calculator and other information about BMI and health at the Center’s for Disease Control website [www.cdc.gov/nccdphp/dnpa/bmi/calc-bmi.htm](http://www.cdc.gov/nccdphp/dnpa/bmi/calc-bmi.htm).
Steve Dewey collaborates with the National Park Service in creating an inventory and maps of invasive and non-invasive plants in Utah's Green River district and the northern Colorado Plateau.

Janis Boettinger is doing a soil survey of Wyoming public lands to develop protocols and methods for further inventories and data quality control. The U.S. Department of Interior's Bureau of Land Management funds her work.

Dan Drost, in collaboration with researchers at Washington State University, studies the reducing fungicide applications to asparagus by monitoring root carbohydrate levels.

Ken Olson examines wildlife and livestock interactions and the nutrient intake of elk and mule deer. His research is funded by the Rocky Mountain Elk Foundation.

In collaboration with the University of Alaska, Keith Criddle conducts economic analysis of Pacific halibut commercial fisheries.

Rudy Tarpley works with the Utah Office of Education to advance the Young Professionals in Agriculture Education In-Service Program.

In cooperation with the U.S. Department of Agriculture's Cooperative State Research, Education, and Extension Service (CSREES), Scott Jones investigates electromagnetic determination of water content and electrical conductivity in saline and clay soils.

With funding from Kraft Foods, Bart Weimer studies sulfur metabolism in brevibacteria, an important component of flavor development in cheese.

Roger Coulombe, with support from USDA-CSREES explores the role of dietary antioxidants in preventing aflatoxicosis in turkeys.
The National Science Foundation funds **Keith Mott**'s examination of the complexity of leaf stomata dynamics and whether leaves behave in a way similar to computers.

**Ken White** investigates bovine egg cell activation with funding from the USDA-CSREES.

**Christopher Neale** is doing multistructural imaging of 1,000 miles of streams and rivers in northern Idaho with funding from the Idaho Department of Environmental Quality.

**Yajun Wu**, in collaboration with Syngenta, is examining genes that might be used to improve plant tolerance to drought and salinity stress.

Economist **Dee Von Bailey** is studying traceability in food production and distribution systems with funding from the Utah Department of Agriculture and Food.

**Jon Takemoto** does peptide antimicrobial testing with funding from Synvax, Inc.

The Wildlife Trust funds **Layne Coppock**’s training doctoral candidates for Ethiopian wildlife conservation.

**Richard Beard** is revising study guides and developing examinations for the Utah Department of Agriculture and Food.

**Kelly Kopp** is developing improved water loss estimates for turfgrass using advanced micrometeorological techniques with funding from the Utah Division of Water Resources and leading landscape irrigation workshops for the Jordan Valley Water Conservation District.

**Jeanette Norton** studies the physical processes affecting microbial habitats and activity in unsaturated agricultural soils with funding from the Binational Agricultural Research and Development Fund.

The Idaho National Engineering and Environmental Laboratory funds **Bruce Bugbee**’s investigation of strontium uptake, partitioning, phytotoxicity, and spectral transmission in crested wheatgrass.
New Faculty & Staff

Seeds

Michael Gooseff is assistant professor in the Department of Aquatic, Watershed and Earth Resources. He studies the transport of dissolved substances in streams and the exchange of water in to and out of the saturated sediment adjacent to and under streams where bacteria and other biota interact with it. Gooseff earned a bachelor's degree at the Georgia Institute of Technology, and master's and doctoral degrees at the University of Colorado.

Daniel Rosenberg studies environmental factors affecting the distribution and abundance of animals in managed ecosystems. His work focuses on how animal populations respond to environmental stress, including human influences, and ranges from understanding individual animal's space use and how individual performance affects population dynamics. Rosenberg is assistant professor in the Department of Forest, Range and Wildlife Sciences. He earned a B.S. at Virginia Polytechnic Institute and State University, and an M.S. and Ph.D. at Oregon State University.

Ronald Ryel joins the Department of Forest, Range and Wildlife Sciences where he teaches and investigates plant physiological ecology. His research interests include plant responses to stresses in arid and semi-arid environments and how plants affect ecosystem functions. Ryel's UAES supported research examines net ecosystem carbon exchange in semi-arid rangeland communities and how carbon fluxes are affected by soil water dynamics. He earned a bachelor's degree at Michigan State University, a master's degree at Utah State University, and a doctoral degree from the University of Wurzburg.

Rudy Tarpley comes to the Agricultural Systems Technology and Education department following faculty appointments at Eastern New Mexico University, Texas Tech University and the College of the Southwest. Tarpley's career is a blend of academic training and classroom experience with advanced degrees agricultural education—master's and doctoral degrees from Mississippi State University—paired with 13 years of experience as a high school agriculture teacher. He also had a two-year stint as the agricultural news anchor on KBLK TV in Lubbock, Texas. His years of work in educational research and evaluation make him an asset to the Utah State University College of Agriculture's curriculum and advising committees. He currently studies the experiences of young professionals in agricultural education.
Fighting Animal Disease at the New Central Utah Laboratory

Utah has a new line of defense against animal diseases. The Central Utah Veterinary Diagnostic Laboratory in Nephi opened its doors in August to serve livestock producers, veterinarians and animal owners in the central and southern parts of the state. The laboratory, a branch facility of the state diagnostic laboratory in Logan, is a cooperative venture of the Utah Agricultural Experiment Station (UAES), Utah State University and the Utah Department of Agriculture and Food.

Services at the laboratory are vital to the economic strength of the state’s animal industry as scientists diagnose diseases, discover toxins and provide proof of good health prior to animals being sold or transported across state lines. In addition, technicians at the laboratories are on the front lines in the state’s defense against diseases such as West Nile virus and chronic wasting disease, and aid veterinarians in diagnosing maladies in companion animals.

The new 5,000 square foot facility replaces the branch diagnostic lab in Provo which has served veterinarians and livestock owners since 1979. The new laboratory provides a wider array of tests than its predecessor, and houses a powerful lift to unload large animals. The lobby doubles as a conference room for continuing education seminars. In addition to a new building, two new staff members—an office assistant and a serologist/microbiologist—will be available to better serve clients.

Jane Kelly, veterinarian and diagnostician currently at the Provo lab continues to work with animal owners and veterinarians at the Nephi lab, and both the Logan and Nephi locations are under the direction of Thomas Baldwin. In recent years the Utah Veterinary Diagnostic Laboratory staff has performed more than 37,900 diagnostic tests annually.

State Veterinarian Mike Marshall said, “The better our labs are the better our diagnostic services will be whether we are working with pets or food animals. We have great cooperation in the state between people in agriculture, public health and wildlife management, and we are dedicated to safe food, safe people, and controlling the spread of disease.”

UAES researcher and Utah State Extension veterinarian Clell Bagley received this year’s Friend of Agriculture Award from the Utah Farm Bureau. Bagley was honored for his outstanding service to individual livestock producers and veterinarians statewide and for presenting seminars on current research and practices to assure healthy, productive livestock operations.

Bagley’s UAES research focuses on understanding and control of Mycobacterium paratuberculosis, which can cause infected dairy and beef cattle to develop chronic diarrhea (commonly known at Johne’s disease). The disease decreases an animal’s market value and spreads the organism to other cattle.
Undergraduate Research Mentors of the Year

Three UAES affiliated researchers—Jeanette Norton, Bruce Godfrey, and Mark Brunson—are among the eight outstanding faculty members honored as Utah State University’s 2003 Undergraduate Research Mentors of the Year. The university considers scholarly research an important part of undergraduate education, providing students many opportunities to gain first hand knowledge while working with faculty experts. To qualify for the award, nominees must have a demonstrated and sustained record of mentoring undergraduates in research, assisting them in sharing new information through publications or professional meetings, and having an impact on student’s graduate school and professional careers.

Since 1996, Norton has mentored 12 undergraduate students in soil microbiology research. Students have been involved in a variety of projects related to the ecology and molecular biology of nitrifying bacteria in agricultural soils. Their experiences in the field and laboratory have enabled Norton to pen excellent letters of recommendation for students moving on to graduate studies in soil science, medical, dental, and other fields.

Godfrey’s students are given many opportunities to apply economics to problems posed by a number of groups and government agencies. Many of the projects have resulted in publication in professional journals and Utah Agricultural Statistics. Two of his students have won awards for their work from the American Agricultural Economics Association.

Brunson works with students interested in understanding relationships between society and natural settings, and how public information and education can be designed to help people live in better harmony with nature. His undergraduate research assistants have worked in locations familiar and exotic, from right on campus, to the jungles of Puerto Rico, to agricultural villages of northwestern Mexico.
USU Researchers Named Fellows

UAES researchers Steve Dewey and Kevin Jensen have been elected fellows of their respective professional societies, a distinction awarded annually to only a small number of each organization's members in recognition of outstanding contributions to their field of study.

Dewey (left) was made a fellow of the Weed Science Society of America. He teaches courses in weed biology and does extensive research on the spread and control of invasive plant species, particularly on pasture and public land. In 2000, Dewey was appointed to the National Invasive Species Advisory Committee by the U.S. Secretary of the Interior.

Kevin Jensen (right), a research geneticist at the USDA- Agricultural Research Service Forage and Range Laboratory, was elected a fellow of the American Society of Agronomy. His research, supported by the UAES, includes improvement within the Triticaceae, Bromus, and Dactylis genera. He serves as associate editor of "Crop Science" and on several germplasm and forage improvement organizations.

Dudley Voted President-elect of AAAS-Pacific Division

Soil scientist Lynn Dudley has been voted president-elect of the American Association for the Advancement of Science-Pacific Division. The division, founded in 1915, serves nearly 25,000 of the more than 10 million scientists AAAS represents, taking in members from California, Hawaii, Idaho, western Montana, Nevada, Oregon, Utah, Washington, British Columbia, Alberta and all other countries bordering or lying within the Pacific Basin except mainland Mexico south to Panama. Dudley's research focuses on soil properties and particularly on saline soils.
To the casual observer the life of grazing or browsing animals looks simple: stroll, sniff, bite, chew, repeat. But people who manage land and animals know reality is not that simple. After years of research and observing wild and domesticated animals in all sorts of situations, Fred Provenza knows that providing the right food is not enough to guarantee healthy animals or habitat.

Animals are not eating machines, that consume whatever food is available. The processes they use to determine what, when, and how much to eat are no less complicated than the ones humans engage in every day. Provenza, professor of forest, range and wildlife science, says that in attempting to simplify and manage animal behavior researchers emphasize understanding and catering to the “average” animal in a group, obscuring the fact that individual responses to food and surroundings vary widely. In “Foraging Behavior: Managing to Survive in a World of Change,” a booklet recently authored by Provenza, he explains that although there is no “mean” weather, soil, plant, herbivore, or person, there are factors that are nearly universal in developing an animal’s food preferences.

Like people, animals learn about food choices first from their mothers and later from their peers. They tend to prefer familiar foods to unfamiliar ones, especially when placed in a strange environment. The pleasant or unpleasant consequences associated with eating a certain food are pivotal in shaping an animal’s food preferences, even when they are not conscious of the information flowing between the gut and brain.

Lambs exposed to various foods with their mothers, like this pair sampling serviceberry, will eat considerably more of those foods than lambs exposed without their mothers.
Your Animals
Like You)

Provenza says an animal begins learning about food from its mother very early in life as flavors from the food she eats are passed along in utero and in her milk. When animals begin to forage, they eat what mom eats and, just as significantly, avoid eating what she does not eat. Those early lessons are remembered. In one experiment, researchers found that when lambs were offered a nutritious food like wheat for one hour each day for five days the lambs who were exposed to the food with their mothers ate more wheat than did those who were not with their mothers. Even three years later, with no further exposure to wheat, the lambs who experienced eating wheat with their mothers ate nearly 10 times as much as did inexperienced lambs and those who had eaten wheat without their mothers. All this learning from mom’s example is especially important for animals who forage because learning to avoid poisonous plants and limit the intake of plant toxins is essential to survival.

Peers become an important influence on young animals as they age and interact more often with animals who have learned different eating behaviors. Young animals encourage one another to explore new foods and habitat, adding new twists to range management and animal nutrition, but increasing the efficiency of the group because when one creature discovers a useful new resource the whole group benefits.

Moving animals from familiar to unfamiliar surroundings presents a special set of problems, Provenza says. It hinders a creature’s ability to thrive because it must learn about new food, water,
These dairy cows in upstate New York have just been released from the confinement barn and moved onto pasture for the first time. There was a lot of running around and not much grazing.

I really wonder about this move to the new pasture... Yeah, I just hope I recognize the food.

hazards, predators, and shelter through trial and error. Studies have found that animals moved to a new environment spend up to 25 percent more time foraging but ingest 40 percent less food than animals of the same species raised in that environment. This is the case even when nutritious food is more abundant in the new environment. A striking example of this behavior was demonstrated when Provenza visited a dairy farm in upstate New York. A herd of Holsteins that had been raised in a barn and provided with daily rations were let out to pasture for the first time. They happily left the barn, ran around in grass up to their bellies, and then ran right back to the barn looking for food. It seems strange that hungry cows would stand at the barn door and bellow instead of just eating the grass, but they didn't recognize grass as food. It's similar to the way that seeing a plate of sushi prompts one person to think, "dinner" while another thinks "bait"—it's a matter of familiarity.

"For a dairy cow raised in confinement, the barn is habitat, ingredients from a total-mixed ration are food, and water comes in a trough," Provenza writes. "...for a beef cow reared on rangelands in the western U.S., riparian areas and uplands are habitat; a diverse array of grasses, forbs, and shrubs are food; and water comes in streams and ponds. When these animals are moved to feedlots, total-mixed rations aren't food and feedlot pens aren't habitat."

Producers can help grazing animals ease the transition from familiar to unfamiliar environments by selecting areas that are similar to those the animal has experienced, with food and water sources that
the animal recognize. Animals that will eventually be in a feedlot maintain their food intake and remain healthier if they are exposed to the foods they will encounter at the feedlot while they are young and still with their mothers.

One of the most important things young animals learn is to avoid or limit their intake of plant toxins. Even though people and other creatures are unaware of the constant loop of signals from the senses and organs to the brain and back that regulate their eating habits, the body monitors toxins and needed nutrients. An animal may have learned about what to eat from its mother and peers, but the way the animal feels after eating a particular food plays a critical role in determining its food choices. Many range plants contain toxins such as terpenes, alkaloids, and cyanogenic glycosides. Eating too much of any of these can have unpleasant consequences. The constant feedback between the brain and body usually signal an animal to stop eating before toxins reach a level the body cannot handle.

A bad experience associated with a particular food can cause an animal to avoid that food for many years. And because the body and brain function without the animal consciously directing them, behaviors are shaped almost automatically and become part of the animal’s eating pattern. For example, sheep in one study were given a nutritious food just prior to anesthesia. While they were deeply anesthetized the sheep received a dose of a common toxin, triggering a response from the gut and brain. The body’s response to the toxin was so automatic and such a powerful conditioner
Ahh, not alfalfa AGAIN. We had that last night. And the night before, too. All we ever eat is alfalfa.

Provenza has learned that when animals consume toxins their need for nutrients increases, allowing their bodies to transform and excrete the toxins and remain healthy. Understanding this principle is important to land managers who use animals to control weedy, invasive plants. Livestock are increasingly introduced to areas specifically to eat weeds that threaten ecosystem diversity and increase fire risk. Some may think that the hungrier the animals are the more weeds they will eat. But most plants—including weeds—contain toxins, so a poorly nourished animal will not eat as much. Provenza points out that in a feeding trial sheep and goats ate nearly twice as much sagebrush and bitterbrush when they were also given energy and protein supplements.

"Understanding the behavior of any creature is simple: behavior is a function of its consequences," Provenza says. "Favorable consequences increase and aversive consequences decrease the likelihood of a behavior." That sounds simple enough, but applying that principle so that animals and habitat thrive is a little tougher and requires people to really think about what their animals are thinking.
As the principle investigator heading Behavioral Education for Human, Animal, Vegetation & Ecosystem Management (BEHAVE), Fred Provenza sometimes feels his job requires him to be equal parts scientist and matchmaker. While he is involved in his own research and teaching, a growing share of his time is devoted to introducing people with land and animal management problems to scientists who can help find solutions, matching questions from an array of people and agencies with what the BEHAVE team already knows about animal behavior, and trying to arrange partnerships that benefit people, animals and the environment.

BEHAVE, founded in 2001 with a five-year grant from the USDA Initiative for Future Agriculture and Food Systems and the Utah Agricultural Experiment Station, is a consortium of experts from Utah State University, University of Arizona, University of Idaho, Montana State University, National Wildlife Research Center and an advisory board of 50 people from across the United States.

The consortium brings together animal nutritionists, plant scientists, range ecologists, and behaviorists, among others, to focus on helping people master and apply behavioral principles in managing ecosystems. That may mean working with dairy farmers, public land managers, and ranchers raising bison all in the same week, all while gathering new research and management information, and experimenting with new and time-tested practices. For example, the group gained new insights about animal food preferences and nutritional needs by blending modern chemistry and plant ecology with animal management practices French shepherds have used and handed down for ages.

"We look at all kinds of information, we do our own research, and find a lot of answers and interesting new questions," Provenza says. "Sometimes it seems a little overwhelming because there are so many people who want to learn about our program and we keep making connections that lead us to more information and more questions."

Many of the questions the group tries to answer seem simple at first. For example, can you teach animals to be more effective and selective weed eaters? Or, if you understand an animal's social organization, learned behaviors, and food preferences can you have rotational grazing without fences? Straightforward questions, but with answers as complex as the ecosystems and creatures they involve.

Among BEHAVE's goals are to: 1) improve economic viability and ecological integrity of pasture- and range-based enterprises; 2) enhance and maintain biodiversity of rangelands; 3) restore pastures and rangelands dominated by weeds; 4) optimize wildlife benefits to land owners, managers and users; 5) mitigate livestock abuse of riparian areas; 6) improve our ability to manage complex adaptive systems. In addition, many of the researchers involved with the project are working with graduate students, shaping a new generation of scientists who will think in terms of applying behavioral knowledge to land and animal management.

"The project has grown and we have made connections with a lot of people," Provenza says. "Our research continues, but we already have a lot of knowledge to share and are meeting with groups all over the West. We have books, fact sheets, a Web site, and give presentations to groups of ranchers, farmers, and public land managers. There is so much information that we know can really help people that we are trying to secure BEHAVE's longevity and looking for ways to make it self-sustaining over the long haul."

For more information, or to order booklets and fact sheets, see the BEHAVE Web site: www.behave.net, or contact the consortium via email, phone or mail.

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It was a new sort of horse race and a Utah State University/University of Idaho team were the first to cross the finish line—with a mule.

Idaho Gem, the world’s first cloned equine and first cloned hybrid animal, was born May 4, 2003, followed on June 9 by his genetically identical brother, Utah Pioneer. Before their younger brother Idaho Star was born July 27, a team of Italian researchers announced the birth of a cloned horse.

It’s rare to be part of a true scientific “first” but when talking with UAES researcher and animal science professor Kenneth White and his colleagues at Utah State and University of Idaho, it’s clear that what they learned along the way as important as the animals’ births.

The mules joined a growing list of cloned mammals that have been born since the first clone of an adult animal, Dolly the sheep, was born in 1996. To date scientists have successfully cloned cattle, goats, pigs, rabbits, an endangered species of wild cattle called a gaur, mice, cats, mules, horses, and most recently, a rat.

The basic procedure for producing a clone is fairly standard across species. Using microsurgery techniques, scientists take an unfertilized egg—a mare egg in the case of the mule clones—and remove the genetic material. Next, genetic material from a cell donor is inserted into the egg. Skin cells from a mule fetus were used to clone the mules. The egg and it’s new genetic material are placed in media in a dish and subjected to a short electrical shock which fuses the egg with the new DNA. The cells begin to divide and form an embryo which is implanted in a surrogate mother to continue developing until delivery.

Of course, every step of the process is not always successful and far more embryos fail to develop than make the long and amazing developmental journey from DNA to healthy baby animal. Between 1998 and 2000, White and his University of Idaho colleagues Gordon Woods and Dirk Vanderwall, DVMs and professor and assistant professor of animal and veterinary science, respectively, transferred nuclei from 134 mule cells into mare eggs and implanted them into mares. Just two pregnancies resulted from those efforts, and both failed to proceed past four weeks gestation. What finally made the difference was the team’s discovery that the level of calcium inside and outside the cells appears to play an important role in signaling the cells to divide. When they increased the level of calcium in the media nourishing the embryos their success rate increased.

Even with this new knowledge cloning cannot be considered an efficient reproductive process. Idaho Gem, Utah Pioneer and Idaho Star are healthy, active mule foals—each with distinctive behavioral traits—and White says the fact that the team repeated its success three times is an important scientific contribution. But the three mules are the result of 113 embryos the team implanted in 2002. Fourteen pregnancies initially resulted from those 113 embryos, and just eight were sustained through the 40-day stage.

With those odds why attempt to clone animals at all. The team believes the cloning process may help in creating new drugs to prevent or cure some diseases in humans. Specifically, White, Woods, and Vanderwall are interested in exploring what equine cloning might teach us about how cancer cells develop and spread. In addition, cloning offers a way to increase populations of endangered species and save them from extinction. The mules illustrate another scenario where cloning makes sense. A mule is the offspring of a male donkey and a female horse and, like all hybrid animals, is almost always unable to reproduce. Scientists think that is because mules have 63 chromosomes, an odd number that cannot be divided equally to produce normal egg and sperm cells which carry half of each parent’s chromosomes. Horses have 64 chromosomes, and donkeys have 62. (Humans have 46.)

The team’s research continues, and more remarkable findings may come years down the road. For now though, the three mule clones are blissfully unaware of their place in scientific history, but behaving like the winners they are.

"What finally made the difference was the team’s discovery that the level of calcium inside and outside the cells appears to play an important role in signaling the cells to divide."
Find Utah Science and other information about the people and projects of the Utah Agricultural Experiment Station online at www.agx.usu.edu

The researchers featured in this issue recommend the following Web sites for more information on their research topics.

**Search**

**Science on the Web**

**Taste and fat**

http://bioweb.usu.edu/tag/

A look at the people and projects in Tim Gilbertson's lab. Links to online journals and other science resources. National Institute on Deafness and Other Communication Disorders


Information about the sense of taste, and why it sometimes doesn't work as it should.

**Obesity and Alzheimer's disease**

The Alzheimer's Association

www.alz.org

The Alzheimer's Association site provides information about the disease, research, and support for people with Alzheimer's disease and their caregivers.

National Institutes on Aging Alzheimer's Disease Education and Referral Center

www.alzheimers.org

This National Institutes on Aging site offers many resources (booklets, videos, etc.) and online information about causes and symptoms of Alzheimer's disease, as well as support material for people caring for Alzheimer's patients.

The Centers for Disease Control and Prevention

www.cdc.gov/ncedphp/dnpa/obesity/index.htm

An extensive web resource for health information. This section of the web site focuses on defining obesity, health consequences of being overweight, a body mass index calculator, and strategies to help avoid obesity and its accompanying health problems.

**Animals' eating behaviors**

www.Behave.net

Behavioral Education for Human, Animal, Vegetation & Ecosystem Management (BEHAVE) is a consortium funded by USDA and the Utah Agricultural Experiment Station to inspire people to master and apply behavioral principles in managing ecosystems. It includes links to information about why people and animals make certain food choices, management practices, and current research updates.

The UAES offers these recommendations as a service to readers, but is not responsible for the content of sites it does not produce.