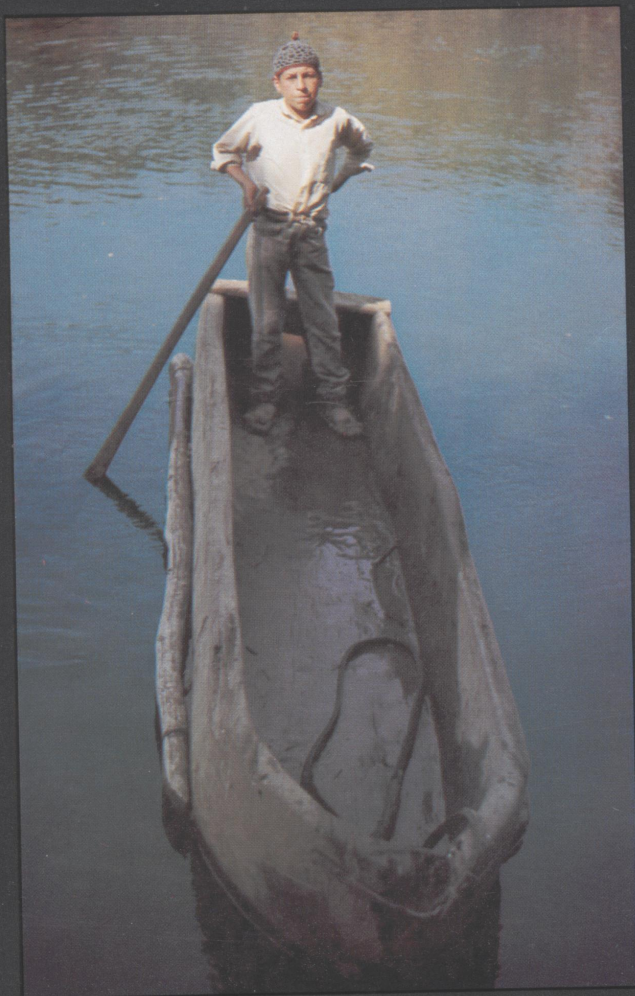


ODYSSEY



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Cover photo:

A young Mapuche Indian navigates the
Río Bueno (The Good River) in his
canoe which has been hand hewn from
the trunk of a luma tree. The Mapuche
Indians of Chile are the subject of the
lead article in *Odyssey* entitled *Hunters
and Harvesters of the Cone*.

ODYSSEY

This is the first issue of *Odyssey*, a magazine published twice yearly by the University of Kentucky Research Foundation under the auspices of the Dean of the Graduate School. Each issue of *Odyssey* describes only a few of the many University of Kentucky research projects underway in a variety of fields.

Odyssey replaces the traditional U.K.R.F. annual report.

Requests for permission to reprint material and readers comments regarding *Odyssey* are welcome and should be sent to the Editor, 307 Kinkead Hall, University of Kentucky Research Foundation, University of Kentucky, (0057), Lexington, Kentucky 40506, Phone 606-258-2861.

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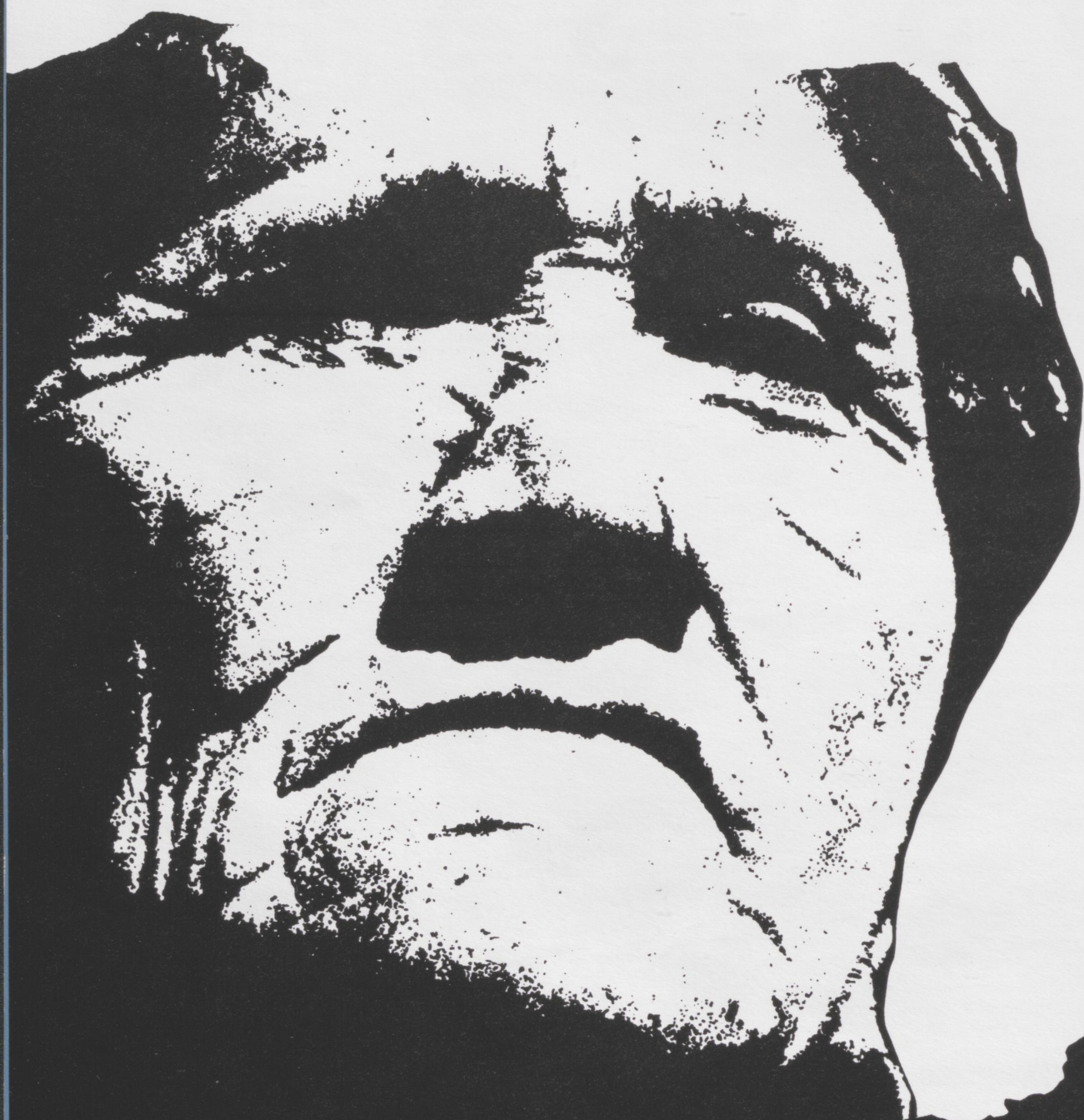
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MAPUCHE

HUNTERS & HARVESTERS OF THE CONE

Skyscraping volcanoes and rolling grasslands, complex Indian societies and Stone Age peoples, highland farmers and coastal gatherers and plains hunters—the wedge-shaped tip of South America embraces a land rich in contrasts. From mighty Aconcagua, the continent's highest peak, the Andes march southward to disappear into frigid waters near the Antarctic Circle. West of the Andes, Mapuche farmers, descendants of indomitable Araucanians in Chile's fertile Central Valley, thrive as one of the largest Indian groups in South America. But east of the Andes only the ghosts of nomadic hunters ride the vast plains that Indians called pampa, meaning "space." They have vanished, along with virtually all the tribes who once inhabited this end of the world. They live on only in the blood of mestizos and in the words of explorers, scientists, and missionaries.

On the first voyage around the world, the intrepid mariner Ferdinand Magellan observed "a land stark with eternal cold" as he sailed through the treacherous strait that bears his name. Indian fires twinkled on every shore, so he called the region Tierra del Fuego, Land of Fire. Even summers could be viciously bitter; two servants with Captain Cook stayed out one summer night and froze to death.

When H.M.S. Beagle anchored off the island in 1832, a seasick young naturalist named Charles Darwin

Hunters and Harvesters of the Cone is reprinted as a courtesy of the National Geographic Society. It appeared originally in the newly released *Lost Empires, Living Tribes* © National Geographic Society.

The author, Tom Dillehay, is an associate professor in the University of Kentucky's Department of Anthropology. Dr. Dillehay also produced the photographs accompanying the article.



A machi beats the kultrun drum in an attempt to communicate with the ancestors.

described the squat, red-eyed natives as "man in his lowest and most savage state." He watched a mother nurse her baby as sleet fell on their naked bodies. He saw stunted men, "their hair entangled, their voices discordant, and their gestures violent." Darwin wondered: "Could our progenitors have been men like these?"

The white man's diseases and weapons finally decimated the Fuegians as well as the grassland hunters. Magellan had called these Argentine natives, who wore grass-stuffed moccasins, Patagones, or Big Feet. Though they are no more, the name has stuck to their semiarid homeland—Patagonia. But Mapuche farmers beat back Inca invasions, withstood new diseases, and for several centuries blocked Spanish and Chilean attempts at domination. Ironically, Mapuche heroism inspired the Chileans in their fight for freedom from Spain in the early 1800s.

Drums beat a hypnotic tempo as seated men and women sing and chant, and small groups prance and gyrate rhythmically around a sacred altar in the center of the ceremonial field. Men on horseback gallop around the edge of the field, their shouts and the thunder of hoofbeats chasing away evil spirits. I watch partially mesmerized, caught up in the nguillatun, a three-day agricultural fertility rite of the Mapuche Indians. It's an early spring morning in a pine forest on Chile's wet coastal strip, and I find it ironic that the friendly people around me are descendants of the legendary Araucanian Indians, an indomitable people whose warriors were so fierce they stopped the Inca's invasion in the mid-15th century, then for the next 350 years defied the Spaniards and Chileans.

I was in Chile to teach anthropology at universities in the heart of Mapucheland, and I had jumped at the chance to participate in this sacred

ceremony. Soon I found myself helping Mapuche men cut wooden poles and branches for their family *ramadas*. As the lean-tos rose, the men chatted about the days ahead, the relatives and friends coming from far away, the food and the dancing, and the goodwill to be shared by all. Late that afternoon, rosy-cheeked women brought us bowls of potatoes and horsemeat. As we ate, a crackling fire of fragrant boughs sent sparks and sweet-smelling smoke into the air.

Possibly more than any other American Indian group, the Mapuche have fought longer and harder to preserve their identity; they have become one of the largest surviving Indian societies in South America.

Now the nguillatun is in its last day. Ramadas surround the field. While some Indians dance and perform rituals, others sit on the ground and chant, communing with their ancestors and their gods.

The dancing stops, and the participants feast once more with relatives and friends. The elder men kindle a fire on the altar and place there the meat of a sacrificial goat or sheep. The ritual priest watches over the activities, while the shaman sits immobile, transfixed by some unseen spiritual force. Now the ritual ends, quietly, and the Indians leave, strengthened in their sense of being Mapuche.

The Spanish conquistadores had called the ancestors of these Indians Araucanos, a name perhaps derived from a fruit-bearing tree called the *Araucaria*, or from the Quechua word *auka*—warrior. Thinking in geographical terms and measuring Indian cultures by their savagery and resistance, the chroniclers identified three Araucanian groups: The northernmost were called the Picunche; the middle group, the Mapuche, lived south of the Bío-Bío River; farther south the Huilliche occupied the territory down to Chiloé Island. The outstanding difference among these groups, as the Spaniards saw it, was the ability of the Mapuche to resist Spanish settlement. The Picunche were quickly defeated and assimilated by the Incas and then the Spaniards. Most Huilliche eventually joined the Mapuche cause, and the story of these two groups became one. Under the leadership of the Mapuche, Araucanian culture and influence expanded eastward across the Andes into the Argentine pampas.

Although today many Mapuche are assimilated into the Chilean way of life, about 200,000 Indians live on more than 2,000 small reservations scattered among numerous towns and estates. Possibly more than any other American Indian group, the Mapuche have fought longer and harder to preserve their identity; they have become one of the largest surviving Indian societies in South America.

In prereservation days the Mapuche followed a semisedentary way of life in tune with the changing seasons. Hunting parties stalked deer, fox, birds, and *guanaco*, a species of wild llama. In summer the Indians gathered an abundance of wild plants and fished lakes and streams. "During the months of February and March," wrote a Spanish chronicler, "the people would line the banks of a river . . . each man was equipped with a long, sturdy cane pole with a pointed, trident-shaped end . . . there were so many fish that the Indians could slap the water, stunning and hooking a fish and bringing it ashore. . . . Within hours they would have enough fish to feed all the people." The Mapuche who lived along the coast dug clams in the inlets and fished the cold waters of the Humboldt Current.

The Araucanians paddled about in



Reverence to past ancestors is revealed in the ancient face carved on a *rewe* pole. At the base of the pole are the *Kultruns* of several *machis*.

plank boats, dugout canoes, and small reed rafts. Chroniclers mention that in some areas llamas served as pack animals. From the Spaniards the Araucanians obtained horses. Today the Mapuche value horses for transportation and also as items of social prestige. Oxen, their only draft animal, are used to till the soil, clear fallen timber, and pull single-axle oak carts.

In the fertile valleys the Mapuche practiced slash-and-burn agriculture. When gardens around the family households wore out, the Indians shifted the plots to a new area. In the past the men cleared the land by girdling trees with stone axes, then burning the downed timber and underbrush. Using crude oar- or shovel-like tools to break up, loosen, and lift the earth, the Mapuche cultivated corn, squash, potatoes, beans, chili peppers, and *quinoa*, an Andean pigweed.

To a Mapuche, working the fields is not strictly a laborious task; it is also a seasonal event of social pleasure. In areas where modern technology has not been adopted or cannot be afforded, the Mapuche plant and harvest on a communal basis, a practice probably learned from the Incas. A man invites his relatives to come with their hoes, wooden prongs, and shovels. Wrote a Chilean anthropologist: "The men break the ground, the women faithfully following behind then, . . . making holes for seeds with their wooden sticks. When the tasks are over, the group retires to the owner's house, to indulge in lengthy conversation, telling stories of their young ones or how their grandparents used to work the fields . . . all graciously drinking and eating at the expense of the owner."

Now as then, each family farms about three to five acres. Households are scattered over the countryside on low hilltops or gently sloping hillsides within sight of each other. The dispersed nature of the community lends itself to the shifting of agricultural plots every few years. Even in the old days, the Indians kept a good distance from their neighbors, fearing poisoning or witchcraft from evil spirits.

During the long era of warfare the Mapuche installed local *toquis*, or war chiefs, seasoned warriors who were wise and gifted leaders. Evidence suggests that lack of centralized leadership made it much more difficult for Spaniards and

Chileans to defeat the Mapuche. Scattered groups had to be tracked down and subdued one at a time.

In times of peace the Mapuche lived in autonomous groups led by an elder, the *lonko*, a practice still followed today. The *lonko* exercises no real authority; his counsel is followed because he is considered experienced and wise, particularly in matters of economics.

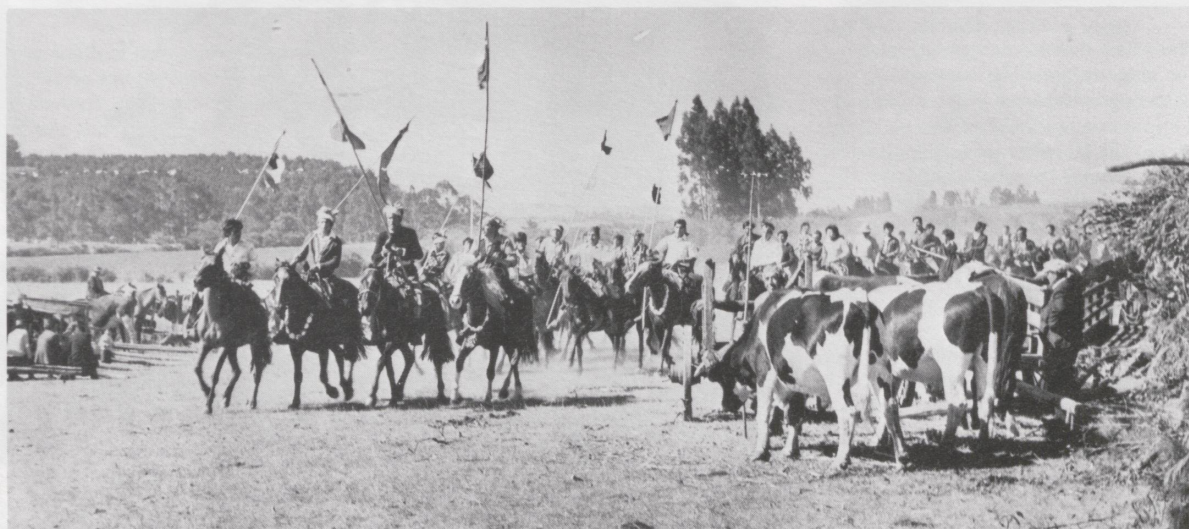
The Mapuche are bound by a strong sense of neighborly welfare, mutual dependence during hard times, and kinship ties. They trace their ancestry through the male line to a common ancestor, the "founder of the lineage." When a young Mapuche woman marries, she resides with a member of her husband's kinship group. Today a monogamous family of parents and children form the Mapuche household, but until the early part of the 20th century, polygyny, or the taking of several wives, was common. I have often heard men speak of their fathers and grandfathers, who were considered rich and powerful because they could support many wives. A Spanish historian described how "The first wife is always the preferred one . . . the other wives look up to her and see her as the true wife of the common husband . . . the first wife directs all the domestic chores. When she says that the fields need to be planted or harvested then the others do it. . . ." Each wife had her own work space within the

household and her own hearth to cook food for herself and her children. Each wife also worked her own land and took care of her own animals.

Standing alone in the countryside, the typical Mapuche household consists of an oval-shaped, thatched house called a *ruka*, a corral made of poles and branches, and a small, planked storage bin. The thick, high walls of the *ruka* insulate against the summer heat and the winter cold. Furnishings are sparse—usually low wooden benches, blankets, beds, woven storage bags, a mill for grinding corn, and a small low table.

Even today the Mapuche are cautious about the outside world. When a visitor approaches the *ruka*, he is met by barking dogs and curious eyes. Children go outside to look, then run to their mother announcing that someone has come. If the person is familiar, he is invited in to visit and drink *chicha de manzana*, a fermented beverage made from apples. A stranger is greeted politely outside the dwelling and after brief conversation may be asked inside.

Often I joined the household of Antonio Alquiapan for a meal. He and I leaned forward on low wooden benches while his wife, Eliana, presided at the fire. She spooned potatoes, beans, and horsemeat—a luxury among the Mapuche—from the pot. We also munched hot peppers, carrots, and bread, and washed it all down with fresh *chicha*.



A ceremonial field bustles with activities of *nguillatun*, a traditional Mapuche religious rite.

We talked in the eating area of the *ruka*, comforted by the warmth and fragrance of the fire. Antonio wiped his eyes often, as people do in a smoky room, his old hands trembling a bit. Antonio was a small man with broad, powerful shoulders. He had worked the land ever since he was old enough to walk the furrows and plant seeds. He showed me a three-foot-long sling he had twined from a local junco weed. "I remember when I used to walk in the open fields near the river, looking for small round stones, and shooting down water cranes that flew in from the coast." I offered to trade for the sling. He said, "I don't wish to give away this one. I made it when I was a boy, and it is the last one I have. It would be like saying good-bye to the old times that my grandfather had taught me."

*Those who do not know the customs of the Mapuche would be impressed by the order and cleanliness of the *ruka* and by the good behavior of the children.*

Those who do not know the customs of the Mapuche would be impressed by the order and cleanliness of the *ruka* and by the good behavior of the children. The Mapuche wife, in constant motion, cares for the smaller children, prepares corn cakes and bread, cleans fresh vegetables, and does other domestic chores. When she does sit down, she cleans household utensils or weaves a carefully designed blanket, poncho, or belt of wool, an art the Mapuche learned from the Incas. The smaller children and unmarried girls help her in all her labors.

The Mapuche man heads the household. Men work the fields and take care of livestock; they also carve wooden bowls, tool handles, and children's toys. Under his father's

guidance, a young boy learns to plow, feed the animals, and deliver sacks of grain or potatoes to the market.

Mapuche families work hard outside in the summer, tending the fields and the livestock, with little time for social visits away from the reservation. The family spends the rain-drenched winter months at home huddled around the fire. Children listen raptly while adults relate tales of their ancestors. The adults take advantage of these months to instruct the children in etiquette and morals in both the Mapuche world and the Chilean world. Youngsters learn to read and write Spanish at government schools on the reservation.

The Mapuche Indian's ancient religion pervades his life. He believes in a unity between the living and the dead, between the natural or visible world and the supernatural world. Sickness and death have no natural causes but come from *wekufes*, or evil forces. The evil spirits will do no harm if religious rituals are performed correctly, according to traditional ways. *Nguillatunes*, or ritual priests concerned with restraining evil, represent the people before the deities at ceremonial events. On a daily basis the shaman—usually a woman—is preoccupied with the eternal struggle between good and evil.



A Mapuche woman wears traditional dress and silver *trapela kucha* breast piece.

The protecting center of the Mapuche world is *wenen mapu*—a supreme celestial land where their deities live. The Mapuche pray to Ngenechan, the supreme being who lives in this land, for food, prosperity, and a long, wholesome life. Another deity, Pillan, resides in the high mountains to the east and controls such catastrophic events as river floods, tidal waves, earthquakes, volcanic eruptions, and drought. He is the omnipresent protector and personifier of the good spirits of the ancestors, especially those of famous lonkos and warriors. In the past the connection between warriors and the supernatural world was bonded by offering the blood of a captured prisoner to the Pillan. One Spaniard wrote, "... standing with their knives in hand ... they would cut open the chest [of the prisoner] and remove the pulsating heart ... then suck the blood from it and blow tobacco smoke on all parts of the heart ... saying to Pillan ... accept this."

But reservation life, coupled with increased efforts to missionize and modernize the Mapuche, has hastened change and reduced reliance on traditional ways. Though their numbers are growing, the Mapuche already live between two cultures, and in the future may belong entirely to neither. As each year passes, more and more Mapuche learn to read and write Spanish, while fewer can recount the old tales and traditions. The proud people of the land of lakes and forests may eventually succumb to the roar of the tractor and the bustle of town life.

Far south of the Mapuche heartland, the Pacific and the lower Andes cradle the southern coast and offshore islands of Chile and Tierra del Fuego. Capt. Allen Gardiner, a 19th-century missionary, described his first impressions of Tierra del Fuego: "It is a land of darkness, a scene of savage desolation. Both scenery and climate coincide in character. The one is gloomy and desolate, the other tempestuous and black." The landscape—a maze of rockbound channels, islands, narrow fjords, and rocky headlands—is lashed by cold rains or sleet and shrouded with clouds and fog. Surf pounds the outer islands, and the winds howl incessantly. Though the temperature seldom falls below freezing, one wonders how unsheltered people survived such a hostile climate.

Four Fuegian groups once occupied this harsh terrain. Afoot, nomadic Ona hunted in the interior of Tierra del Fuego and along the coast. Using plank or bark canoes, Yahgan and Alacaluf fished the cold channels, while farther north the few Chono gathered seafood and hunted along the tortuous



A catholic priest stands before a *machi* shamans' sacred altar, the *rewu* pole, blessing an upcoming Mapuche ritual.

waterways of the Chilean archipelago. Exceedingly primitive, these Indians recognized no chiefs, had no tribes. They lacked the settled arts of pottery, metallurgy, and weaving. Each group spoke a distinctive language. A Yahgan dictionary compiled by an English missionary listed some 32,000 words.

Small migratory bands of Alacaluf and Yahgan lived in wigwams—beehive-shaped shelters made of poles and roofed with skins or bark. The air reeked of smoke, rotting whale blubber, and refuse tossed out the door. Families collected shellfish, fished, and hunted seals, porpoises, birds, and sometimes guanacos. The Yahgan lowered a bird hunter from a cliff top on the end of a seal-hide thong; the hunter seized a nesting bird in both hands and bit the head or neck to kill it. Alacaluf cormorant hunters blackened themselves with charcoal, hid in a shelter until the birds had roosted, then caught and killed them by crushing the skull with their teeth. These hardy Indians braved the raw, menacing climate clad only in a breechclout or cape usually made from seal or guanaco skins. Rolls of fat covered their short bodies, providing warmth and an energy reserve.

Women paddled the canoes while men sat in the bow scanning for seals and sea otters. In the center of the canoe, a fire was kept burning on piles of sand or turf. Even in the worst weather Alacaluf women dove without hesitation into the marrow-chilling waters to bring up shellfish. A Yahgan baby girl learning to swim would sometimes clamber onto her mother's head to escape the frigid water. On shore the Yahgan piled green wood on campfires to warn those out fishing of intruders. European explorers who saw these columns of black smoke called the region Tierra del Fuego—Land of Fire.

Fuegian Indians typically plucked all hair from the body and face except eyelashes and hair on the scalp, which they combed with porpoise jawbones. The Yahgan reportedly tried to pull the beards off visiting French scientists in 1883, so puzzled were they by the hairy growth. Fuegians sometimes painted their faces and bodies; the Yahgan used red to indicate happiness, black for sadness, and white for anger.

Ona hunters camouflaged their bodies, bows, and quivers with yellow clay to resemble dried grass or with chalk to match the snow. Duck hunters, blackened with charcoal and carrying flaming torches, waded into the water and caught the dazzled birds, then drowned them or wrung their necks. If the Ona found a stranded whale, a great delicacy, they would preserve it by burying it in the ice-cold sand.

The Ona devoured everything edible. Besides guanacos, their principal meat source, they ate foxes, seals, geese, eels, mussels, a small burrowing rodent called the tucú-tucú, a variety of roots, bulbs, seeds, and berries, and even tree fungus and sap.

According to Ona legends, many mountains had once been human beings and should be treated with respect. If rudely pointed at, the peaks might cloak themselves in clouds and send downpours. Among Chono taboos, looking at flying parrots might lead to bad weather; throwing kelp or shellfish on the fire would cause rough seas.

The Ona believed that women had once ruled by means of cunning and witchcraft; then men wrested control from them after a wholesale massacre and founded a secret society that met in large ceremonial wigwams. To terrorize the women and keep them away from lodge meetings, the men impersonated supernatural, women-hating creatures. Women could, however, join in the push-me-down dance recalling the days

of female rule. The men pretended to be crippled and let the women "knock them down dead."

An Ona man might obtain a wife by wooing, by killing her husband or father, by kidnapping, or by arranging parental agreements. Although there was no marriage ceremony, at the time of possession the wife sometimes put up a good fight—and the bridegroom appeared later with a scratched face, black eye, or bites. If a man took a second wife, she was often the younger sister of the first.

An Ona mother wrapped her newborn baby in foxskin and tied a dark red eyeshade of guanaco hide above its eyes. When an infant cried continuously, an impatient mother might suddenly scream into each ear. Yet to spare a baby the shock of drinking icy water, she would warm it in her own mouth. A ladderlike framework stuck in the ground held the baby upright, safe from dogs and accidents.

Ona men, clad only in waterproof moccasins and a lengthy robe of guanaco hide, slept in freezing temperatures with their bare legs exposed. Even during the winter, everyone took shelter under a windbreak of skins, and children often went naked.

The advent of the white man brought the eventual extermination of the Fuegian groups. European diseases and the sheep rancher's rifle decimated their numbers during the last half of the 1800s. Professional hunters received a bounty for the ears of Indian men, women, or children. Today these aboriginal societies have disappeared, leaving only a few mestizos acculturated to the white man's world.

North of Tierra del Fuego, Patagonia unfolds east of the Andes. Dry southern plateaus flatten into the pampas, the grasslands to the north. Sparse in population but rich in animal life, the prairies formed the homeland of the Puelche and Tehuelche Indians.

Home to the Mapuches is a cluster of pole and thatch-covered *ruka* houses, nested in a grove of trees.





Elder Mapuche women converse about the recent initiation of a young *machi* shaman.

Dependent primarily on hunting, these Indians of the grasslands stalked guanacos, small game, and rheas. Hunters used young, tame guanacos as decoys or camouflaged themselves with rhea feathers. Each band, headed by a chief, claimed its own hunting grounds. Trespassing on another band's area would lead to war, so it was customary for a stranger, before entering foreign territory, to send three smoke signals and wait for a reply. During the 18th century most of the plains tribes acquired horses. Quickly mastering the art of horsemanship, the Indians tirelessly pursued guanacos with spears and whirling bolas and began raiding isolated white settlements.

Continuously feuding with each other, the Puche wore horsehide armor and fought with lances at close range rather than with bows and arrows from a distance. Mounted bands carried their horsehide-covered huts with them. Commoners wore horsehide robes, while prominent individuals cloaked themselves with guanaco, otter, or fox skins.

During the *nguillatun* fertility rite a plate of food is placed on the steps of the *rewe* pole for the ancestors.





Song and dancing feet around the sacred *Llané-Llané* altar during nguillatun rite allay a propitiation to the deities and ancestors of the upper *wenu mapu* world.

The Tehuelche, tall and dark skinned, wore shoulder-length silver earrings, conical hats, and loose guanaco-skin cloaks decorated with colorful geometric designs. They painted themselves with a mixture of grease and red earth or charcoal. Always on the move, they lived in large communal tents facing downwind. In front a fire burned constantly—in the day for cooking, at night for warmth and scaring off wild animals. When a young man negotiated a marriage contract with a girl's father, he specified how much he would pay in horses, rhea feathers, or guanaco hides. Once the arrangements were made, he could not speak to the girl until their wedding day.

Like their brothers in other parts of South America, these plains Indians resisted European colonialism. As immigrants flooded the frontier, the Indians retaliated; in one massive raid, 2,000 braves took 200 captives and 20,000 head of cattle. But in 1879 an Argentine general with an arm of 8,000 overran the pampas and wiped out the Puelche. In other campaigns the government subdued the Tehuelche and marched them to Buenos Aires, where the men were forced to join the army. Women and the aged were placed in institutions. Urban families adopted the children. The white man took a terrible toll, leaving only a scattered population of mixed-blood descendants.

As early as the 17th century, renegades of mixed Iberian and Indian blood roamed the grasslands. Known as gauchos, these cowboys hunted the "wild" cattle that had escaped from the Spaniards' grazing lands. The feral herds supplied food as well as hides and tallow for sale in the markets. When authorities attempted to regulate the slaughter of open-range cattle, many renegades resisted. Thus, violence became an aspect of gaucho culture that later played an important role in the upheavals of the region and transformed

the gaucho from outlaw to hero. In the early 1800s free-roaming gauchos fought alongside Gen. José de San Martín for Argentina's independence from Spain.

The gaucho was easily recognized by his rugged dress and hunting bolas, his knives and lassos, his barbecued meat and bitter herb tea, and his special brand of folk poetry and music. Eventually his dependence upon the wild cattle depleted the herds, and the gauchos shifted to cattle raising. Today remnants of the old gaucho population have come to be identified with the way of life of the ranch hand or cowboy; and their romantic traditions, which in part grew out of the nomadic Indian existence, are remembered in folk music and dance, poetry, novels, and legends. The ghosts of the vanished plains Indians ride on in the gauchos of South America.



Professor Tom Dillehay

AN INVISIBLE WORLD

Most of us enter the high school physics laboratory with the greatest reluctance, tiptoe out with a passing grade, and avoid the subject forever after. There are a few reasonable explanations for all this uneasiness:

Our view of the invisible world of atoms and electrons, of dynamically moving matter, is the product of research by physicists, but we understand very little of the ways in which they have learned to see it.

They insist on the intelligibility of the universe and find great satisfaction deciphering its language, but their decipherings are relayed in another code— $R=0.210 \pm 0.015$ with $J=8.5 \times 10^{-7} \text{ A/cm}^2$. . . etc.

Our own—most of us, perhaps—basic miseducation in the sciences has left us unduly anxious about numbers, about science and particularly about the visible and unseen worlds of physical research.

In a way, our fears are justified: it does get complicated. But there is an antidote—try spending an afternoon with a physicist, and if you can, find an interpreter of these puzzles as amiable and cooperative as University of Kentucky Physics Professor Keith MacAdam. Laboratories can be as cozy as kitchens. As the tuneable laser at your elbow rends atoms through the tiny window of the "crossed beam atomic collision apparatus" which he designed, you will learn that MacAdam sees things—some things—pretty much the way you see them.

For example, you see atoms as little balls with those things . . . electrons . . . flying around the nucleus, like little planets orbiting a sun. You might assume that MacAdam's outlook would be more sophisticated, and unquestionably it is, but he, too, finds practical reasons to visualize atoms as little balls.

"Atoms don't look like that, not really," MacAdam explains. "But that's the Bohr model—a big heavy blob in the middle with one or more electrons whirling around the outside." If atoms don't look like that, why should a physicist, of all people, harbor an inaccurate image? "It reminds you that atoms are dynamic," he says.

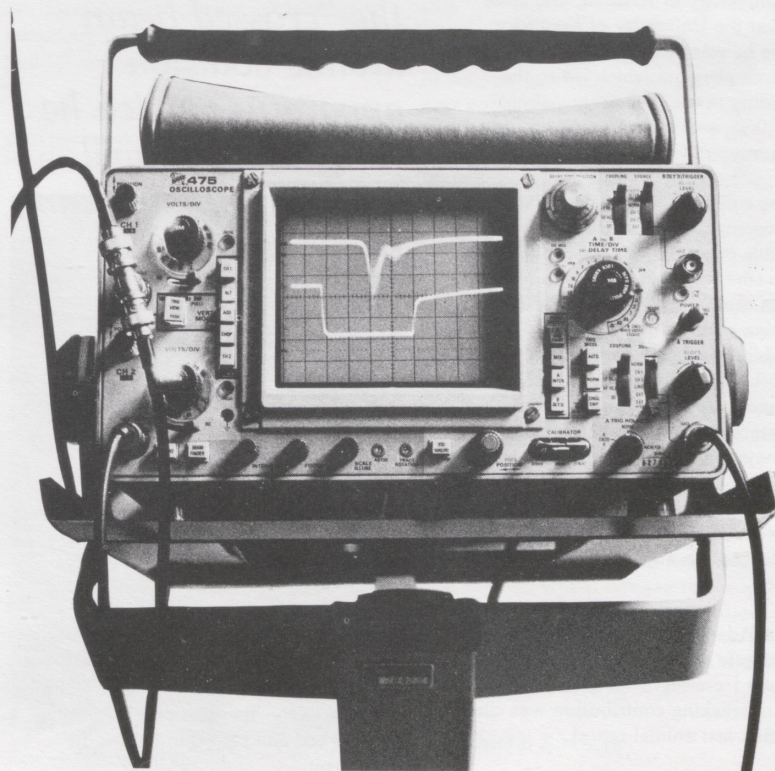
"When you first study about atoms, perhaps in a high school chemistry class, you learn that electrons are in some sense, clouds. That picture remains accurate and valuable as the student progresses. But when you give up the idea that an electron is a point you give up the idea of movement. The

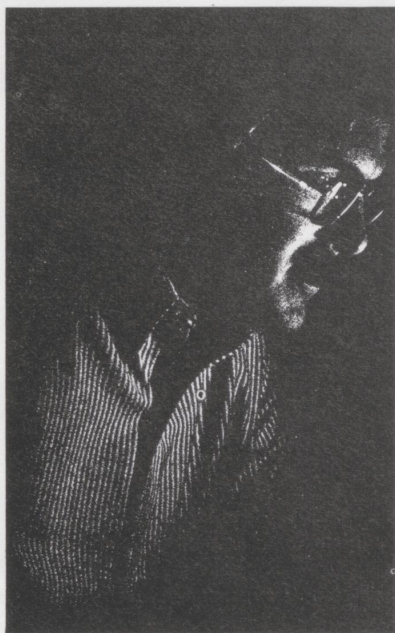
cloud model helps to emphasize that the electron has a well defined orbit, but it does not give you a picture of the dynamics, of the movement of the electron."

Some of these elusive dynamics are occurring at this moment in the atomic-collision device, which with its monitoring computer and laser, occupies about half of the laboratory. This afternoon, as on most afternoons, MacAdam and his associate, Richard G. Rolfes, are experimenting with collisions between atoms and ions. The flashing red digits of the microcomputer track the collisions.

The type of atom that interests MacAdam and Rolfes and the National Science Foundation, which supports the work) is the "highly excited" Rydberg

The oscilloscope displays field ionization of individual atoms, the primary detection process in MacAdam's experiments.

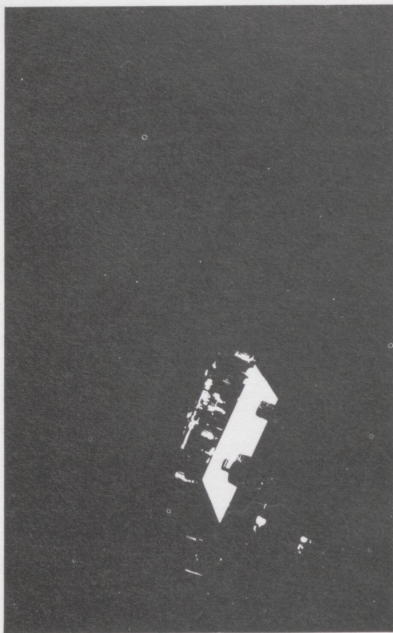




atom. The Rydberg atom is an unstable atom which, stimulated by a shot from a laser, has had one of its electrons, MacAdam says, "knocked way the hell out into an enormous orbit." He has been observing Rydberg atoms since 1973, first at Yale University, then at the University of Arizona, and since 1977 at the University of Kentucky, where he was offered a chance to start a research program which led to the awarding of the NSF grant—about \$171,000, with more money on the way for a more powerful laser.

The collisions recorded by the microcomputer have at least three possible outcomes: As the ion passes the atom (the collisions are not exact—ion grazes atom) it may knock the distantly orbiting electron off; the second possibility is that the ion may disrupt the orbit of the electron—"as an enormous asteroid would disrupt planetary orbits if it passed through the solar system"; thirdly—and this is what interests MacAdam—an event known as "charge transfer" may occur—the electron is knocked off and captured in orbital motion around the "projectile," the ion.

MacAdam says he is the first to investigate the phenomenon of charge transfer from highly excited atoms. His groundbreaking contribution was cited in NSF's last annual report.



As the tuneable laser at your elbow rends atoms through the tiny window of the "crossed beam atomic collision apparatus" which he designed, you will learn that MacAdam see things—some things—pretty much the way you see them.

The laser, which through an ingenious arrangement of mirrors and diffraction gratings, shines amber and violet rays into the crossed-beam atomic-collision apparatus, is indispensable for this work. Until the mid-1960s, when the "tunable laser" was developed, it was impossible to excite the atom efficiently and selectively: the electron could not be detached and placed in its specific large orbit.

"The first lasers put out light beams of definite color or wave length, depending on the materials they were made of," MacAdam says. "A ruby laser put out one kind of red light, the helium-neon laser put out another. These were fixed wave length lasers.

"If you want to use a laser to excite atoms, you must know the specific wave lengths at which the atoms can absorb light and have a tunable laser which can be adjusted to match those wave lengths."

(At this moment, Rolfes, who at 35 is two years younger than MacAdam, and holds a Ph.D. in physics from the University of Cincinnati, turns out the laboratory lights while he changes the laser wave length).

An analytical technique known as field ionization is used to study the collisions. The more highly excited states are fragile, MacAdam observes: a measurement of the electrical attraction necessary to "tear an electron off" in field ionization helps to determine the state of the atom before or after the collision.

MacAdam currently is interested in the tendency for electrons, once detached from nuclei, to orbit the projectile ions at about the same distance as they orbited their old nuclei before collision.

"This is a major change in the atom—to be torn apart. It is disrupted. Its electron is captured by another nucleus . . . You might suppose that the electron would fall into the smallest orbit." Instead, he says, "the orbits are approximately reproduced."

Investigations of this kind do not lend themselves to modest explanations. "Understanding the behavior of charged particles," MacAdam says, "is important if you are investigating things which are universal. What we learn about atoms has universal application. It produces basic understanding . . . These collisions are taking place in stars, in fusion plasmas, in gas lasers and elsewhere."

The inspiration which led MacAdam into his career was universal in implication but practical in character.

His father, David L. MacAdam, is a physicist. Until his retirement he worked at Eastman Kodak Co. Now he teaches colorimetry at the University of Rochester.

MacAdam's physicist father was also his inspiration. "He was able to explain in vivid terms why things behaved as they did. He always seemed to have the answer."

"He showed me so much about what was going on around me," MacAdam recalls. "He was able to explain in vivid terms why things behaved as they did. He always seemed to have the answer."

"When I first had physics in school I noticed that most students were terribly afraid of it. The teacher warned us that it was very difficult and then said, 'Well, let's go anyway.'"

"For me this was laughable. Physics provided the most reasonable and sensible explanation for how nature worked."

It bothers him to see that children are not more encouraged early in their school lives to learn about science. "This is a crucial point. If you miss an early education in science or math, you will miss it all. Because science and math adhere as much as possible to a logical structure, it's difficult to get in except at the ground floor." One of the tragedies of American education, he feels, is that social pressures tend to force girls out of the sciences, and those students who remain often are taught by teachers who, themselves, feel "no inspiration about science or math."

MacAdam holds a B.A. in mathematics from Swarthmore and has his M.A. and Ph.D. in physics from Harvard University. At Harvard he was

awarded the Frank Knox Memorial Travelling Fellowship and for two years after he received his doctorate, in 1971, he worked at a Postdoctoral Research Fellow in physics at the University of Stirling, Scotland.

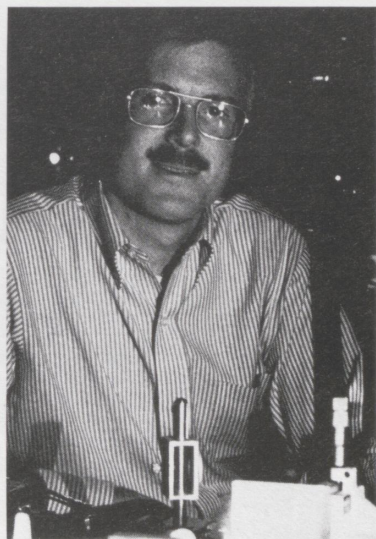
That period away from the United States seems to have some connection with his decision to accept an assistant professorship four years later at the University of Kentucky.

"In Scotland, we (he is married and has two children) learned to live a more modest and less hectic life."

He already had decided that he wanted "a career in academic science." When he was offered an opportunity to join the scientists—"all with excellent credentials"—who over the past decade have been making the University of Kentucky's Department of Physics and Astronomy a vibrant center of activity, he accepted without reservation.

The University has no "gilt edged reputation" in physics; it is not MIT. But MacAdam saw Lexington as a place where he could "learn my own value," and work closely with other young researchers who had been encouraged to see themselves as scientists competing nationally for achievement, prestige, and for research grants.

At the outset, MacAdam was provided with University funds so he could start equipping his laboratory. For



Professor Keith MacAdam

a research scientist this is crucial: "You have to make it clear to the foundations and funding agencies that you are serious and well equipped and ready to hit the ground running."

Professor Fletcher Gabbard, chairman of the Department of Physics and Astronomy, has played a key role in the building of the faculty. He says the University has been able to hire a strong faculty in physics and astronomy by offering young researchers tangible support and challenges.

"The most fundamental reason that we've had so much success with our recruiting is that we've been able to offer this rather exceptional opportunity to grow and develop in a stimulating atmosphere. We've attracted some of the most able young people in the country, and we've done it by being able to offer them substantial startup funds or seed money."

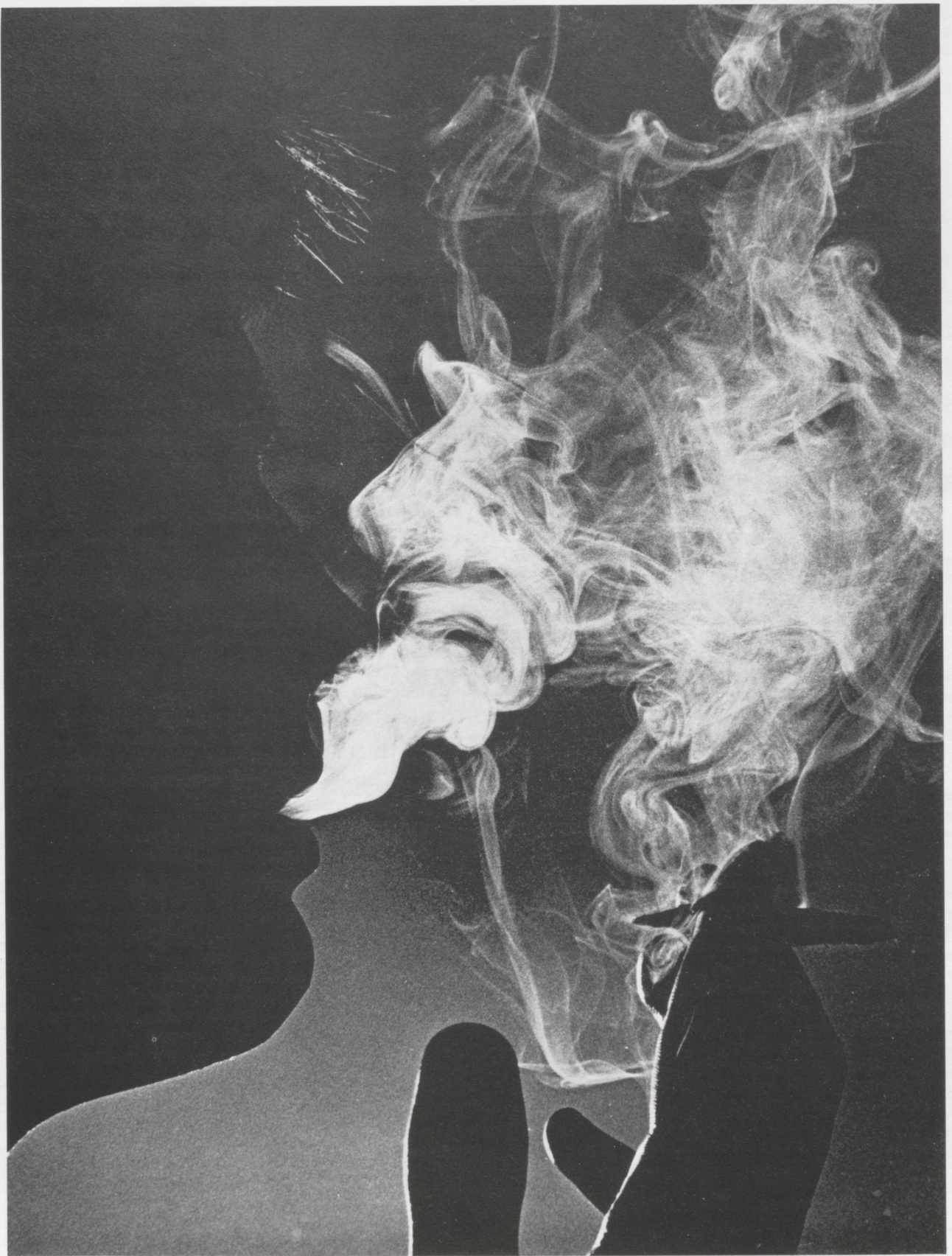
"We say, We're serious about this. We want to build an outstanding program here. Come and help us do it."

Like many university administrators and professors, Gabbard fears that progress may be jeopardized by budget cuts.

"We're fighting very hard to be able to hold on to what we have, and we may not be able to do that," he says. "It hasn't happened to us yet, but if we don't turn things around it will happen. It's absolutely predictable. The active and well recognized people with national reputations and mobility are the ones who are going to leave first."

MacAdam has no intention of leaving UK, but he appears to be one of those scientists on his way to some eminence. By the time full recognition comes, however, he may be mobile but immovable. The crossed-beam atomic-collision apparatus would need a very large packing crate, and then there's the microcomputer, and all those mirrors for the new laser (bought with \$40,000 in extra money which NSF squeezed out of Congress) would have to be re-aimed. Then there are those little atoms and ions, and detached and undetached electrons—they would all have to be gathered up somehow. . . .

—Michael J. Kirkhorn



MARIHUANA: INNOCUOUS OR HARMFUL?

Drugs have become a habit with Drs. Harwin Voss and Richard Clayton.

For the past six years, the two UK sociology professors have been researching national patterns of drug misuse and abuse in one form or another. Indeed, they have established themselves as nationally recognized authorities.

However, the professors are quick to point out that they are not now, and never have been, conducting their research by giving students marihuana or other drugs. Their research is based on data collected from a national sample drawn randomly from the files of the Selective Service System.

Their study defines the parameters of heavy marihuana use among young men and what effects years of heavy marihuana consumption have produced.

They are currently conducting a national exploratory study that will define the parameters of heavy marihuana use among young men and determine what, if any, effects, years of intensive marihuana consumption have produced. Their study will also examine changes in patterns of marihuana use as related to life events, such as marriage, fatherhood, job promotion, job loss,

arrest, etc., with the assumption that the causal direction of such a relationship could be in either direction.

"The key is there is no epidemiological study of a normal population that has looked at heavy marihuana use," Dr. Clayton says.

The first drug-related study that catapulted the two researchers into national prominence was begun in 1974 with UK sociology Professor John A. O'Donnell as the principal investigator. Dr. O'Donnell, now deceased, pioneered the study that was the first to examine drug use in a national, random sample of young men, 20 to 30 years old. The study was published as a monograph by the National Institute on Drug Abuse (NIDA) in 1976. The publication provided such a broad data base, that the Director of NIDA billed it as "an encyclopedia of contemporary American drug use."

As a result of the national sampling frame, they have been quoted in such diverse publications as *Psychology Today* and *The National Enquirer*.



Professor Richard Clayton

Obtaining a national sample was no easy task, according to Voss and Clayton. Indeed, it took White House intervention for Selective Service to surrender its list of the country's young men, ages 20-30. "Our lawyer had negotiated with their lawyer and we were at an impasse," Clayton said. "Then all it took was a call from H. R. Haldeman (in the Nixon administration), and they turned the files over to us. The administration, at that time, was very concerned about drug use, and was willing to help us."

From that list a random sample was chosen and 2,510 men between the ages of 20 and 30 were interviewed. The interviews were conducted by a survey organization from Temple University. The extent of reports of marihuana use obtained in this study provided the impetus for their most recent effort.

Based on the previous interviews, a sample of 450 men, now between the ages of 27 and 37, was chosen to be interviewed about the effects of chronic marihuana use.



Professor Harwin Voss

Although the results have not been tabulated, Voss and Clayton are willing to speculate, and both have some different ideas about what will be found.

"I think marihuana is one of the less dangerous drugs being used today," Voss says. "In the U.S. the major problem is alcohol. Its use causes more disruption than marihuana. As for drug abuse, cocaine is a growing menace. I don't like the word abuse, because it implies a judgement, but alcohol clearly damages the body's vital organs. As far as the medical effects of marihuana are concerned, I don't know. I suspect there will be at least a few negative aspects, but whether or not they will warrant stringent controls is something else. The effects may be negligible when weighed against the problems enforcement presents. We will have to wait until the results are in."

Clayton says he expects the results of the study will demonstrate the negative effects of marihuana use. "I think it (marihuana) is a dangerous substance that has been so politicized that the dangerous effects have gotten short shrift in terms of publicity. I think that its use increases the likelihood a person will in turn sell it and that increases the chances of a criminal record, and it also increases the likelihood that the user will go on to other kinds of drugs. My guess is that its use is likely to produce a greater number of hospital stays, because it lowers resistance, and it is also my guess that long-term, heavy pot use is related to cancer.

The purpose is to inform people so that if there are negative consequences from heavy marihuana use, then people should reconsider the health, social, and legal aspects.

"We already know that there is a link between heavy drug use and lower educational attainment and that heavy use certainly increases one's chances of being arrested. I tend to think that the causal link goes in that direction."

"As far as the study goes, my own supposition is that most people have the causal order backward," says Voss. "Social problems such as lack of motivation in school or the inability to maintain a job are not caused by marihuana, but these situations may cause people to use marihuana as a coping device. The purpose of our research is to inform people, so obviously if the results show negative consequences, then everyone should reconsider the health and social, as well as the legal aspects.



"Regardless of what we find, whether it is innocuous or harmful, we are not going to control it by law or legal means. As many as 50 million Americans have smoked marihuana. Consequently, you have to recognize that any attempt to control it legally now results in discriminatory and selective enforcement."

"Although I agree you really can't legislate its use, I am not in favor of legalization," Clayton says. "It would be a mistake. If we find out there are harmful effects, then by legalizing it, the government would be facilitating illness."

Voss and Clayton agree that their research will discover the answers to some interesting questions that will have far reaching effects. For example, what will the marihuana users interviewed have told or plan to tell their children about pot? Since the majority of the marihuana users responded to a question from the earlier study by saying pot was the only drug they perceived positive benefits from,

"The question of whether marihuana use is a recurring or non-recurring behavior is an important one."

chances are they may not totally discourage their offspring. Although, the users at the time of the first interview found pot a positive drug, during the time lapse between interviews, health problems or negative experiences could have changed their perspective. "The question of whether marihuana use is a recurring or non-recurring behavior is an important one," Clayton says. "The answer could have an effect on the type of controls the government chooses to impose to deter people from smoking marihuana."

"We really agree more than it sounds like," Voss says. "We see the same kinds of problems with legal controls, and we are waiting for the results of our study to see what kind of effects the data will show."

"I don't know, I think you may be more liberal than I am," Clayton says and laughs.

They have had this discussion before, and they still enjoy it. Perhaps that is why they make such an affable team. Since the first study they have worked together on others, including one on cohabitation, as well as the on-going pot project.

Occasionally they are kidded about their controversial subject matter, but they take it lightly. "My mother-in-law finally decided what I was doing was worthwhile when she saw my research (the co-habitation study) quoted in *Us* magazine," Clayton jokes.

But they don't take their research lightly. "It is interesting research, and it is important," Voss says. "It gives us a clearer picture of our society, and perhaps the information needed to help improve it."

—Tawny R. Acker

UNDERSTANDING THE SOYBEAN

How does a plant "decide" how many seeds to produce? Dr. Dennis Egli, professor of agronomy at the University of Kentucky, wants to find out.

He is working with the soybean, the Cinderella crop of the last 10-15 years in Kentucky, the United States and the world.

In Kentucky alone, soybean acreage has quadrupled in the last decade, and now provides \$400 million in annual income to Kentucky farmers, second only to tobacco in delivering dollars to the farmer's pocket.

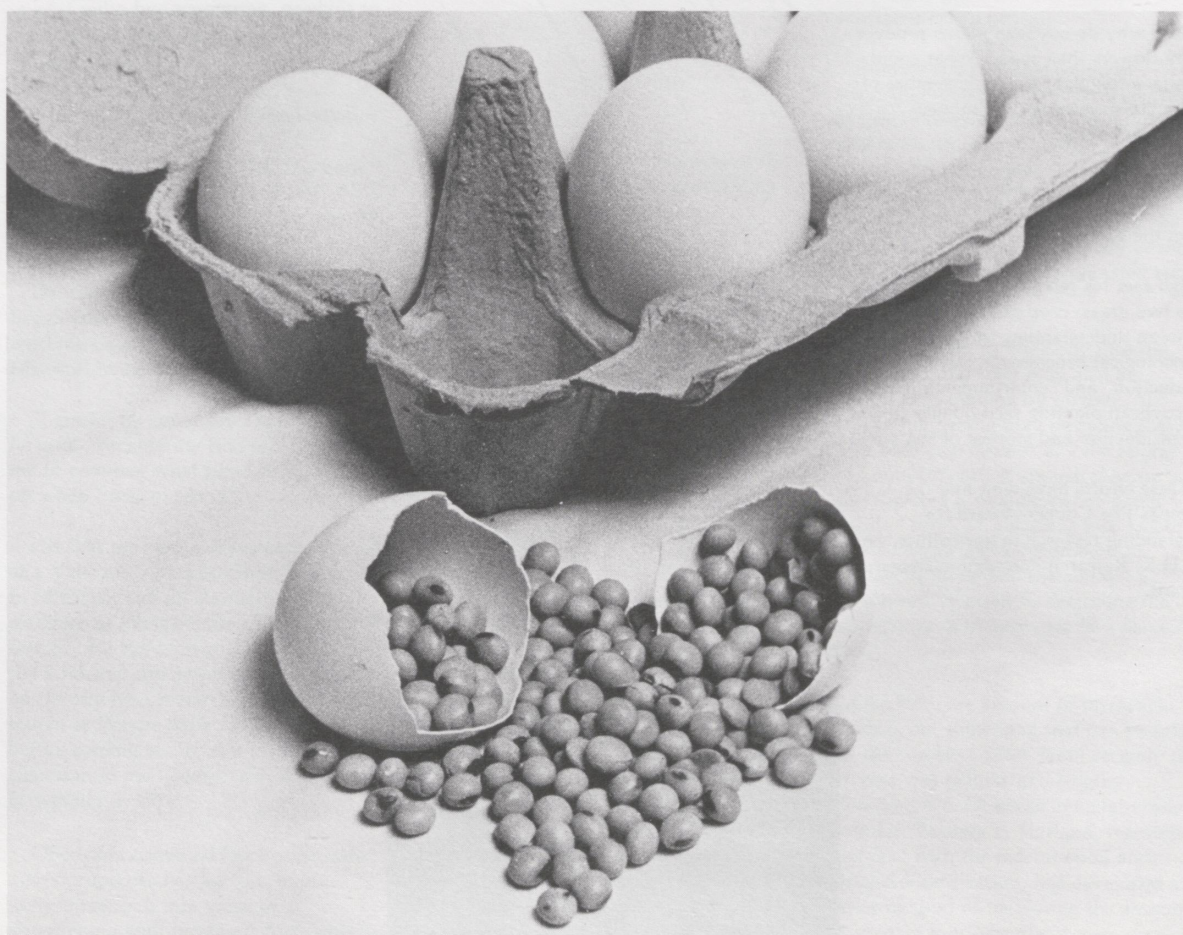
Soybean acreage provides \$400 million in annual income to Kentucky farmers, second only to tobacco.

Moreover, the humble soybean feeds billions worldwide with its cheap, high-

quality protein, requires no expensive nitrogen-feeding of the soil it grows in, and can be doublecropped with, say, wheat, during a given growing year.

Small wonder, then, that a small army of the best young scientists—with Dr. Egli in their forefront—is studying the soybean in fields and laboratories all over the world.

Egli is a crop physiologist whose research aims at increased yield, an aim supported not just verbally but by generous extramural funding from the U.S. Department of Agriculture, the



Kentucky Soybean Association and the American Soybean Association.

Over the last decade, Egli has studied many varieties of soybeans, isolating and observing in exhaustive detail, the physiological factors that determine seed yield—such things as nitrogen supply, nodulation, seed growth characteristics, flower and pod abortion, size of sink for photosynthesis, and length of filling period.

Research into the length of filling period—how long it takes the pod to grow fat and full—seems very promising, Egli says. Soybean varieties now in commercial use require 25-35 days for the seeds to fill, but it may be possible to develop other varieties that keep on filling at the same rate for 40 to 45 days. To that end, Egli is working with UK plant breeders. In his 11 years at UK he has continually sought help from these geneticists, as well as from agronomists and plant physiologists.

And why do soybean plants produce more flowers than seeds? What could persuade the plant to produce more of those life-sustaining (and money-producing) seeds?

"I have a hunch," says Egli, "that the key is the supply of carbon or sugars from the plant's leaves."

Egli sees his research effort as divided into two areas: crop physiology, to "gain an understanding of the important physiological processes involved in yield production" and "environmental effects on soybean planting seed quality during the production and storage of the seed."

These efforts have won him the Thomas Poe Cooper Award for outstanding research in agriculture, and the U.K. Research Foundation Research Award.

The work is painstaking, but its aim is nothing less than more and better food for the world's population.

"The readout comes very slowly," the young professor observes. The work is painstaking, but its aim is nothing less than more and better food for the world's population.

Egli spent a sabbatical year in Australia and last summer joined nine other outstanding researchers for a tour of major U.S. and European research facilities, discussing along the way the applications of his work.

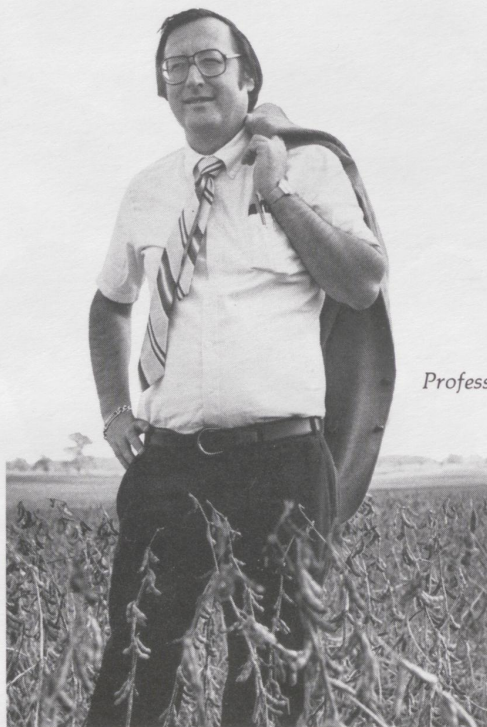
Egli came to soybeans almost by accident, an outstanding young Ph.D. (1969) in crop physiology-ecology from the University of Illinois looking for a place and a crop to grow in. At the time, UK was looking for a soybean scientist: some 500,000 soybean acres in west Kentucky were gradually and profitably increasing and spreading eastward.

Egli happened to have done his dissertation on soybeans ("Photosynthetic Rate of Three Soybean Communities as Related to Carbon Dioxide Levels and Solar Radiation.")

Soybeans, 11 years later, now blanket 1,600,000 acres of Kentucky.

Egli, too, has grown: to associate professor of agronomy in 1974, and professor in 1979. To five book chapters, 37 articles in referred journals, 16 experiment station and extension booklets, and dozens of invited papers at soybean, agronomy and other agriculture meetings from Calgary to Chicago.

—Betty Tevis



Professor Dennis Egli

SUPER ZINC?

Eating 24 oysters a day would not improve your amorous activities, but it would supply you with the USDA daily recommended amount of dietary zinc. And that is something most people may not get enough of, according to Dr. Donald Oberleas, chairman of the Department of Nutrition and Food Science at the University of Kentucky.

And he should know. Zinc has been an integral part of Oberleas's diet literally and figuratively for the past 10 years.

Dr. Oberleas's interest in zinc research began while he was a graduate student working on a Ph.D. at the University of Missouri in 1959.

"I guess you could say I was lucky," he said. "because my first job allowed me to continue what I had been working on while I was in school."

His first job was as a research chemist at a Veteran's Administration Hospital in Michigan and an instructor of medicine at Wayne State University in Detroit. He has remained a member of the academic community, although he has jointly held research positions. He taught at Wayne State for 11 years before coming to UK as a professor and chairman in the College of Home Economics in 1976.

Oberleas's continual fascination with zinc's properties has led him to his current research into ways of determining with increased confidence

whether an individual or segment of the population may be at risk of obtaining inadequate zinc from their diet.

Oberleas predicts zinc deficiency will begin surfacing as a factor in many maladies often attributed to other causes.

In order to determine the amount of dietary zinc any given person is receiving, Dr. Oberleas has had to define the amount of dietary zinc present in a variety of foods, and then, through interviews, construct dietary recalls of subjects.

In addition to documenting the amount of zinc in foods and collecting interview data, there are other complicating factors. For example, a substance called phytate.

Phytate is a chemical found in varying amounts in plant proteins, such as beans, cereals and soy beans, that affects the amount of dietary zinc absorbed by the body. Dietary zinc binds to phytate, which is not absorbed in the gastrointestinal tract. Thus, the dietary zinc taken into the body at the same time as phytate is eliminated with the phytate.

Zinc secreted by the body into the gastrointestinal tract may also be subjected to binding by phytate. So although a person may be eating foods with high zinc content or even taking zinc supplements, if enough phytate is also ingested a zinc deficiency could result. Therefore, Oberleas also has to be able to calculate the amount of phytate in foods and the amount a person eats in order to determine the availability of dietary zinc in a person's diet.

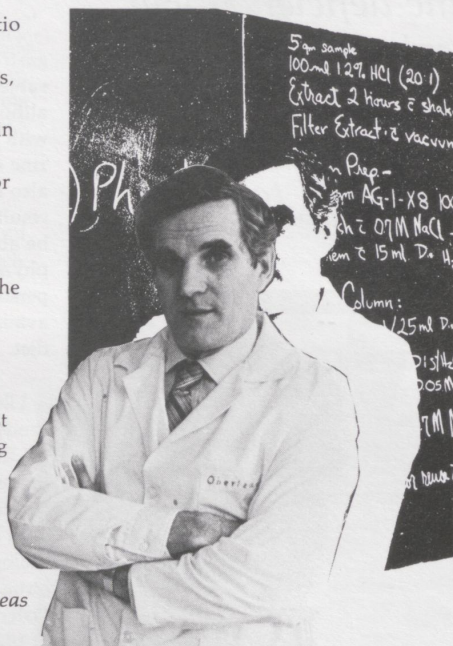
Like zinc, the amount of phytate in foods is not something that can be taken off the content's label. Until recently the process was tedious and lengthy. However, Dr. Oberleas in collaboration with Dr. Barbara F. Harland, research biologist with the federal Food and Drug Administration, has developed a faster method of measuring the amount of phytate in foodstuffs.

There are a few things the molar ratio does not take into account in its prediction of human dietary zinc status. Oberleas says. It does not take into consideration the amount of zinc lost in sweat (which is comparable to the amount of zinc contained in plasma) or in menstrual losses. The increased amount of dietary zinc lost through urination when a person has an infection is also not controlled for in the formula. The extra zinc needed for pregnancy and lactation are also not part of the formula. In other words, certain people have a tendency to be more at risk than others, and this must be taken into consideration when using the molar ratio, he says.

"Zinc deficiency is not an easy diagnosis to make," Dr. Oberleas says. "There are few, if any, easily recognizable symptoms in marginal states of zinc deficiency, but it plays an essential role in good health. It affects growth rate, the development of secondary sexual characteristics, wound healing, appetite and behavior or rate of learning. But people do not usually consider these as very diagnostic. For example, if Johnny doesn't learn as quickly as everyone else, no one does

Dr. Oberleas is currently one of a few in this country studying zinc's interaction with phytate. "There are only a few of us doing this kind of research. Several of them are my good friends. We have to be careful not to talk shop in front of each other," he says with a chuckle, "lest you give your ideas away." But in a more serious tone he adds, "We are all out there trying to discover as much as we can as we can as quickly as we can. We are in the 'trace element era,' and I have been fortunate enough to be working on the right research at the right time."

Professor Donald Oberleas



AN AFFAIR OF THE HEART

Code blue means that someone's heart has stopped beating in the Coronary Intensive Care Unit at the UK Medical Center.

Every minute is vital, any hesitation may mean the difference between life and death.

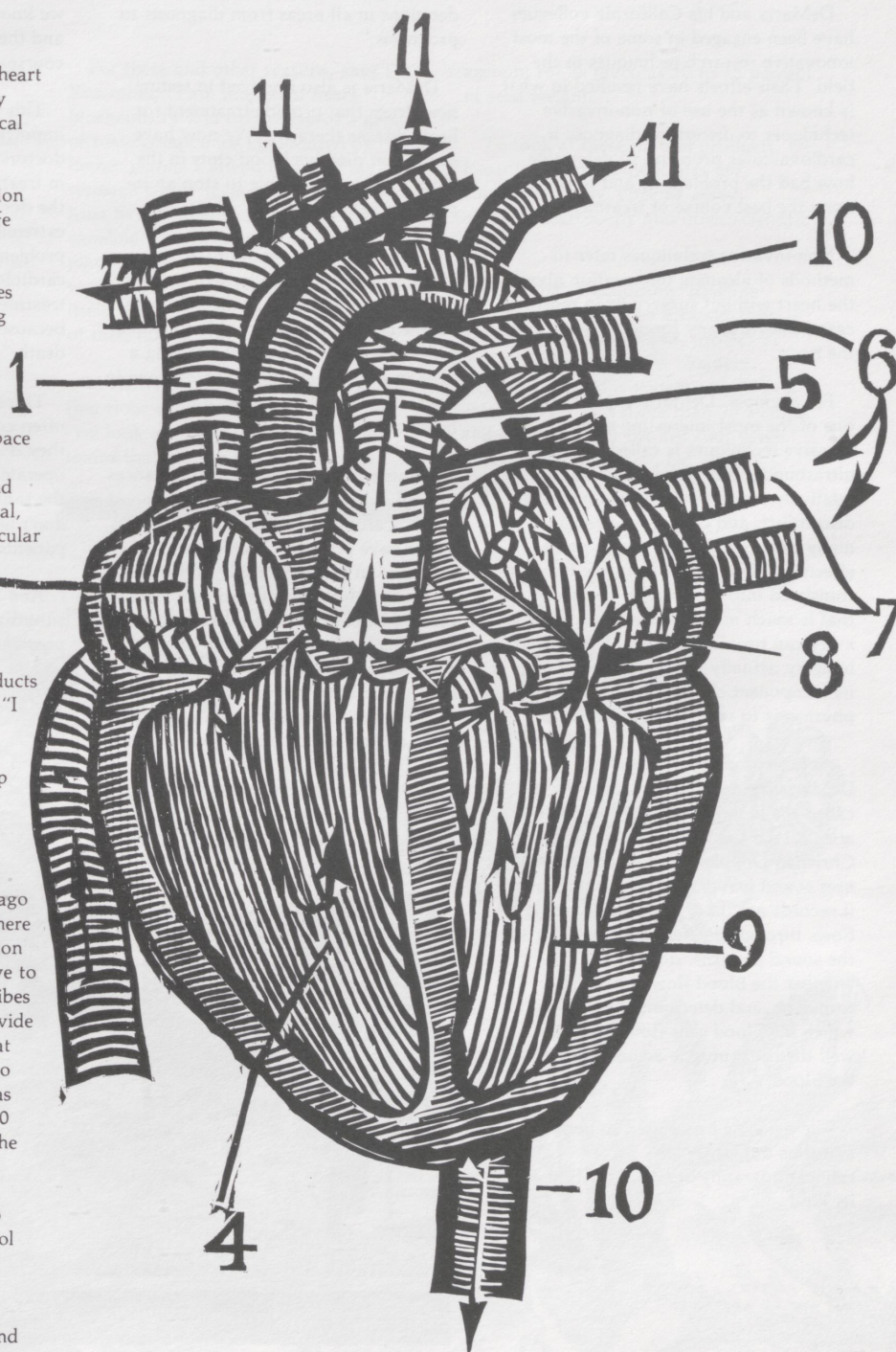
It is this real-life drama that makes cardiology a compelling, challenging profession for UK Medical Center's Chief of Cardiology, Dr. Anthony DeMaria.

He seems to thrive on the hectic pace that his duties, not only as chief of cardiology of the Medical Center and the Veteran's Administration Hospital, but as the director of the Cardiovascular Division at the UK Medical School, require. "You just find the time to get things done," he says.

And he does. In addition to his administrative duties, DeMaria conducts clinical research and treats patients. "I think it is crucial to maintain an involvement with all of the areas I oversee," he says. "You have to keep your hand into the clinical side, as well as the administrative side. Besides, I enjoy it."

DeMaria came to UK six months ago from the University of California where he was associate director of the section of cardiovascular medicine. His move to UK was prompted by what he describes as a feeling that, not only did it provide a "good career opportunity," but that Kentucky is a state that, "responds to excellence." "And I think that UK has the potential for having one of the 10 best cardiovascular departments in the country."

With DeMaria from UC came two new additions to UK's Medical School faculty, Reginald Low and Patricia Takeda, and the UC Head of Non-Invasive Technology, Oi ling Kwan, who assumed that position at UK, and



two post graduate cardiology fellows, Steven Nissen and John Waters.

"We worked as a team at the University of California, and we are continuing the effort here," says DeMaria.

DeMaria and his California colleagues have been engaged in some of the most innovative research techniques in the field. Their efforts have resulted in what is known as the use of non-invasive techniques to discern or diagnose a cardiovascular problem, to determine how bad the problem is, and to decide upon the best course of treatment.

Non-invasive techniques refer to methods of gleaning information about the heart without surgery or in most cases, inserting any foreign objects into the body.

For example, DeMaria explains that one of the most interesting new non-invasive techniques is called, ultrasound. "It is absolutely safe, relatively inexpensive, causes no patient discomfort, and can be repeated as many times as necessary with no ill effects." Sound waves from the heart are translated into a picture of the heart that is much more detailed than what an x-ray can provide, he says. Ultrasound imagery actually divides the heart into its component chambers, allowing physicians to see the damaged areas.

Another non-invasive technique DeMaria has spent time developing is called the Doppler echocardiography, after a 19th Century Austrian physicist, Christian Doppler. This technique also uses sound waves, but the sound waves it records are those from the blood as it flows through the heart. By listening to the sound patterns, doctors can tell whether the blood flow is normal or turbulent, and determine the velocity at which the blood cells flow, and how well the heart muscle actually pumps the blood.

The machine being used to perform, and thus test, Doppler echocardiography at UK is the first of its kind.

When DeMaria was in California, he started conducting clinical research using the non-invasive techniques. "Many people were skeptical, they thought the techniques were not stable. Needless to say, that has not been the case. These techniques have allowed cardiologists to make more informed decisions in all areas from diagnosis to prognosis."

DeMaria is also involved in testing new drugs that provide treatment for heart disease therapy. "We now have drugs that dissolve blood clots in the heart making it possible to stop an in-progress heart attack.

He recently led a team of UK physicians in successfully performing this procedure known as thrombolysis. "Someday, it may be possible to stop a heart attack right away by injecting a drug in a vein—maybe it can be done in the ambulance on the way to the hospital," he says.

Because of the technological advances in cardiovascular research, DeMaria says, "Cardiology is where the action is. There have probably been more advances in the last decade in this field, than any other area of medicine. The facts of life are, that in many respects medicine is often as much an art as a science, because your ability to gather data under some circumstances is severely limited and you end up making decisions on less data than you would like. But, now in cardiology, with these new advances we can make more informed decisions, because we have more precise data."

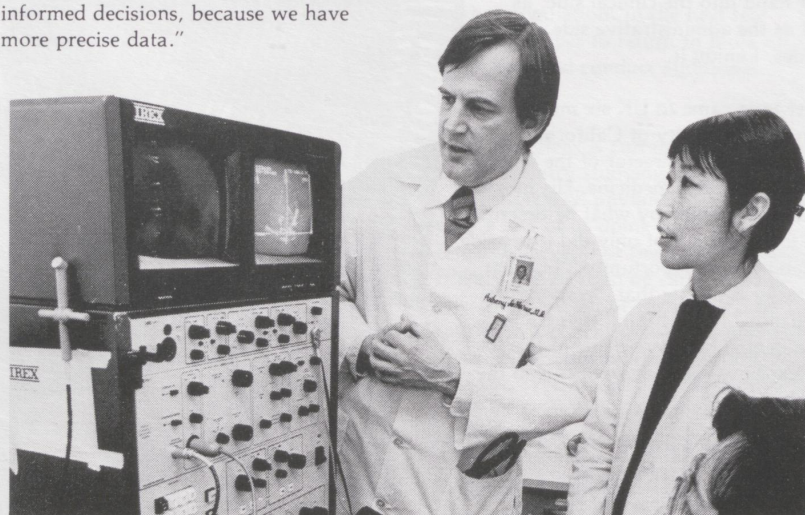
For example, 30 years ago most of the information gathered by a cardiologist would be obtained by a stethoscope or an x-ray. But now, he says, we can easily measure pressures within the heart with balloon floating catheters, and even see the heart components with the aid of ultrasound. "In many cases we know precisely what the problem is, and therefore, can determine the best course of treatment."

This kind of precision is particularly important in cardiology, because doctors do not have the same latitude as in treatment regimens. "In many cases, the doctor can delay surgery, or some extreme treatment, if the patient's problem seems to be stable. But, in cardiology you can't always delay treatment until the problem worsens, because the next problem could be death."

There is a saying that surgeons are often considered dull people because they don't like surprises when they operate, he says. "And you could say the same thing about us, 'Cardiologists don't like surprises when they treat patients.'"

And DeMaria is working to make sure cardiologists have as few as possible.

—Tawny R. Acker



Professor DeMaria and associate, Oi ling Kwan

LEAFY GREEN CHEMISTS

For millennia plants have fought the insects and pathogens that are their mortal enemies, with no Homer or Caesar to celebrate their victories. Now they may have one.

Dr. Gerald A. Rosenthal, professor in the UK Thomas Hunt Morgan School of Biological Sciences, is a plant biochemist and a world-class scientist with more than a touch of the poet.

"Plants," he says, "have been successful because they are superb chemists. They use their own natural chemistry as a strategy of defense.

"If you cannot run and hide from your enemies, you have to develop other ways of avoidance or fighting back."

For these and other reasons, says Dr. Rosenthal, "I am interested in the biochemistry and toxicology of a group of toxic compounds synthesized by higher plants. I intend to spend my research career trying to understand at least two of these—canavanine and canaline. I want to find out how the plant makes these compounds, how they work, how the plant avoids poisoning itself, and especially, the biochemistry of their interaction with insects . . ."

In Dr. Rosenthal's laboratory on the first floor of UK's Research Facility 3, "we look at non-protein amino acids, toxins that go into the seed, that can

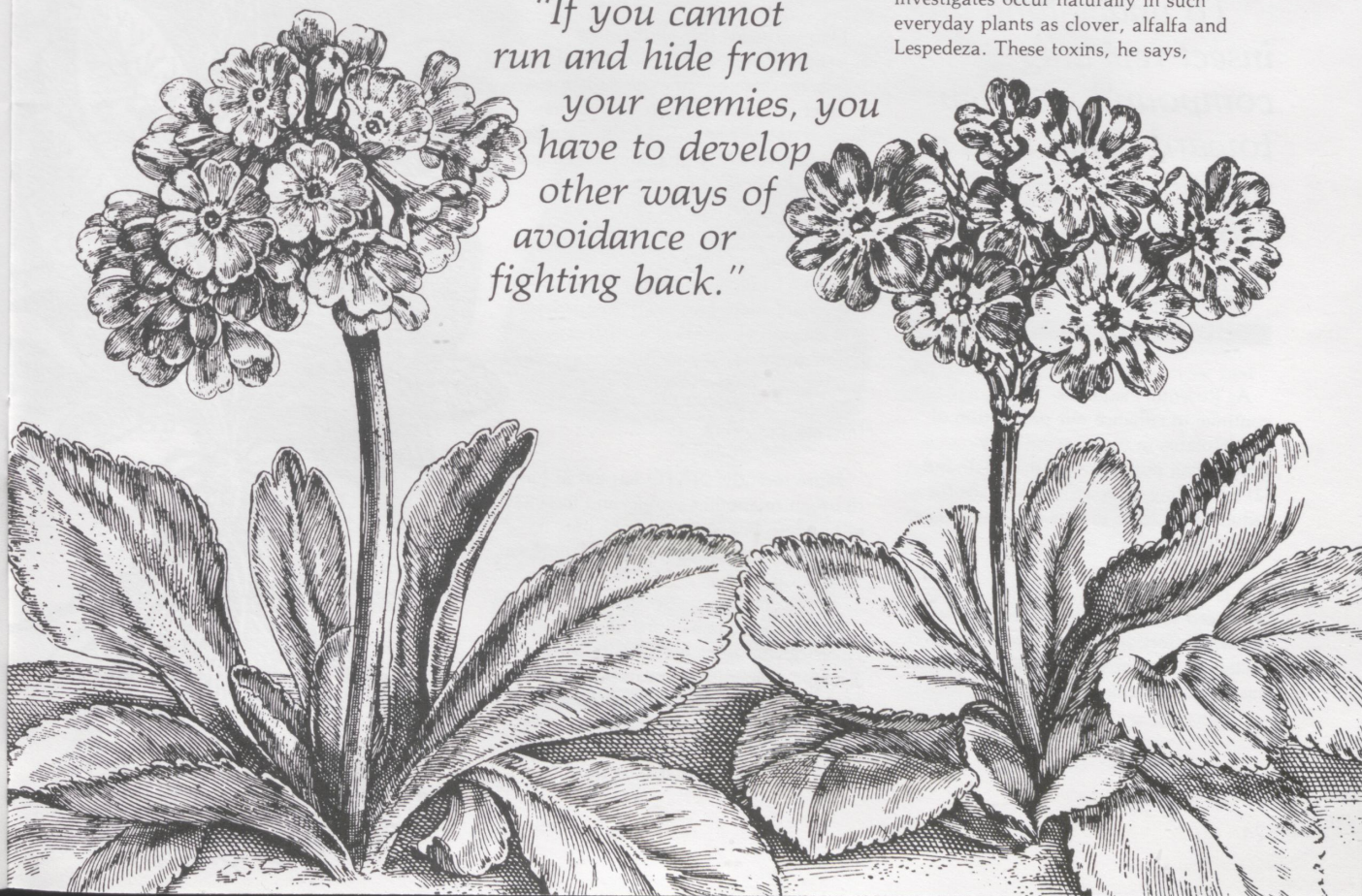
account for as much as 10 to 15 percent of seed weight."

To look at these natural products, Dr. Rosenthal and his associates use chromatography, enzyme assay, electron microscopy and other scientific tools.

Rosenthal is acquiring "baseline information" and then disseminating it in seminars, monographs, articles in scientific journals, book chapters, lectures ("Gerald is widely sought as a guest speaker . . . more than 20 lectures and seminars over the last four years," observes his chairman, Dr. Wesley J. Birge).

The toxic compounds Rosenthal investigates occur naturally in such everyday plants as clover, alfalfa and Lespedeza. These toxins, he says,

*"If you cannot
run and hide from
your enemies, you
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avoidance or
fighting back."*



"mimic essential compounds in all living systems," and therefore to understand canavanine and canaline well is to gain a bit better understanding of all life.

Rosenthal has become part of an emerging new field—biochemical ecology—an area of apparent interest to the National Science Foundation which has generously and continuously funded the UK professor's biochemical studies of selected compounds since 1973.

The National Institutes of Health have similarly supported Rosenthal's research for 13 years. They are interested in non-protein amino acid enzymology and toxicology.

There are some 20,000 distinct compounds, some toxic, that are made by plants and not by animals. Systematically, humans have bred toxic substances out of our food plants.

It is only recently that we have begun to ask: how can we use compounds toxic to insects and pathogens, to improve production?

To understand an insect-repelling compound is a step toward using it as a weapon to save a crop or at least to minimize loss.

As Rosenthal explains, "We can continue to enhance our production of edible plants in two ways: (1) by introducing novel genetic material, and (2) by finding more efficient means for reducing losses to insects and pathogenic organisms."

It is likely, he says, that man in advanced societies is approaching the limits of effectiveness with fertilizers and pesticides. It seems likely that Rosenthal has an idea whose time has come.



Professor Gerald Rosenthal

To understand an insect-repelling (or -killing) compound is a step toward using it as a weapon to save a crop or at least to minimize loss. Dr. Wyman Dorough, entomologist and director of the UK Graduate Center for Toxicology, says Rosenthal knows as much about the biochemistry of plants as anyone else in the world.

Dorough adds that studies like Rosenthal's on the chemistry of natural products, often become the basis for "modern drugs and pesticides on the market today." Sometimes these studies isolate a product such as physostigmine, a naturally-occurring substance from which pesticides can be developed.

Rosenthal organized a Gordon Research Conference on the "Chemical Aspects of Plant-Herbivore Interaction" and this fall at San Diego for the Entomology Society of America a major symposium on the "Biological and Chemical Aspects of Plant-Insect Interaction."

More recently, NATO has asked him to organize another symposium in 1983 at London, England, to, as he puts it, "look into some practical applications of these ideas."

He has been named one of six Americans in a scientific team instituting a major cooperative research program between the U.S. and the Republic of China (Taiwan), under the aegis of the National Science Foundation. "We will be looking," Rosenthal says, "at the

pests that attack rice, and other crops" in the Far East.

Rosenthal's ideas, says his colleague Dr. Birge, have stirred the national scientific community; his toxicological investigations into the adaptive (protective) significance in plants of non-protein amino acids, have found their way into the new textbook, *Biology by Arms and Camps*. He is the co-editor of a new volume on *Herbivores, Their Interaction with Secondary Plant Metabolites* and senior editor of a four-volume *Methods in Plant Biochemistry*, in preparation by Academic Press. He recently completed his own treatise on the *Non-Protein Amino and Imino Acids of Higher Plants*.

—Betty Tevis



THE PLANTLY ART OF SELF DEFENSE



The substance in one laboratory dish is frostily white, another is threaded through with serpentine blue, a third seems to consist of tiny pink blossoms. These deceptively beautiful growths are fungi. It is hard to believe that something so benign could also be so aggressively unfriendly to mankind and to the fruits (or vegetables) of human cultivation.

By living as they have always lived, for untold millions of years, encroaching, infecting plants, these fungi have become the enemies of mankind.

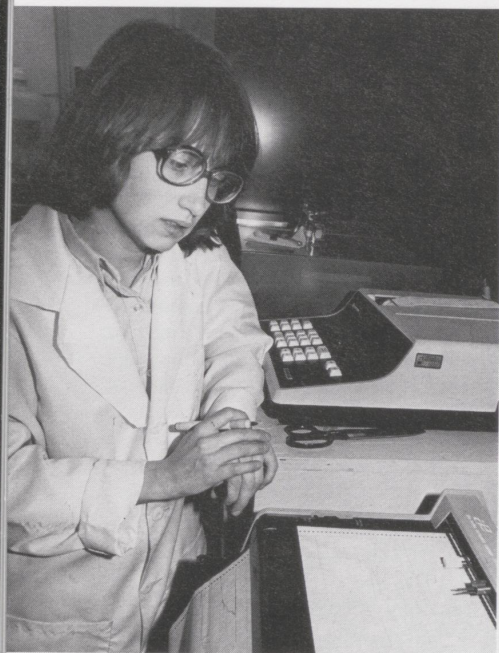
They destroy potatoes and other edible plants—and they do so with a deftness which challenges the abilities of our best scientists.

But they are unfriendly. These dishes from the biochemists' refrigerator contain specimens of criminal behavior. By living as they have always lived, for untold millions of years, encroaching, infecting plants, these fungi have become the enemies of mankind. They destroy potatoes and other edible plants—and they do so with a deftness which challenges the abilities of our best scientists.

"It is a dynamic encounter," said Dr. Joseph Kuc, as he returned the dishes to the refrigerator in his laboratory at Plant Science North. "It is a question of survival. We are trying to tip the balance very much in favor of the plant."

The potato—or any other plant—is fully capable of resisting infection from bacteria, virus or fungi. This much is certain. But the invader may outsmart the plant. If a potato is to resist infection, Kuc said, "it must recognize

Everything I Always Wanted to Know—



Carol Preisig and I spent a couple of days infecting potatoes—grisly work, but somebody has to do it—and as we worked side by side measuring out the chemical signal for immunity synthesized by the fungus, smearing it on the potato slices and looking for results, I learned something about being a doctoral student in Dr. Kuc's research group.

Preisig started at the University of Kentucky about 2 1/2 years ago, interviewed a number of professors to determine who she would work with, and decided that she felt some compatibility with Kuc. After she learned the basic techniques of demonstrating induced resistance in plants, he gave her "free reign," and now she is beginning to put together her own research programs.

She grew up in Fort Bragg, California, and spent 2 1/2 years studying the "standard curriculum—classics, history" at Reed College in Portland, Oregon. After learning that

she did not have "what it took to be a first-rate mathematician," she worked at Portland State, studied for a year in Hungary, and finally found in botany courses at Oregon State University, Corvallis, that by studying plants she could learn "everything I always wanted to know."

Graduating in 1978 with a degree in forest management, she worked as an intern at Crown-Zellerbach, the forestry corporation, where she got her "first taste of organized research," studying roots, regeneration, morphology, to "see whether the way you plant something is important—It is."

She came to Kentucky for personal reasons, joined Kuc's group and spends most of her time with the researchers who work in a laboratory in the Cooper Forestry Building. She values the biochemical training—minutely demanding because the purity of samples and the uniformity of procedure is very important—she has received as a member of the group. It has carried her from forestry to a "broader orientation"—into the integrated multidisciplinary study of plant pathology.

She is very interested in the offshoots of Bostock, Laine and Kuc's discovery of the two fatty acids which elicit turpenes. Exactly how do they do it? Is the fatty acid itself the active component, or some metabolite of the acid? Where are the biochemical pathways? How do different enzymes modify the fatty acids? Is it possible that some of these enzymes are keys to making the fatty acids elicitors?

Kuc says she is "very promising" and when she sits down with him to report her latest findings they pore over her graphs, and his genuine interest in her work makes it clear he regards her as a fellow researcher who is helping to further the research into induced resistance.

—M.J.K.

CONTINUED FROM
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that the intruder is not also a potato. If it does this promptly it is more likely to resist infection. The intruder or pathogen which successfully infects a plant will prevent recognition. A successful race of pathogen produces compounds in advance of itself which prevent the summoning of the immune reaction. Fungus and bacteria gain time to reproduce; the virus gets plants to make virus."

Its defenses neutralized, immune reactions summoned too late, the plant sickens.

Kuc, professor of plant pathology at the University of Kentucky, is one of the world's foremost experts on the intricate reactions through which plants identify and resist disease. As the world's population grows, deeper understanding of immune reactions in edible plants becomes vital and perhaps indispensable. Dr. John P. Fulkerson, principal scientist at the United States Department of Agriculture, says Kuc's work is of "enormously great potential," and that assessment is shared by Kuc's peers at other universities and laboratories.

Plants yield to disease because they do not summon their deftness soon enough or in sufficient strength.

Within five years—sooner, if Kuc and the international research group he has assembled at UK are lucky—they may discover the chemical nature of the "signal" through which plants muster their inherent immune reactions. Through research at UK, the signalling compound already has been isolated; this breakthrough may lead to widespread plant immunization through the application to crops of the compound or its derivations.

Immunization through field spraying would reduce dependence on chemical pesticides and improve chances for the breeding of resistant plants. Breeding is currently the agriculturalist's major weapon against plant disease, but the breeding of productive plants with disease resistant strains may reduce yields. Pesticides have notorious drawbacks: poisonous residues, and the targeted predators often develop immunity to the pesticides.

Kuc is pleased with the naturalness and safety of the processes for immunization which are being developed in his laboratories. "We have introduced nothing, no new chemicals," he said. "We have simply recognized timing."

Timing is crucial. Plants yield to disease because they do not summon their defenses soon enough or in sufficient strength. Research has shown that all plants have the ability to resist any disease they might encounter. Evolutionary common sense supports the findings: plants which could not resist disease would be extinct; any plant which has evolved must have been able to resist disease.

So Kuc and his colleagues step into a natural process not as surgeons but as therapists. "All plants have chemically based systems for defense," he observed. "It's not a matter of whether the plant can resist infection but whether a plant can engage the infection in time and in sufficient magnitude. All plants have mechanisms for disease resistance—all susceptible plants, all resistant plants . . . I believe you could say that we (University of Kentucky researchers) have been instrumental in hammering that insight through."

Immunization is a complicated process. Plants may be threatened by several different diseases, and one of these may weaken the plant so it cannot resist the others. Nevertheless, immunization can be accomplished and probably accomplished on a large scale. In one of his many papers, Kuc put it this way.

"Immunization is effective against viral, bacterial and fungal diseases. It is likely that immunization is dependent upon the activation of several different mechanisms and therefore is stable . . . Immunization can be considered to have

One of the diverting misconceptions that Kuc and his research group have dispelled is that "resistant" plants resist disease while "susceptible" plants do not. Kuc rejects the distinction.

stood the test of time and contributed to the survival of plants throughout evolution . . . Since immunization utilizes mechanisms for resistance in plants, it may be considered as natural and as safe for man and the environment as disease resistant plants (are) . . .

"The ability to immunize susceptible plants implies that the genetic potential for resistance is in all plants . . . Recent results from my laboratory indicate plants can be immunized by chemicals extracted from immunized plants. This suggests the possibility of immunization by field spraying or seed treatment."

If these remarks suggest to you that Kuc feels confident that plants, using their own powers, can withstand infection, in effect practice botanical self reliance, heal themselves, then you are beginning to understand his approach to plant disease.

One of the diverting misconceptions that Kuc and his research group have dispelled is that "resistant" plants resist disease while "susceptible" plants do not. Kuc rejects the distinction. Even the unfortunate American Elm tree could resist Dutch Elm disease if its immune reaction could be summoned quickly and decisively seal off the disease before

infection spread. And the Elm itself does not need to be the focus of investigation: Because plants have, generally, a quality known as "low specificity," immune agents from one plant can be used to immunize other plants against virus, bacteria or fungus.

Reports of induced disease resistance in plants date back more than a century. But while "immunization rapidly became and still forms the basis of preventive medicine against infectious disease in animals," Kuc observes, immunization intended to control plant disease has developed only very recently. Through the support of agencies such as the United States Department of Agriculture, the Rockefeller Foundation and the Kentucky Tobacco and Health Research Institute, some of these developments have occurred in UK laboratories.

None of this activity would have occurred in Lexington if Kuc was not a member of the faculty. His international reputation as an expert in the control of plant disease has concentrated the attention of plant scientists on UK. He has received a research award from the UK Research Foundation, was named Distinguished Alumni Professor in 1978, received a Senior Scientist Award from the Alexander von Humboldt Foundation, has been elected corresponding member of the Deutschen Phytomedizinischen Gesellschaft and has been named a Fellow of the American Phytopathological Society.

After returning from a stay at the Plant Protection Institute in Braunschweig, Germany, he was joined this year in his laboratories and greenhouses by several scholars from other nations, among them, Dr. Eris Tjamos of the Benaki Institute of Phytopathology in Athens; Dr. Pierre DeWit of the University of Wageningen, Netherlands; Dr. Gerhard Wolf, of the University of Göttingen, Germany; and Dr. Grzegorz Maniara, of the University of Wrocław, Poland. Dr. Nabil A. Garas, an Egyptian researcher, is a permanent member of the research group.

Fulkerson recalled two episodes which suggested Kuc's eminence as a member of the international community of plant immunologists.

"At a national meeting there was a large session where Joe was giving his paper," Fulkerson said. "There were many papers, the room was just full, the session had gone on the whole morning. Joe gave his paper and one of his strongest professional critics jumped up and said it was one of the finest papers he had ever heard in that area and represented an astoundingly good piece of work."

Kuc and his colleagues have identified in a fungus the alarm compounds which signal potatoes to protect themselves against the onset of a disease called late blight.

"Joe is a very argumentative type. Because of his hairshirtedness in presentations he tends to excite voluble responses. But it was very unusual for this to happen, for this praise to be offered in the middle of a meeting. It's the sort of thing which might have been said privately in the hallway, but not in the meeting itself

" . . . And then he went to Russia in 1978. The Russians were very aggressive with me about what I could contribute. I knew how anxious folks in the laboratories were to have Kuc come. They really went to him. It's just another example of the respect in which he is held."

The accomplishments of the UK research group have been remarkable. In 1974 Kuc and his associates learned how to immunize plants for their lifetimes (immunization cannot be transmitted from generation to generation). Recently Kuc and two colleagues, Dr. Richard M. Bostock, one of Kuc's doctoral students, now on the faculty at the University of California,

Davis, and Dr. Roger A. Laine, a biochemist in the UK Medical Center, published what Kuc called a "startling" finding: They identified in a fungus the alarm compounds which signal potatoes to protect themselves against the onset of a disease called late blight. These compounds, previously and apparently mistakenly thought to be proteins or carbohydrates, were correctly identified by Kuc, Laine and Bostock as fatty acids.

"Since the alarm signals have been identified," Kuc said, "it should now be possible to pinpoint their mode of action, how they regulate resistance mechanisms, and of course the compounds or their derivations may find use in disease control. We have found that these alarm compounds are relatively simple, compared with proteins or carbohydrates. Now we can study what happens to them in the potato and how they stimulate the synthesis of the antibiotics which are important in inhibiting pathogens."

The discovery of two warning substances—Eicosapentaenoic acid and Arachidonic acid—which alert a plant to the presence of a dangerous intruder places Kuc even more prominently in the forefront of the study of induced resistance.

In the presence of a pathogen, these acids sidetrack metabolic processes which usually produce steroids, resulting instead in the production of antifungal sesquiterpenes and, in the potato, of a substance called lignin, which seals off the attacking fungus. A plant does not seem to circulate the anti-microbial compounds for immunity; unlike an animal it must confine infection locally if it is to survive.

Kuc's laboratory is one of perhaps a half dozen across the country where plant geneticists, physiologists, biochemists and other researchers are making important discoveries about induced resistance. Scientists at other institutions readily acknowledge Kuc's leadership.

If the agents which stimulate the immune response in plants can be identified and isolated, their effectiveness can be amplified.

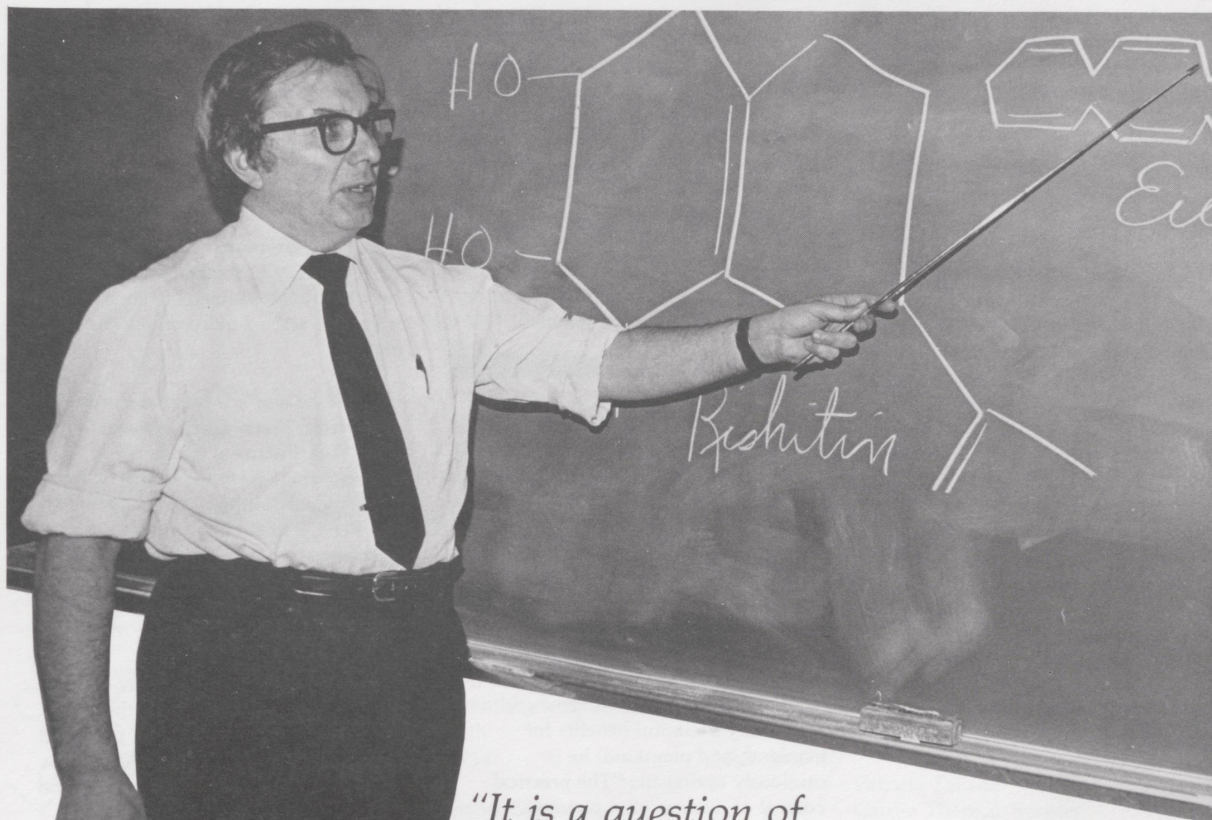
Dr. J. M. Daly, professor of agricultural biochemistry at the University of Nebraska, said the isolation of Eicosapentaenoic acid and Arachidonic acid may correct some mistaken directions in the research.

"A number of researchers have reported the existence of other signalling compounds, but there seems to be a possibility that their samples were contaminated by the two substances that Kuc discovered," Daly said. "The contaminants would have brought about the effects. This work of Joe's should influence people to look at the purity of their own preps."

"There is a general notion growing," Daly said, "that in most if not all plant disease there are signals from the pathogen which would induce the resistant response. In the past, people assumed that it was a specific signal for a given host—this was the key. More recently it has been argued that the response to disease is a general one and that successful pathogens turn off the resistance response. Joe has provided a general signal."

Dr. Robert Goodman, professor of plant pathology at the University of Missouri, praised Kuc for "taking induced resistance into the field and showing the world that it isn't a pipe dream. It can be done."

Goodman predicted that the immunizing of plants would be widely employed "in the not too distant future."



Professor Joseph Kuc

"It is a question of survival. We are trying to tip the balance very much in favor of the plant."

"If he has the signals in hand," Goodman said, "that's a step in the right direction, because if the agents which stimulate the immune response can be identified and isolated, their effectiveness can be amplified."

Kuc's investigations began with findings extrapolated from animal science. His collaboration with medical researchers opens another subject for speculation: Will this research into plant immunity lead to improvement in the treatment of human disease through the development of new antibiotics, which are, he has observed, no more than the "pesticides of medicine?" Will they lead to new methods of stimulating the immune system in animals?

Fulkerson is confident that discoveries in plant immunology, coupled with advances in genetic research over the last decade or two, will produce breakthroughs in disease control, because, in a peculiar way, plants are wiser: "They made their evolutionary peace with pathogens millions of years ago. They are there to be manipulated, ready tools in our hands, provided that people like Kuc do the work they do."

Kuc maintains that his plant investigations "will stand on their own." He is willing to speculate about the possible influence of his work on research into animal disease: "Since immunization in plants is effective against diseases caused by fungi, bacteria and viruses, it is possible that the compounds for immunization may prove effective against diseases caused by these infectious agents in animals. Though highly speculative, it may

develop that higher plants may serve as a source of a new class of antibiotic substances, or of greater understanding of the signals which activate resistance mechanisms in animals."

Dr. Laine, Kuc's and Bostock's medical collaborator, was drawn into plant research primarily because his skill with the mass spectrometer and other equipment used to analyze the structures of biochemical compounds would help the plant pathologists to "chase down the biological activity that caused the potato to generate antifungal activity."

When, after about a year, the team purified one of the antifungal substances, they learned that the Hormel Corporation produced the same substance for resistance to fungus in animals.

This finding alone would suggest possible analogies between Kuc's research into plant immunity and medical research into animal immunity. But Laine suggests that the implications of Kuc's research overshadow the analogies.

"Economically that research is going to have tremendous consequences," Laine observed. "We rely for our food supply on about ten species of plants. A major disease could cause calamity, and has. The potato blight caused by the fungus which Kuc is working on in his lab is what killed millions of Irish and forced the migration of millions more."

"Kuc is one of the really outstanding scientists on our campus. He is in the forefront of his field. His science is top notch and well recognized. His contributions are as striking in this area as any that have been made in immunology in animal sciences."

What next?

Current experimentation in UK plant immunology laboratories has four important objectives: "We would like," Kuc said, "to have the chemical structures for signals which elicit immune mechanisms of plants; we want

The invader may outsmart the plant. If a potato is to resist infection it must recognize that the intruder is not also a potato.

to understand how these signals activate immune mechanisms; we want to isolate and chemically characterize phytoalexins (plant antibiotics) and other aspects of the defense mechanisms." Fourthly, of course, Kuc wants to see these findings turned into helpful and harmless chemical substances which would be applied for control of diseases in the fields.

About this possible outcome and its potentially bountiful benefits for mankind (and plantkind) he is cautiously optimistic: "The practical control of disease, on a preventive level," he has written, "utilizing and perhaps improving on a mechanism that has stood the evolutionary test for survival, is a distinct possibility."

Other possibilities are not so distinct. Like other UK scientists, Kuc is beginning to feel the unbountiful effects



of cuts both in the University budget and the tightening of outside funding. He had just been forced to replace a departing greenhouse technician with a technician needed in the laboratory and he was trying to figure out where to get \$10,500 for a new centrifuge, to replace one which was worn out.

But Kuc probably will not be deterred by temporary obstacles dropped in his way by budget cutters. He is, after all, a man who started out working for nothing.

While he was a student at Purdue University, Kuc worked summers at New York Botanical Gardens and in this fragrant refuge from the Bronx he found not only a vocation but also a mentor. Dr. Peter Pascal Pirone, plant pathologist at the Gardens, showed the undergraduate biochemist the direction he has followed with increasing success for more than three decades.

They remember one another with affection. "In everyone's life there are some persons who have been profound examples," Kub observed. "Pirone was mine. He would take me for walks and show me things, and he kept emphasizing that we know very little about disease resistant mechanisms in plants. Under his guidance I decided to apply chemistry to plant pathology."

Pirone is the father of Dr. Thomas P. Pirone, presently chairman of UK's Department of Plant Pathology, where Kuc works. Now retired, spending only two days at a week at the Gardens, he recalled that Kuc, a New Yorker and graduate of Bronx High School of Science, lived in Queens and took the subway to the Bronx every day to work on plants—the first summer without pay.

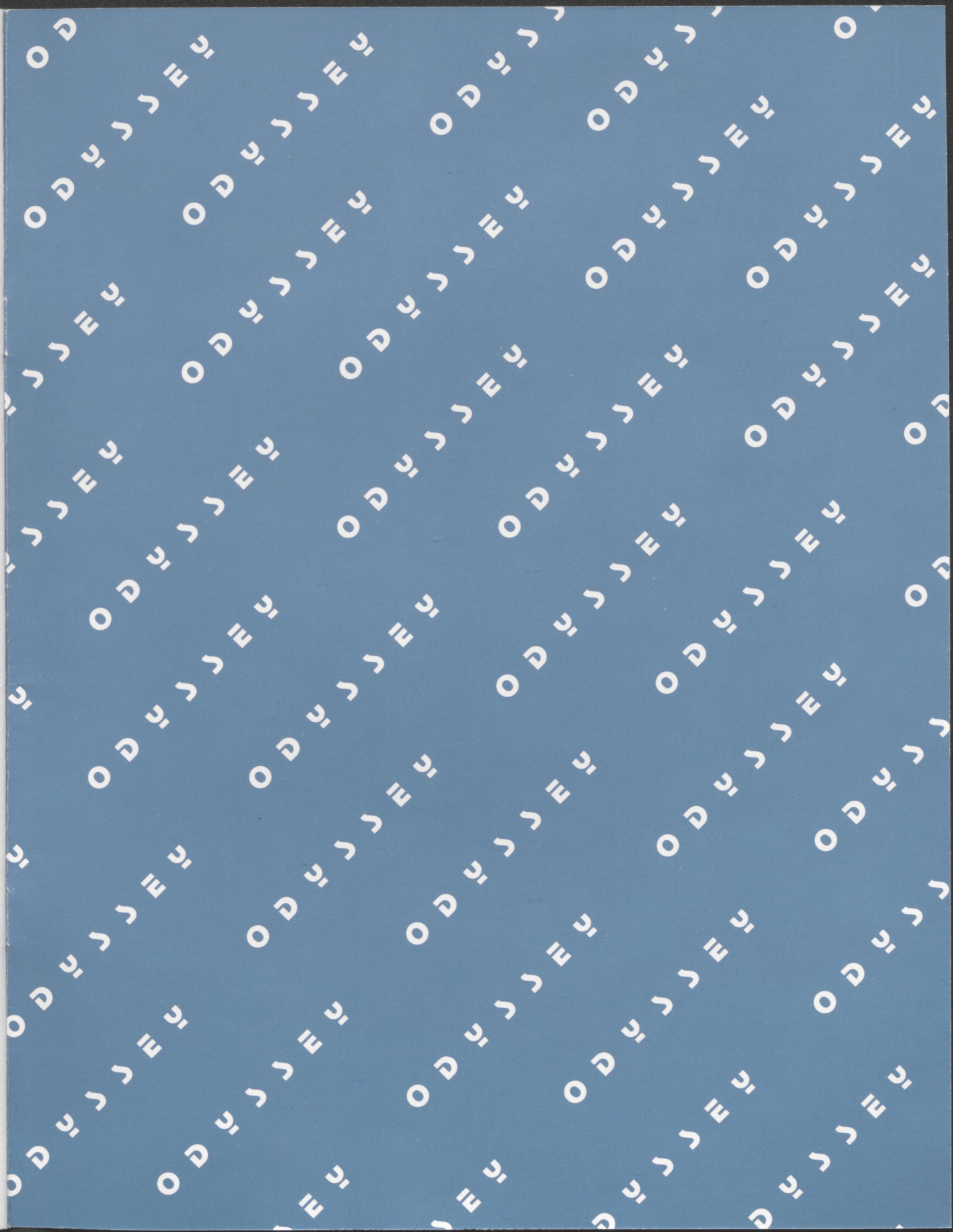
"We were working on ways to provide nutrients for plants through the leaves," Pirone said. "Kuc did careful work analyzing the amount of nutrients which were needed to feed the trees. I presented his results at the National Shade Tree Conference. I remember that he was very faithful and very capable."

"The second summer we found a way to pay him."

—Michael J. Kirkhorn

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