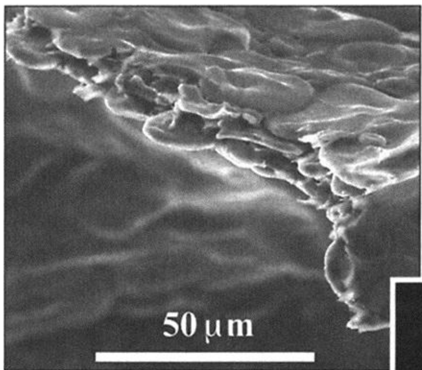
FOOD SCIENCE

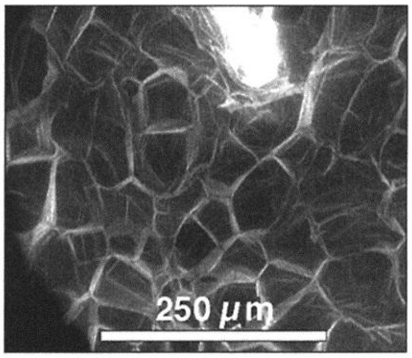
Why Is a Soggy Potato Chip Unappetizing?

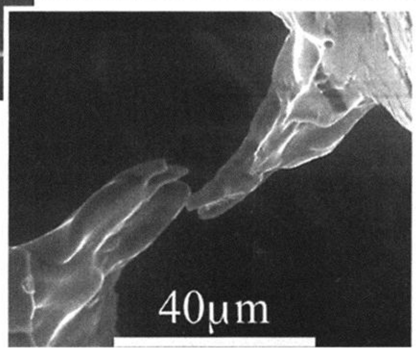
Researchers don't have the answer, but at an unusual workshop they tried to get a feel for how texture influences palatability

ERICE, SICILY—Contemplate, for a moment, a few of the world's greatest mysteries: What came before the big bang? How did life originate? Why is a firm strawberry jam less scrumptious than a soft one? That last enigma, at least, is yielding to the practiced tongues of molecular gastronomists. The key is texture, an elusive attribute that practitioners of the science of taste are just beginning to get a feel for. Texture is complicated, says Alan Parker, a colloid scientist at Firmenich, a flavor and fragrance company in Geneva, because it is part cognition, part physics, and part chemistry. Not to mention a dollop of fun.

Every other year since 1992, several dozen chefs and scientists have descended on this Mediterranean resort town—better known for its summer physics and cosmology schools hosted by the Ettore Majorana Centre for Scientific Culture—to take part in a weeklong International Workshop on Molecular and Physical Gastronomy.* Past sessions here have tackled problems of flavor and heat transfer. (Cooking is largely the business of adding heat.) This year, the topic was texture.







The architecture of crunch. Micrographs show food at the breaking point: clockwise from upper right, carrot and wet and dry bread crumbs.

The workshops themselves are the brainchild of the late Nicholas Kurti, a low-temperature physicist and cooking enthusiast from Oxford, U.K., and Hervé This, the former editor of *Pour la Science* (the French edition of *Scientific American*), who's now affiliated with the Collège de France in Paris. The duo coined "molecular gastronomy" in 1990 to describe the science of cookery.

What does cooking have in common with cosmology, Ettore's usual fare? Not much. Local physicist Beatrice Palma-Vittorelli explains that when Kurti called her husband Ugo, a physicist, one day to ask for his help in finding a venue for a gastronomy workshop, Ugo mistakenly heard "astronomy" workshop. The rest is history.

So is at least some of the distaste hardcore scientists have shown toward food science. "People like to do heroic things," says Gordon Williams, a mechanical engineer at Imperial College, London, and the properties of food are not considered "serious science." An oft-cited milestone in the subject's journey toward respectability is the Nobel Prize in physics won in 1991 by past Erice attendee Pierre-Gilles de Gennes, for demonstrating how large molecules flow. His discovery relates to what happens in stirring a drink, and in moving food around in the mouth. "De Gennes legitimized the study of the everyday," says Parker.

And that's what the gastronomy workshops are all about. In this year's powwow on texture, however, the participants nearly bit off more than they could chew. Texture may be "too difficult to solve," says Len Fisher of the University of Bristol. U.K., but it's "too important to ignore."

The problem is that texture is tough to define. Scientists understand it as the orientation and size of crystals in a material, or as the internal morphology of multicomponent materials, says Peter Barham, a polymer physicist at the University of Bristol and the co-organizer of this year's meeting. But to the senses, texture is connected to how food breaks apart in the mouth, say, or to its stickiness—qualities described with adjectives like smooth or crunchy or slimy. Individual differences complicate the picture; so does the fact that the acceptability of textures is largely learned. "It's not like ceramics," says Athene Donald, a food physicist at Cambridge University in the U.K., "where you can say, 'This one's brittle.' "

Erice is a workshop, not a conference, so presentations are kept to a minimum. The format, open discussion, is designed to mix disciplines: Chefs get ideas about how to cook better, traditional food scientists learn something about quality (not a high priority in the food industry, which is concerned with bulk product), and academic scientists come away with ideas to test.

In the laboratory, the study of texture is still a nascent discipline. Williams is unusual in having spent the last 10 years examining the viscoelastic properties of cheeses by squashing them in little cylinders, "because it's interesting." The food industry, too, which funds most work related to food, relies heavily on a "cook and look" approach but is moving toward more exact science because of a need to reproduce successes and to create particular textures. It is a big jump from characterizing the material properties of food to understanding texture, though. "We are getting numbers [from mechanical tests] like 42, and we get answers [from tasting panels] like 'It's rubbery,' " says Williams.

Indeed, foods are "macromolecular messes" in which you might find small bubbles, droplets, or particles, says Fisher, whose calculation of the optimal way to dunk a biscuit won him an Ig Nobel prize in physics in 1999: "All sorts of mad things can happen." Moreover, owing to the viscoelastic properties of foods, how fast or how slow we chew them affects how they flow in the mouth. With foods, says Parker, "things are happening along many, many length scales and at the same time."

A particular challenge is to untangle texture from taste: Potato chips, for example, become unpalatable when soggy, although their chemical composition remains the same. At the University of Nottingham, U.K., Andy Taylor and Tracey Hollowood

* 5 to 10 May.

CREDITS: (CARROTS, TOP RIGHT) PNAS; (BREAD CRUMBS, UPPER LEFT AND LOWER RIGHT) D. J. STOKES AND A. M. DONALD, J. MAT. SCI. 35, 599 (2000)

are working to understand why increasing the viscosity (or resistance to flow) of a food makes it seem less flavorful, even though experiments indicate that viscosity has no effect on the amount of aroma that gets into the nose. Edmund Rolls, a neuroscientist at Oxford University, and his colleagues showed in 1999 that neurons in the brains of macaque monkeys respond to the texture of fat in the mouth—particularly to liquid fat such as cream and liquefied chocolate-hazelnut spread—independently of neurons clued in to smell or taste. The tip-off was that neurons responded just as much when the monkeys were fed harmless amounts of silicone oil, which has a fatlike texture but no taste or smell. Because humans and macaques have evolved to savor fat, and because the monkeys were more readily sated by liquid fat than by solid, Rolls hypothesizes that taking fat as a liquid, or chewing foods well to liquefy the fat in them, may have application in weight control.

The science of texture, like that of food generally, is a subtle and sophisticated one. But "to understand texture you have to be eclectic," says Parker, "because you do not know in advance if the answers to the questions you ask are in the *Journal of Neuroscience* or *The Physics of Sliding Friction*." The scientists hope that meeting challenges like this will help move the science of food off the back burner. **–GISELLE WEISS**

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MARINE MAMMALS

Scientists Use Strandings To Bring Species to Life

Some scientists worry that eye-catching efforts to rescue stranded marine mammals may detract from less glamorous—and smellier—research

ASSATEAGUE ISLAND, VIRGINIA—The baby whale wasn't fast enough to escape the ship's giant propeller. With its backbone shattered and blood streaming from five deep gashes on its right flank, it was dead within minutes.

Robert Bonde, a marine mammal researcher with the U.S. Geological Survey in Gainesville, Florida, didn't witness that marine hit-and-run earlier this year. But the anatomist had little trouble reconstructing the last moments in the life of the 8-meter-long northern right whale, now a rotting carcass here on an isolated beach. "It looks like the ship caught him from behind, just as he put his head down to dive," Bonde concluded after examining clues provided by the size, depth, and location of the slashes.

Bonde and his colleagues have spent decades trying to better understand the lives—and deaths—of seagoing mammals by examining the thousands of whales, dolphins, seals, sea lions, and manatees that wash up on shore each year (see table). Most don't survive: Live animals account for less than one-fourth of the 3000 reported in an average year in the United States. And most are dead for days before they're found, leaving researchers to dub their work "stinky science."

Still, the knowledge acquired from beached animals is fueling moves to beef up stranding science in the United States and elsewhere. Responding in part to the need for more information about endangered species such as the right whale, Congress last year approved a plan to give up to $15 million over the next 3 years to the 25-year-old U.S. stranding network, a sometimes uneasy alliance of about 400 private research institutions, independent wildlife rescuers, and government agencies. And beachcombing scientists around the world are discussing ways to improve international collaboration.

The growing interest in stranding work, however, is dogged by debate. Some researchers and animal-welfare advocates want to pull out all the stops to rehabilitate and release the animals back into the wild—at upward of $1 million for a large whale. But others say that it's often more humane—and more fiscally prudent—to euthanize some of the victims and invest more in the mundane job of analyzing the samples that are harvested. The tension underscores the "uniquely difficult role" played by groups that respond to strandings, says wildlife veterinarian Andrew Stamper of Disney's Living Seas pavilion in Orlando, Florida: "They must be both a humane society dealing with the welfare of stranded animals and an objective institution collecting scientific data."

Whale tale. Researchers Scott Kraus (*left*) and Robert Bonde (*right*) prepare to necropsy a stranded right whale killed in a collision with a ship.

Carrion hunt

At least since Aristotle pondered why dolphins would wash up along ancient Mediterranean shores, humans have been interested in stranded marine mammals. But the systematic study of strandings didn't really begin until the early 1970s, when governments began outlawing whaling and giving new legal protections to all marine mammals. The changes sparked U.S. efforts to collect stranded animals and use the specimens to learn about wild populations.

REPORTED STRANDINGS ALONG THE U.S. COAST, 1994–98

Region	Whales/dolphins	Seals/sea lions
Maine to Virginia	1013	1768
Carolina to Texas	3683	44
California	624	10,147
Pacific Northwest	119	1098
Alaska	462	172
Total	**5901**	**13,229**

CREDITS: (LEFT TO RIGHT) D. MALAKOFF; SOURCE: NATIONAL MARINE FISHERIES SERVICE