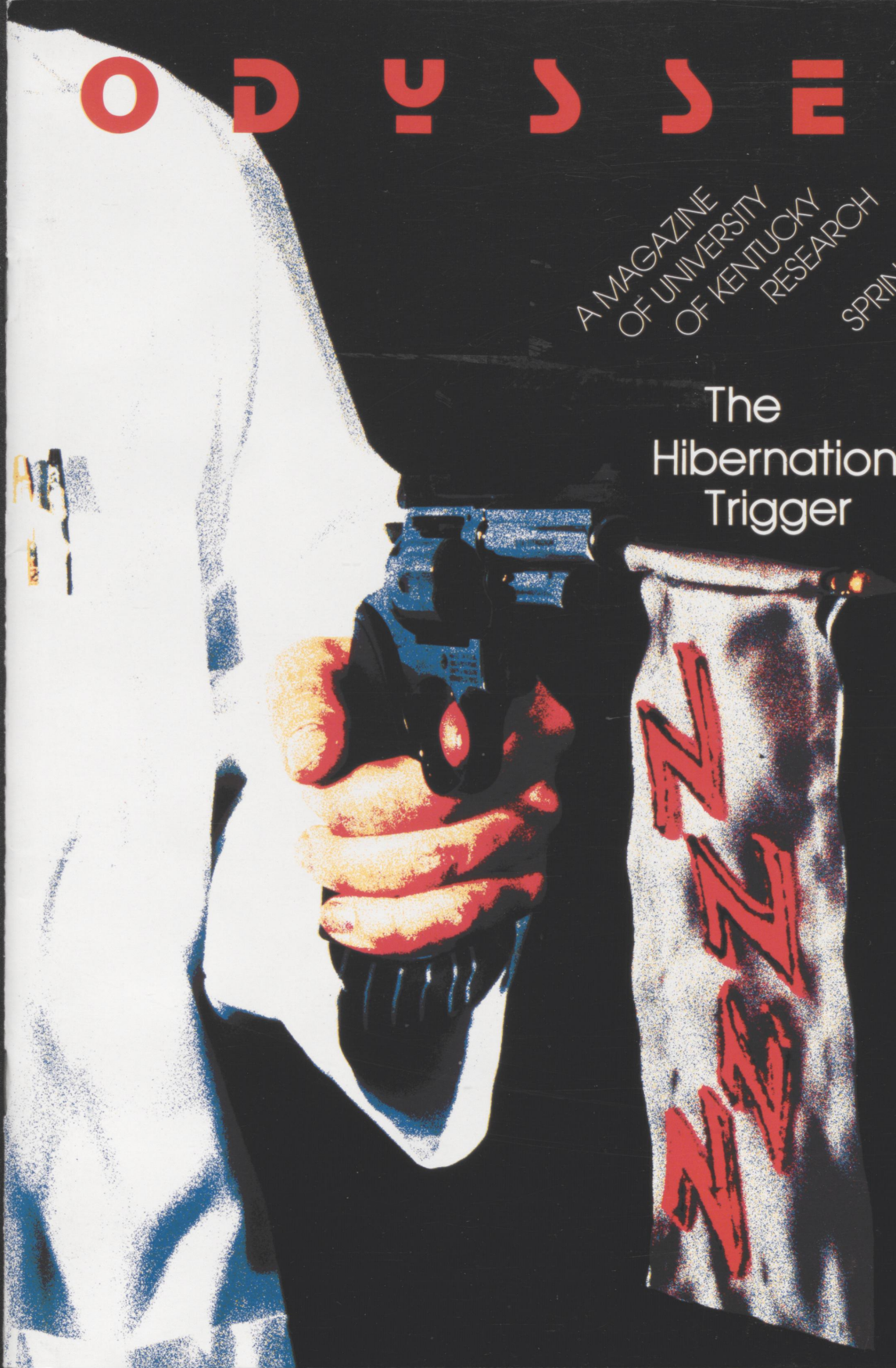


O D U S S E U

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OF KENTUCKY
RESEARCH
SPRING 1985

The
Hibernation
Trigger



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The Hibernation Trigger	2
Acres of Soybeans in a Test Tube	5
Earthworms in Jeopardy	10
The Lowly But Critical Flow-ers of the Earth	
Safer Mines	12
Research Summer Helps Decide Career	14
How Can This Marriage Be Saved?	16
A Talking History of Medicine in Fayette County	17
Detecting Cancers Sooner	19
Black Poetry to the Neighborhoods	21
A Pathway to Understanding Cell Growth and Cancer	23
Bach to Basics with Computers	25
Silicon Solar Cells	27
Directory of UK Researchers	28

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The Hibernation Trigger

By Tawny R. Acker

Something pulled the trigger. The small, furry body slumped forward and rolled into a tightly curled ball. The woodchuck's respiration, heart rate and body temperature dropped dramatically. Although there were no visible signs of life, the woodchuck was indeed alive. It had entered an artificially-induced state in order to survive the scarcity of food in winter.

Dr. Peter Oeltgen was hooked. Only moments before, the woodchuck had been squirming furiously as it was injected with plasma from a hibernating ground squirrel. Something very powerful and very miniscule in the blood was responsible for the change in the animal's condition and Oeltgen was going to identify it. He named the unknown substance the Hibernation Induction Trigger (HIT).

Oeltgen, UK associate professor of pathology and toxicology and head of the chemistry section in Pathology Services at the Veterans Administration Hospital, became involved in hibernation research in the 1970s after being invited by Loyola University physiologist Wilma Spurrier and U. S. Navy physiologist Albert Dawe to join their research team.



Scientists used to consider hibernation nothing more than a reaction to the cold and a throwback to cold-blooded ancestry. There was even debate as to which animals were true hibernators.

Spurrier and Dawe had begun their research in the late 1960s. Prior to their work, hibernation was basically a phenomenon for descriptive speculation. Some scientists considered it nothing more than a reaction to the cold and a throwback to cold-blooded ancestry. There was even debate as to which animals were true hibernators.

Now a generally accepted scientific

definition of hibernation is that it is a unique phenomenon in which the entire animal participates. This means that each organ at tissue level may be capable of entering the hibernating state in which energy expenditure and food consumption are minimal.

Ground squirrels, woodchucks, brown bats and European hedgehogs are the four major groups of animals which are considered true hibernators.

That is, the animals' core temperature drops approximately 30 degrees until body temperature is only one or two degrees above that of their environment. Their heart rate slows from as much as 100 to 150 beats a minute to one or two beats a minute. For instance, bats whose summer active heart rate while in flight is over 1,000 beats per minute, slows in hibernation to less than 10 beats per minute. Respiration also slows and oxygen consumption decreases. Hedgehogs, for example, can continue to live without taking a breath for 150 minutes. During hibernation the animals have no urine formation and no protein catabolism.

As the animals enter hibernation, they experience something called shivering thermogenesis. That is, as the core body temperature drops, it

drops from the body's trunk outward to the limbs. This phenomenon is very similar to the way a human's body reacts as part of the symptoms of hypothermia, the often deadly condition which occurs as the body's core temperature drops and the heart fibrillates. However, in animals experiencing thermogenesis, the heart does not fibrillate.

If humans were able to achieve the state of hibernation, it could mean an immediate cure for sleep disorders. It would also provide a natural anesthetic and increase the possibilities of successful match-ups for organ transplants.

It is a crucial distinction in the way the bodies of hibernators and non-hibernators respond to the same internal conditions. Whatever chemical or hormonal substance that allows hibernators to exist in the neutral state between life and death also gives their bodies resistance to tumor formation and provides a natural anesthetic which deadens their reaction to pain. During hibernation, the animals can sustain twice as much exposure to radiation without harm and organs removed from the animals can exist for transplanting purposes nearly twice as long as those taken from the animals during an active period.

In these terms, hibernation does seem to possess the mythical qualities attributed to it in *Rip Van Winkle* and *Sleeping Beauty*—prolonged sleep, without any disturbing side effects, except the loss of time. And the implications for humans are staggering.

If humans were able to achieve the state of hibernation, it could mean an immediate cure for sleep disorders. It would also provide a natural anesthetic and increase the possibilities of successful match-ups for organ transplants. Exposure to higher doses of radiation without side effects could have positive effects for cancer victims. And certainly weight loss and gain could be more easily controlled.

Although these are only speculations based on current research, scientists are not ignoring

them. In fact, they are actively working toward their realization. A Stanford University neurophysiologist is studying the connections between sleep, warm-bloodedness, and hibernation. A physiologist from University of California at Davis is interested in applying the information from hibernation research in controlling weight.

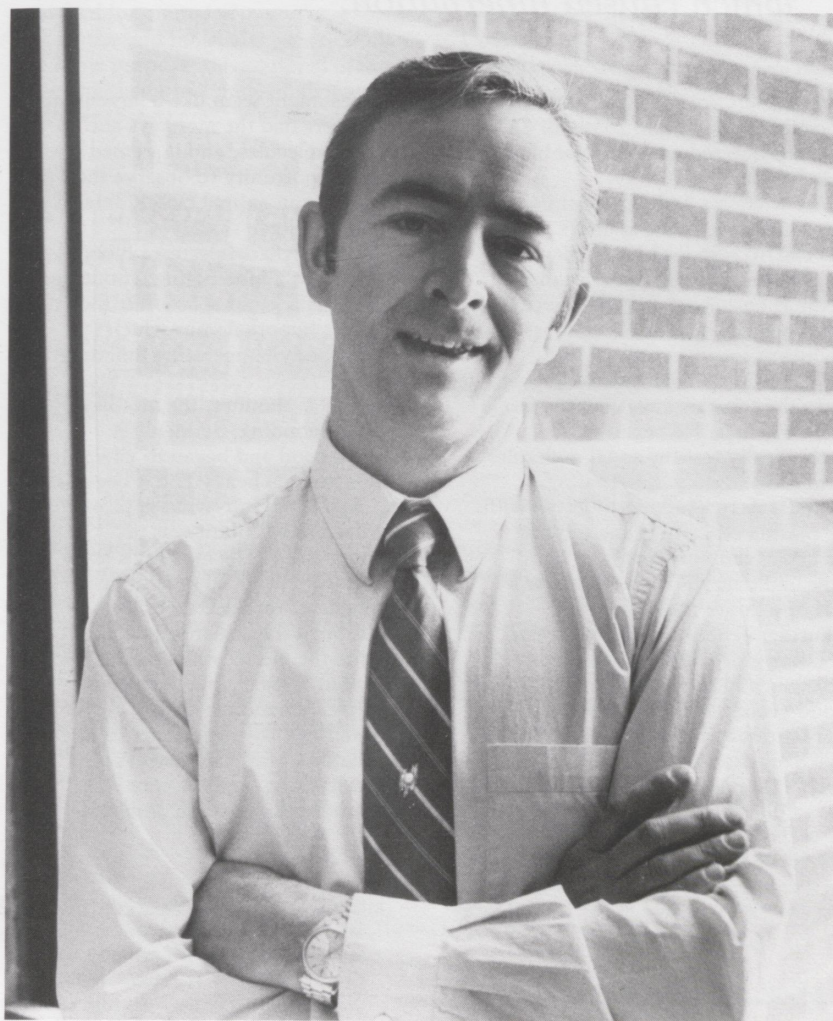
Oeltgen says it is now a matter of identifying what triggers hibernation in these animals and how the substance can be transferred, refined or recreated in other animals before the speculations can become reality.

He is perhaps the researcher closest to identifying HIT. The odyssey began nearly two decades ago with the work of Dawe and Spurrier and the addition of Oeltgen and Dr. Robert Meyer, now a professor at the University of North Carolina.

In 1968 Dawe and Spurrier decided to search the blood of hibernators for an agent that might be responsible for the regimented periods of activity and sleep which characterize hibernations.

They carefully extracted blood from a hibernating ground squirrel as it slept in a hibernaculum—a cold laboratory constructed to resemble a

continued on page 4



Peter Oeltgen

The Hibernation Trigger continued

natural environment. The extracted blood was then injected into two summer-active ground squirrels, which were also placed in the hibernaculum. Within 48 hours, the active squirrels were hibernating.

The following summer, Dawes and Spurrier continued their research using more animals. This time, 23 active squirrels were injected with blood drawn the winter before from hibernating squirrels. Three squirrels were also injected with blood from hibernating woodchucks. Within 52

into fractions and testing each fraction for HIT activity. He is particularly interested in analyzing the specific amino-acid sequence of HIT. His research toward that end is being financed by a genetic-engineering firm.

"We are trying to make headway in fully identifying the molecules in HIT," Oeltgen said. "When we do this the clinical applications will follow."

Perhaps the most dramatic experiment in HIT research recently occurred when Oeltgen, Dawes, and Meyers injected the albumin-bound HIT into a rhesus monkey.

"The change from testing rodents to

temperature and the monkey's did not," Oeltgen said. "But it would have been interesting to see what would happen if we could have given repeated tests."

An important observation the researchers gleaned from this experiment was that the HIT effect on the monkey resembled the human response to an opiate or an opium-based drug such as morphine.

Repeating the experiment with several monkeys, the researchers observed the same results. Following this clue to the identity of HIT, Oeltgen dosed some of the primates with naloxone, an opiate blocker that

The scientists had demonstrated that something in the animal's blood was clearly responsible for triggering the chemical reaction which caused hibernation.

days, the squirrels injected with woodchuck blood and 20 out of 23 squirrels injected with squirrel blood were hibernating.

The scientists had demonstrated that something in the animal's blood was clearly responsible for triggering the chemical reaction which caused hibernation. Oeltgen then dubbed the substance HIT and delved further into the identification process.

From earlier experiments, Oeltgen knew the substance was in the plasma of the animals. He began to methodically test the small molecules from the plasma of hibernating animals. Active animals injected with the plasma containing the smaller molecules did not hibernate. This indicated that HIT was somehow a part of a larger molecule.

Further experiments showed that HIT was indeed a part of a larger molecule and somehow bonded to the blood protein albumin. Oeltgen's current research is aimed at isolating HIT from albumin on a molecular level. This requires separating albumin

primates might seem like a large jump, but Meyers had the monkeys and I had the molecules, and it seemed like a good opportunity to observe the reaction on an animal closely related to man," Oeltgen said.

The researchers injected a blood protein from a hibernating woodchuck into the ventricular space near the monkey's hypothalamus which controls body temperature and heart rate.

Within 15 minutes, the monkey began responding. Suddenly it shunned food and began to yawn. Its eyelids became heavy and it began to gag. And it fell into what appeared to be a deep sleep. But it was no ordinary sleep. The monkey's body temperature dropped several degrees, and its heart rate decreased by half.

Although the researchers will not say that the monkey hibernated, they agree that these changes are those usually experienced only by hibernators. "By definition a true hibernator's heart rate decreases to almost nothing, and the core temperature drops to an ambient

halts the brain's receptors to the opiate. The injected monkeys abandoned their hibernation-like sleep almost immediately.

Oeltgen says the implication is that the trigger somehow activates the brain's opiate receptors directly or indirectly. And he speculates that HIT is an opiate-like molecule or a neurophomone that causes the brain to manufacture opiates. However, this is only a theory, but one Oeltgen hopes to test.

More importantly, these experiments removed the research from the realm of strictly hibernating animals and their habits. "For the first time our research demonstrated that the HIT molecule can exert a profound effect on a non-hibernating model, the primate, without any life-threatening effect," Oeltgen said.

"Whether or not the benefits we observe in the hibernators will prove useful to man still remains to be seen," Oeltgen said. "But the indications are positive and the implications profound."

Acres of Soybeans in a Test Tube

Genetic Engineering of a Cinderella Crop

By Moira Skinner

A first glance into the lab reveals neat stacks of Petri dishes, hundreds of them. On closer inspection, those smooth rounds of plastic display small cream-colored blobs, some sprouting tiny green "mouse ears." On nearby shelves, small vials hold bright green leafy spindles a few inches long.

The globs actually are masses of plant cells, the tiny ears, embryos. The spindles are the more advanced shoots.

These are soybean test tube babies. They, along with some distant cousins growing in the greenhouse, are making agronomic history.

They don't look different than other soybean plants. What sets them apart is their conception: not from a fertilized zygote — sexual reproduction — but from single vegetative or "somatic" cells, perhaps from a leaf, stem, flower, or seed. With careful nurturing, the single somatic cells were grown into whole plants.

The leader of this lab and discoverer of the soybean cell-to-plant regeneration system is Dr. Glenn Collins, cellular geneticist extraordinaire in the University of Kentucky College of Agriculture.

The mature, thriving soybean plants grown from single microscopic cells embody one of his research goals. They also represent the path to another — improving soybeans through genetic engineering.

Developing a soybean cellular system is a natural step in Collins' ongoing work. After joining the UK faculty in 1966 as a tobacco breeder and geneticist, he established a firm reputation in traditional breeding programs. In the early '70s Collins became more and more interested in nonconventional approaches to plant genetics. A sabbatical leave in 1973 to the John Innes Institute in Norwich, England, helped build his interest in cellular genetics.

Cellular genetics is part of a larger field referred to broadly as

biotechnology, or more specifically as genetic engineering, explained Collins. That means using cells instead of whole plants, and includes molecular biology, such as recombinant DNA, gene splicing, cloning and similar techniques.

"The theme of our laboratory," said Collins, "is to genetically alter plants in a positive direction, either for production purposes, so that they're easier to grow, or for utilization purposes, for better food for people and feed for animals."

Cellular and molecular genetics fills the same purpose as traditional plant breeding, he noted, and supplements traditional methods. "It's just a

various manipulations. Culture allows easy application of a selective agent, like an herbicide, and identification of the resistant cells. When the question is disease resistance, it's difficult and risky to expose large numbers of plants in the field to a disease organism, but safe and simple to do so in culture.

In the lab, the researcher also can control environmental conditions such as temperature or moisture, and keep them from interfering with the expression of plant or cell response, Collins said.

As his cellular work with tobacco progressed, Collins became interested in applying the same techniques to

In two ounces of liquid in a culture flask, Collins can grow 50 million cells. With hundreds of flasks in the lab, at 50 million cells each, he has available billions of cells and innumerable different genotypes.

shortcut, a more efficient and sophisticated approach at changing the genetic composition of the cell — the basic unit of a plant or animal."

Working with masses of cells instead of acres of whole plants offers several advantages. Growing and testing in the field is an effective process in changing traits, but it is slow and time consuming. Growing enough plants for optimum genetic variability is impossible or impractical.

But in two ounces of liquid in a culture flask, Collins easily can grow 50 million cells. With hundreds of flasks in the lab, at 50 million cells each, he has available billions of cells and innumerable different genotypes.

That enables the geneticist to select naturally occurring mutations or to induce mutations and to perform

other field crops. When the College of Agriculture decided to move deeper into cellular genetics, and in 1978 created a full-time faculty position for somatic cell research, Collins applied and secured it. He soon took to the lab with red clover and soybeans.

"We've also done some work in corn and fescue," he said, "as we are basically concentrating on the crops that are most important to Kentucky."

Indeed, the importance of soybeans extends far beyond the Commonwealth. The legume is an extremely important oil and protein source worldwide and is a major food crop for humans and animals. It has far more potential as a human food than it now enjoys, especially if

continued on page 6

Acres of Soybeans in a Test Tube continued

researchers succeed in changing the distinctive flavor that has limited its use.

"The soybean is a Cinderella crop because it has such outstanding characteristics as high protein content, and good food and feed value, and it is just ready to be utilized," Collins said. "Interest has been strong, the markets strong, and it has replaced other crops in the production cycle, especially in the Midwest.

"It's changed agriculture. Even

Kentucky produces a lot of soybeans, usually doublecropped with wheat so producers can grow two crops a year."

There's a tremendous amount of work to be done to make soybeans an even stronger crop. Besides the standard traits to improve in a crop plant, such as disease resistance, insect resistance, uniformity and tolerance to herbicides, heat and drought, geneticists also can strive to improve the quality of the major product — the seed — and the oil and protein it contains.

So to Collins and others studying legumes, the incentive was great to

improve soybeans and to use cellular and molecular techniques to do so. But before applying genetic engineering approaches to soybeans, Collins faced a major hurdle. There was no cellular system developed for soybeans; that is, no one knew yet how to reduce soybeans down to the single cell level and then regenerate an entire plant.

"For some reason," Collins said, "the large seeded legumes like soybeans, peas and beans are difficult to manipulate, while the small seeded legumes like alfalfa, red clover, and birdsfoot trefoil, are relatively easy."

He and a former graduate student, Greg Phillips, had developed a cellular system for red clover, and laid the groundwork for soybeans. They published a journal article in 1981 showing how they derived tissue cultures and pushed regeneration to the point of obtaining embryonic plants for soybeans. But the tiny plants failed to mature. There was more work to be done.

The prospect of a generous grant from a seed company, Agrigenetics Corporation, provided more incentive for Collins to carry on the soybean regeneration work. The company's representatives had approached Collins first in 1981 with the intention of supporting soybean research.

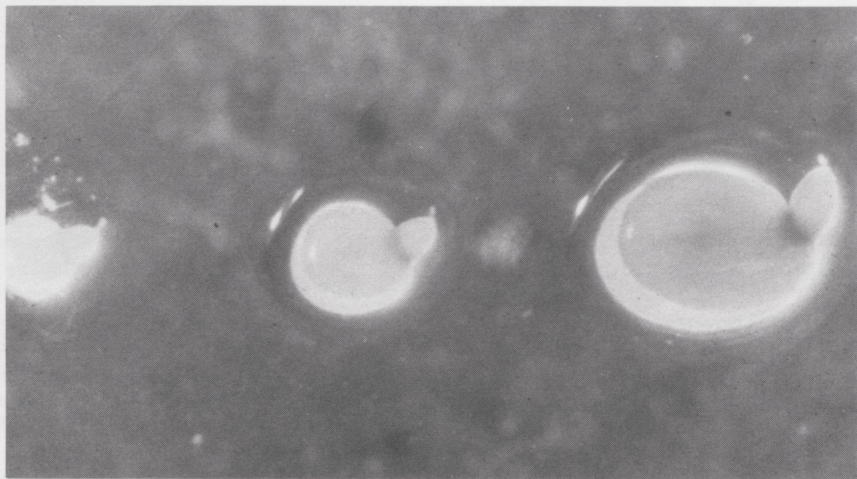
"At that time," said Collins, "I told them we just weren't far enough along. We didn't have the personnel, we were short on lab facilities."

Fortunately, that situation changed. By mid-1983, Collins had more resources at his fingertips. The UK College of Agriculture began showing strong support of cellular and molecular genetics research, not only in agronomy, but throughout the College. More labs were made available and older labs renovated. New researchers were recruited in several departments.

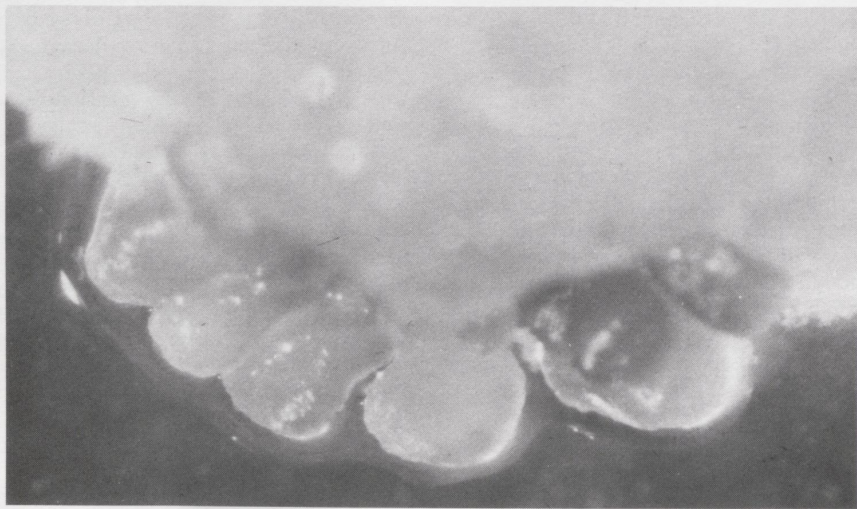
"The strength in this kind of work is numbers of people in different specialties," Collins said. "We draw upon people in plant pathology, biochemistry, horticulture, any area, if we have a need for a technique or piece of equipment."

The arrival of Dr. David Hildebrand in 1982 boosted the soybean research. Well-versed in plant genetics, chemistry, and agronomy, and fresh from a postdoctoral fellowship studying biochemical genetics in Japan, Hildebrand

The Stages of Plant Regeneration from Soybean Cell Cultures-



Immature soybean embryos.



The first appearance of somatic embryos on callus produced from an immature soybean embryo.



A later stage of development of somatic embryos.



Plantlet derived from a "germinated" soybean embryo.

represented the molecular side of the genetic engineering team.

"I was hired to be sort of a bridge between plant breeding — traditional plant improvement — and molecular biology," Hildebrand said. "My obligation is to take the latest in molecular genetics techniques and improve plants, ultimately moving the work to levels the breeders can capitalize on.

"I found it was just what I was looking for," he added.

With Hildebrand on board, Collins was ready to tackle the commitment of the soybean regeneration work.

Agrigenetics accepted their proposal and funded the work for a two-year period beginning in December 1983.

"I think Agrigenetics was interested in us for two major reasons," Collins said. "One, our experience and involvement with legumes, and second, our track record. Without sounding too boastful, we're the most advanced lab in the country for tobacco, and I think also the top lab for legumes.

"We have a large laboratory and a productive record, and they knew that we knew what they wanted us to do."

What Agrigenetics wants Collins

and Hildebrand and their colleagues, including Dr. Paul Lazzeri, to do is remove a bottleneck. The seed company wants to put specific genes into soybeans, to impart new resistances to crop stresses or pests such as plant diseases, insects, and nematodes, and to improve drought and temperature tolerance.

But until there's an effective cell-to-whole plant system for a particular plant, there's no way to transfer genes.

"That's why we have placed research programs for regeneration with people we believe to be outstanding researchers throughout the world," said Dr. Dale Hansen, president of Agrigenetics Research Corporation, the seed company's research arm. "We have done that for each of the major crops that we sell.

"That's why we're working with Glenn Collins. He's considered one of the leading people on the forefront of plant regeneration for soybeans."

Agrigenetics has had its contract with Collins for only a little more than a year, but, Hansen commented, "he has done very well during that short period of time. This type of research takes a long time to accomplish so we don't expect miraculous results in a year."

Yet Collins and his crew are within months of perfecting the soybean cell-to-plant regeneration system. They have regenerated plants growing in the greenhouse, some of them as far along as flowering and producing seed.

A two-pronged strategy helped push the work along at a rapid pace. First, Collins and his associates, including soybean breeder Dr. Todd Pfeiffer, undertook a massive study of soybean genotypes to find the most promising for tissue culture. They looked at more than 800 different genotypes to pick out 20 or so with the best response, instead of randomly taking a few and hoping they could get conditions right to make those few respond.

The experimentation on responsiveness yielded about 25 different genotypes, including some wild genotypes that will hybridize with cultivated soybean varieties.

"That's been very good for us," Collins said, "because in just the first year we've regenerated plants from cell cultures of two of the wild species,

continued on page 8

Acres of Soybeans in a Test Tube continued

and we also have plants regenerated from different cultivated soybean genotypes, too."

Another approach — the second prong of their strategy — was finding the best source of plant tissue to introduce into culture. That piece of tissue, called the explant, can come from any part of the plant — flower, stem, leaf, root or seed — and from either mature or embryonic sources.

The UK researchers found exactly what they predicted, that the most responsive explant sources are embryonic. They decided to concentrate on immature flower buds and embryos.

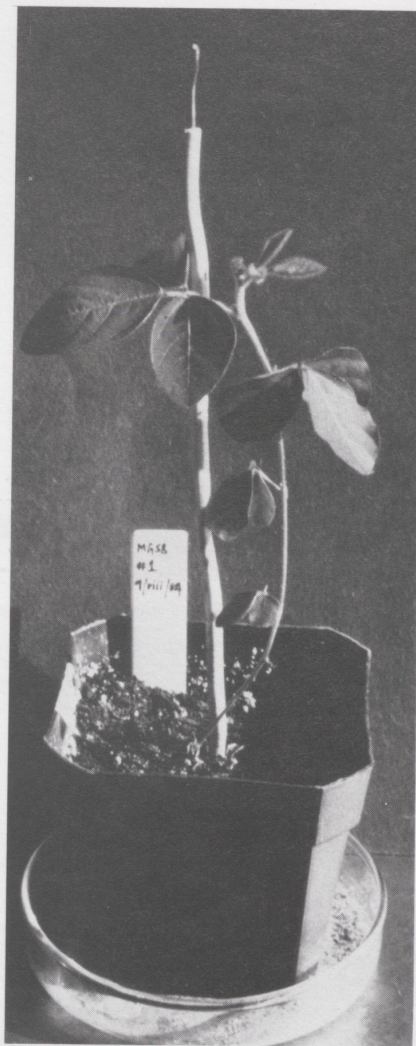
As Collins explains, "The basis for the response, we think, is that embryonic tissues are still at a cell-division, growing, active stage. They are much more easily induced in culture to continue division and to differentiate back into plants."

Taking plants down to the single cell level and back up into new plants is a complex, painstaking process of nurturing. First, the researcher isolates a complex tissue, say a piece of young flower bud, surface sterilizes it, and puts it in culture in a Petri dish. There it is nourished by a medium composed of sugar as the energy source, chemicals, and hormones, and exposed to optimal light and temperature conditions.

The first response is that on the explant's cut surface, cells proliferate in a tumorous mass, called a callus (the cream-colored blob in the Petri dish). After a few weeks on a solid medium in the Petri dish, the callus typically is transferred to a flask of liquid medium and put on a shaker. As the liquid is agitated, gases are exchanged, and the mass of dividing cells is broken into a finely divided suspension culture, resembling chicken broth afloat with little particles.

The cell division is so rapid that it's necessary to pour out half the suspension culture weekly and add more liquid to dilute it, or it would become packed solidly with cells.

When the researchers decide it's time to select cells, they pour the suspension culture back onto a solid medium and apply a selective agent, perhaps an antibiotic that kills all but resistant cells. These hardy survivors



Regenerated plantlet potted in soil.

form colonies, and after a few weeks are placed on a medium especially composed to stimulate plant regeneration.

Once a plant emerges, it lives in the lab until it reaches two to four inches, then moves to a pot in the greenhouse.

The entire nurturing process, from single somatic cell to entire plant, can take as little as two months or as long as two years. It all depends on the manipulations — genetic engineering or mutant selection, for example — performed on the suspension culture.

Collins is matter-of-fact as he explains the complex, miraculous procedure. But this established researcher has sustained an enthusiasm that breaks through in his conversation.

"What really excites me is not

reducing a plant down to a single cell," he said, "but the fact that the single vegetative cell is able to regenerate the whole plant."

"It fascinates me that you can take a single cell from a leaf of a plant, isolate it, make a genetic change in it, then put it under the right conditions and tell it — a somatic single cell, not a fertilized zygote — to regenerate into an entire plant, and it does it."

"And it's generally a normal plant," Collins said, as if not quite believing it. "It is able to flower, produce seeds, and pass the new trait on to its progeny."

The cell-to-plant regeneration process, fascinating in itself, sets the stage for the equally astounding techniques of genetic engineering. Close to unlocking the mystery of the soybean cellular system, the UK team is pushing hard now on the molecular work.

The first goal is to alter the soybean fatty acid composition. It seems soybeans contain much more than enough of a fatty acid called linolenic acid, which results in an off-flavor. Collins and Hildebrand hope to reduce the level of linolenic acid in commercial soybeans from the present six to eight percent to one percent or less. That would solve a problem for the processing industry and remove an obstacle to using soybeans for human consumption.

Hildebrand has identified mutants with very low levels of linolenic acid. His plan is to isolate the gene which triggers low linolenic content and to transfer that gene to the familiar, commercial soybean varieties. To do so, he'll use such molecular techniques as gene cloning and splicing, and a way of inserting new genes into plant cells using the Ti plasmid.

"The Ti plasmid has been called nature's genetic engineer," Hildebrand said. "It's far and above the best system for putting genes into plants because bacteria does most of it for you naturally."

Here's how the system works. The scientist identifies the desired gene in a plant cell, isolates the gene using special chemical separations, and clones the gene to increase its number. Then the researcher puts the copies into transfer vectors or carriers, and that's where the bacteria come in.

The vector commonly used is a bacterium that causes crown gall disease, which is widespread in soil,

and which infects tissues of plants like tobacco, tomatoes, clover and soybeans. The bacterium actually enters the plant and splices in some of its own genetic material, including the new gene put in by the scientist. The cells of the recipient plant incorporate the foreign genetic material into their genetic apparatus, and become transformed.

Collins and Hildebrand are working now on isolating genes involved in lipid biosynthesis. They are also perfecting soybean transformation systems using the Ti plasmid such that soybeans could be transformed with lipid biosynthesis and other genes. Once they develop the way to insert genes into soybeans, the possibilities for future improvements to the plants

therefore make their protein more balanced and valuable for the human diet.

After Collins and Hildebrand succeed in changing traits in soybeans and regenerating the desired plants, their work will not be over. Many evaluations will follow, to see what will be transmitted to the progeny, generation after generation. Then, they will collaborate with the plant breeders to start moving the changed plants toward ultimate use by farmers.

The practical, mission-oriented approach appeals to Hildebrand. "To me," he said, "it is very exciting to be able to do basic research so we can better understand the system, but then to be able to build on that basic foundation and actually come up with something that may be of value to society."

A newly-released book co-edited by Collins and Joseph F. Petolino at United AgriSeeds in Champaign, Illinois, typifies the problem-solving direction the UK genetics team takes. The book, *Applications of Genetic Engineering to Crop Improvement*, is unique in philosophy and organization, according to Collins. Experts in traditional plant breeding, cellular genetics, and molecular genetics each wrote chapters on six major plant problems, such as disease resistance or stress tolerance.

"Its purpose," said Collins, "is to get people in conventional, cellular and molecular areas to begin thinking how their individual research can contribute to solving a problem."

Along with the individual work, scientists in the three fields need to collaborate. While conventional breeding and genetic engineering may differ in methods, the goal is the same — advances in crop improvement that will benefit farmers, industry and consumers.

After all, noted Collins, the basic genetics are the same — the inherited characteristics transmitted through generations.

"Cellular and molecular genetics is a more rapid, selective, and sophisticated process," he said, smiling, "but it's not really any different than what we were doing 25 or even 50 years ago. We are just using genetic engineering as a tool to supplement conventional plant breeding, and help make it more efficient and productive."

"It's actually sort of overwhelming, when you realize you can take a single cell from an organism, manipulate it and change its genetics, and then get a whole new organism. It's a powerful capability."

Professor Glenn Collins

"It's actually sort of overwhelming, when you realize you can take a single cell from an organism, manipulate it and change its genetics, and then get a whole new organism. It's a powerful capability."

The Ti plasmid system isn't fully understood, said Hildebrand. "As is often the case in plant improvement, we know how to use it long before we understand the whole process."

are many. Another tactic they may take, for example, is to change the amino acid composition of soybeans to elevate the methionine level. Although the plants have a high protein content, they are known to be low in that particular amino acid. It turns out that methionine contains sulphur, in which plant protein is generally deficient. Increasing methionine in soybeans would



Shown in the Culture Laboratory, the "nursery" for the soybean genetic research, are Professor Collins and Postdoctoral Student Paul A. Lazzeri from England. Dr. Lazzeri, under a fellowship from Agrigenetics, plays an integral role in the research program.

Earthworms in Jeopardy

The Lowly But Critical Plowers of the Earth

By Erik Kirkhorn

Many children have had the experience—two friends leave the seemingly unbearable confines of their homes, prepared for one of the few things their mystified parents will let them out for after dark. One carries a flashlight, the other is armed with a gardening tool in one hand and a bucket in the other. After finding a suitable spot, they patiently wait for the large, slithering creatures known as “night crawlers” to surface from holes in the ground. Of course, the earthworm’s purpose is not questioned. They are simply there to be gathered.

This is all most of us know about earthworms. They are available for fishing, or as a diversion for kids with nothing better to do at night. Beyond that, we hardly ever see them and there is little reason to initiate further investigation into their survival. We do not think of their immense importance in farming as they till the soil.

“It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures [worms].” Charles R. Darwin

In fact, earthworms and other soil invertebrates are crucial aspects of the environment. In agriculture, the earthworm is critically important to soil fertility. Charles Darwin is still considered to be one of the first authorities on earthworms. In 1881, Darwin wrote that “The plow is one of the most ancient and most valuable of man’s inventions; but long before he existed, the land was in fact regularly plowed and still continues to be plowed by the earthworms.”

Since Darwin’s observations, it has become widely known that the earthworm is a vital component of soil fertility. Besides improving the soil structure, they are involved in aerating and humidifying the soil. Humification is the process in which organic matter is decomposed and converted to chemical forms which aid in plant growth. As earthworms feed, they consume soil which becomes mixed with organic matter. The burrowing action of these invertebrates serves to distribute the organic matter throughout the topsoil layer.

Chemicals (insecticides, herbicides and fungicides) used to ensure maximum agricultural output are now thought to be jeopardizing the survival of these organisms. Many pesticides are considered by some as major contributors to the demise of the earthworm. Research during the past twenty years has ranged from virtual ignorance of non-target soil

organisms to full-scale investigations into the selection of those chemicals that give maximum pest control with minimum effect on earthworms and related species not intended as targets.

H. Wyman Dorough is an interesting and amiable man who has spent the last twenty-five years studying the relationship between pesticides and their effect on particular organisms. Dorough, a UK professor of entomology and toxicology, said his interest in the subject began when

he was working in a lab as an undergraduate at Auburn University.

“In the 1950s, around the time I was in college, there wasn’t a whole lot of concern about the use of pesticides relative to their possible effect on organisms other than pests. There were basically two groups to think about then, humans and pests. However, the pesticide’s effect on pests was often the major concern. If it killed, fine. If not, then make it a little more toxic until it does its job,” he said.

Dorough became interested in why one compound may be so toxic to one species and not another. “I am interested in differences between pesticides,” he said. “I find these differences intriguing and it’s still the thing that keeps me going. I’ve never been concerned with just one organism, I’m interested in the differing responses among species and why they are different. And after twenty-five years, I still don’t know the answers to most of the questions.”

Rachel Carson’s *Silent Spring* marked the first time the public became aware of the potential dangers of widespread chemical use in the United States and elsewhere. The book, published in 1962, created enough concern that some chemicals, which had become pest-killer standards, were eventually banned. “DDT was relatively safe for humans, but when that was banned, new compounds had to take its place. These new compounds were usually more toxic,” Dorough said. He also pointed out that the problem was particularly serious to the small farmer who usually applied his own pesticides and, therefore, was often in contact with these toxicants.

Often, toxic compounds affect “higher” animals in the food chain which consume those below it. This is the case when an earthworm, containing toxic pesticides, is consumed by a bird.

Dorough's current research involving the earthworm *Eisenia foetida* began about two years ago, initially sponsored by the National Pesticide Impact Program of the U.S. Department of Agriculture. He pointed out, though, that most of the money currently comes from the College of Agriculture.

While rats are commonly used to test the dangers of chemicals, until now there hasn't been an established test species in the field of testing soil invertebrates. *E. foetida*, the common manure worm, is "easily cultured, matures rapidly, and is hardy, showing low natural mortality when used as a test organism," according to Dorough.

The chemical exposure to earthworms is amazing. More than 500,000 tons of herbicides, insecticides and fungicides are produced annually for application to United States land. As little as one percent of the material actually reaches the target organism. The remaining material spreads into the ecosystem as pollutants. Chemicals from automotive emissions, industrial accidents, and illegal dump sites also enter the soil.

The use of containers filled with soil containing the test chemical has been the most common method for testing chemical toxicity to earthworms. Dorough's research involved exposing individual earthworms to concentrations of chemicals in paper-

radically different from that spent on air and water quality. Water and air pollution was studied long before soil. "Water and air pollutants have a more direct implication to man," Dorough said. "If you compare soil, water and air, you have to consider it a matter of significance as related to human health. It's difficult to learn soil dynamics. It's easier to monitor a stream or air."

Dorough added that it was time "to include other phases of the environment. Sometimes the resources and the right people don't get together. In the '50s and '60s, there was very little work done in this area. The most significant problems had to be addressed first and that was done.

More than 500,000 tons of herbicides, insecticides and fungicides are produced annually for application to United States land. As little as one percent of the material actually reaches the target organism. The remaining material spreads into the ecosystem as pollutants.

"The earthworm is very important to the ecosystem and is a good representation of the major tillers of the soil. A rich organic soil is one of our best chemists, and for good production, you need an active soil. Leaf litter is turned back into soil by the earthworm," he said.

"Earthworms, of course, cannot compete with a plow. We're concerned with lawns, pastures, forests and other areas which are 'cultivated' largely as a result of earthworm activity," he said.

Dorough added that the primary concern is to find the most effective pesticide which does not harm man, or the earthworm. "Our No. 1 objective is the safety of the user and consumer. All pesticide users need to be educated about the pesticides they are using and their possible harmful effects. We feel that the health of humans comes first, but that the quality of the environment must be considered as well."

lined glass vials for 48 hours in the dark. The approximate lethal concentration was considered as the lowest exposure that killed 50 percent or more of the earthworms.

Dorough stressed that the number of combinations of compounds which must be tested and the relative length of time this type of research has been going on require that the initial test procedure be rapid and relatively inexpensive.

"We've been able to show that some pesticides are more harmful than others and that there are certain chemical classes that appear especially toxic to earthworms. Most phenols, for example, are extremely toxic. We haven't been able to isolate one pesticide which can be used safely across the board. Some very, very good pesticides are often toxic to man and their use is very limited," Dorough said.

The amount of time which has been spent studying soil organisms is

Now we must expand our research to additional problem areas."

He has received inquiries from England, India, France and other countries concerning the findings of his research. "We can provide those people responsible for the applications of pesticides with some pretty good ideas about which ones are minimally hazardous to the earthworm. Unfortunately, these are not always the best chemical for controlling the pest of concern. We still have a long way to go."

Thus, this unseen and segmented organism which provides endless fascination for children and is necessary for certain types of fishing is paving the way for safer chemical compounds. It has been inadvertently damaged in the past, but Dr. Dorough and others in his field are ensuring its dual role continues as chief soil tiller and, as Aristotle wrote, "the intestines of the earth."

Safer Mines

By Erik Kirkhorn

Dr. Konstanty Unrug sat in his comfortable third floor office inside the relatively new mining building. The wall behind him was empty except for two small paintings of outdoor scenes which hung beside each another. It was an unseasonably warm February afternoon and the only light in the office came from the open window.

Unrug, a professor of mining engineering at UK since 1978, spoke of his recent research concerning mine safety in Kentucky, and pointed out why mining is somewhat different in Europe.

"American mines have always had a shallow and flat roof design that allow for moderate ground pressures and therefore are very attractive to miners," he said while drawing quick renditions of mine designs with a magic marker to illustrate his statement. "This type of excavation design is economically cheaper and saves time. Miners here do not have to continually haul away extra rock, as their European counterparts do. They can get to the coal quicker."

Unrug explained that a common European entry has a different shape of excavation. The roofs are horseshoe shaped, which takes more time to cut and is more expensive, but has a higher load carrying capacity.

Unrug and a group of his colleagues have studied the perils of mining in Kentucky for about three years.

But Unrug's interest in mining did not begin until later in his adulthood while living in Poland.

He was born in Luczyce, to farming parents. His father owned a large farm and was an "electrical engineer who spoke four languages fluently." The younger Unrug was interested in nature and spent his childhood growing up in the country.

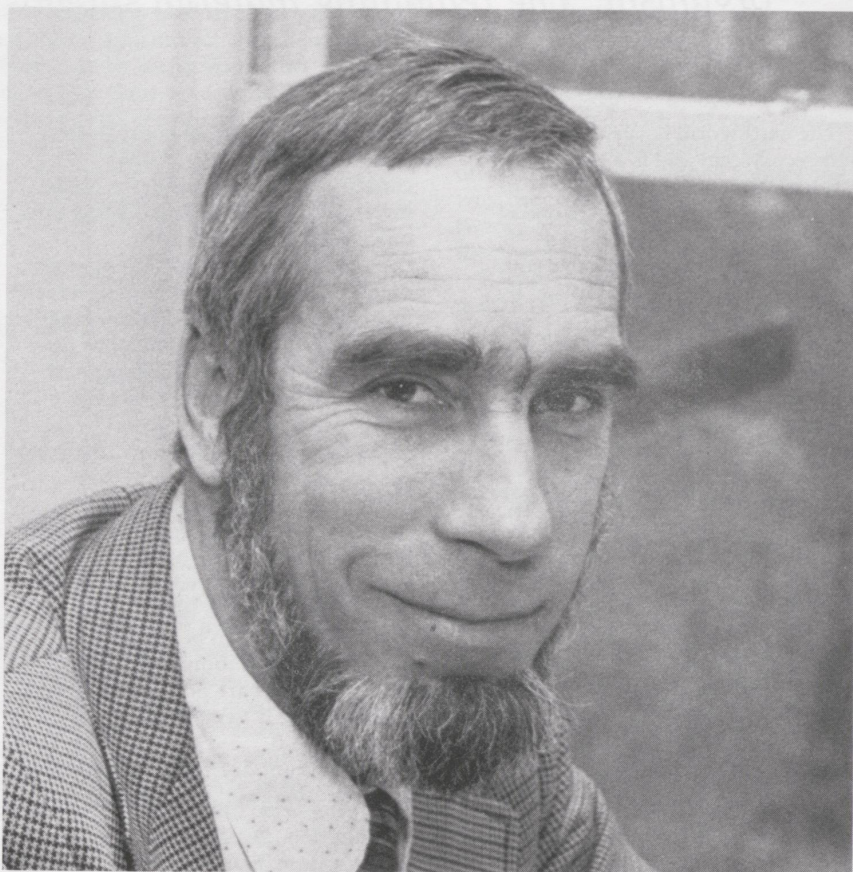
"I became interested in geology initially. When there was a Communist takeover in Poland, my father was labeled a capitalist and we were given 24 hours to pack up everything and leave. That was the way it was for anybody who owned more than the average," he said.

"My family moved to Krakow where I obtained my high school education and later passed an entrance exam to the Academy of Mining and Metallurgy. But since my father was a supposed capitalist, I was told there were no openings in geology." Unrug was finally accepted.

Around 1956, there was a type of thaw in Poland and schools began to be a nicer place to be in. After graduation, Unrug worked two years in the industry and then returned to the academy. There he received a Ph.D. in 1971 in rock mechanics - underground construction and a D.Sc. in 1971 in rock mechanics. He attained the position of associate professor there before leaving in 1977.

In Poland, he was a consultant for large companies and has had substantial experience with large mining projects in coal and copper mines. In Austria, he consulted on projects involving the Third World and Europe. "I've had fairly broad exposure to the tremendous dimensions of mining. I became a miner by accident, but I've learned a lot," he said.

Unrug said the general public does not recognize that mining will always be potentially dangerous. Miners accept the risk of falls as being part of their job; however, they try to minimize that risk as much as possible. He said that a roof could fall in a mine after the initial cut "within a



Dr. Unrug brings his background in European mining techniques to the development of safer mines in the U.S.



matter of minutes or a matter of years.

"Our research is concerned with the continuing factors which can lead to falls. It is impossible for the miners to identify roof failure mechanisms themselves. We will transfer the knowledge we gain from this research to the coal industry. Our final conclusions have so far been practical," he said.

Unrug said a problem has been that of very complex research due to the wide variety of mining conditions in combination with "the local experience of the miners" which has resulted in the need to establish new safety measures.

"The main problems of the industry have had to do with the introduction of technological improvements. The economical part of this is very important and must be considered also," he said.

"Traditionally, the industry has always been run by the old-timers. They have been using experience as the only justification for their practices. Now, the situation has changed and new ideas are being sought at the decision-making level. To spend a little bit on engineering or research pays very much in operational terms," Unrug said.

In Germany and his native Poland, Unrug pointed out that mining is a

highly respected and well-paying profession.

"For some reason in the United States, mining does not have the right rank. I think miners are hurt by the media and there has been a definite lack of knowledge about mining here," he said.

Unrug became quite animated when discussing roof falls and said the public only hears about the falls where people are injured. "Only one percent of the roof falls in coal mines result in fatalities. Ninety-nine percent do not hurt anybody. Nevertheless, roof falls cause about 60 percent of all mine fatalities."

The objectives, as outlined by a

Safer Mines continued

research proposal, are to "establish a data base on ground control restraints including geological and engineering coal seams and surrounding rocks, roof support procedures and ground stress determinations in an active mined area. Analysis of geological and roof quality data to determine the effect of selected parameters on roof stability and to develop procedures for the selection of optimum mining directions, excavation shape, roof support techniques and roof quality assessment to minimize roof fall problems."

Unrug and his co-investigators Tad Cyrul, Ed Thompson and graduate students study these problems in mines all over Kentucky, West Virginia and Indiana.

Roof falls are time dependent, and Unrug said there are two areas which must be identified in mines. There are disturbed zones, which deserve special treatment, and non-disturbed zones, in which a structural design approach can be applied.

Fresh rock is going to be more stable, because air and moisture cause weathering and deterioration of rock material, especially shales.

There are certain precautions workers can take before and during the mining process. There must be additional means of support in disturbed zones and miners must not cut more than necessary. "Big entries may cut more coal, but are more dangerous," Unrug said. "Sometimes, a company may make a wider cut to be able to bring in huge, efficient machines, but this is often dangerous and can lead to serious roof problems. They have to be careful when applying roof bolts to choose the right type to the given conditions."

Roof bolts, which provide roof support, are often a problem associated with falls. "They have to maintain certain tensions, so that the roof will stay supported. It is impossible to recognize visually. In time, some changes in roof structure are taking place and it is important to know the significance of some of these changes."

To overcome the disadvantages of almost non-visible roof defects,

Unrug's group has been installing sophisticated equipment in the mines. Sensitive instruments and cameras are being used to detect fluctuation in the mine's geological and support systems. Unrug has 8 x 10" pictures of fractures in the roof varying from one-fifth of a millimeter to fairly sizable ones which could lead to a fall. Observation of roof strata separation is part of the roof monitoring system of the research program. These seemingly tiny cracks in the shale turn into larger ones rather quickly, Unrug said.

"Mining is not a pure science, we cannot do research for research's sake. In mining, you cannot insulate yourself in a lab and stay there, you have to go into the field and help them (the miners) solve their problems."

Unrug also indicated his research helps students in mining at UK. "It is beneficial both ways, we can learn a lot and disseminate this knowledge to students here."

Thus, this pensive man who has lived through some "rough times" has committed himself currently to the safety of a unique fraternity of miners. Miners who share a mystique not many of us take time to understand.

Research Summer Helps Decide Career

By Moira Skinner

Sometime midway through medical school, most students come to a crossroads of career choices, about what to specialize in, where to practice, or even whether to practice — they could teach or do research instead.

When Chris Maynard, a 27-year-old University of Kentucky med student from Oklahoma, faced that choice, a summer experience in a research lab helped him make that decision.

Maynard is one of the dozen or so students each year who try their hand at research through UK's summer grant program. Available since the school opened in 1960, the program gives first and second year medical students the opportunity to learn what research is about and whether it's the future for them, according to Dr. Roy Jarecky, director of the UK medical

school's student counseling and enrichment programs.

"A summer research grant enables a student to work closely with a faculty member, to learn about the research process, what a hypothesis is, how one collects data, and how one comes to appropriate conclusions," Jarecky said. "It helps a student learn something about critical thinking, which is very worthwhile for a physician working with patients as well as for anyone going into academic medicine."

Students choose from a variety of projects, from "hard bench" clinical and biomedical problems to sociological studies in the community. They spend from six to 10 weeks on their projects, and receive a modest stipend of about \$1,000. The grants are supported by the medical school

itself and by outside agencies such as the National Institutes of Health, the March of Dimes, the National Institute of Aging, the Kentucky Heart Association, and the Central Kentucky Blood Bank.

If frequenting a lab all summer whets the appetite for more, a student can always continue a project, sometimes finding additional support. That's what Chris Maynard did.

Now in his third year, Maynard spent the summer of 1983 studying glucose transport mechanisms in cancer cells under the supervision of pharmacology professor Don Diedrich. The ultimate goal was to develop a lead into how diabetes occurs, by pinpointing how insulin sensitivity is lost in developing red blood cells.

Insulin, Maynard explained, speeds

up the transfer of sugar from the outside to the inside of cells. So when the pancreas releases insulin, the cell's sugar transport system works faster and blood sugar is transferred into the cells and stored to be used later.

Without insulin, a person's body is less able to store blood sugar inside the cells in the form of glycogen or converted to fat. So the blood sugar stays high and will be spilled out in the urine; that's the hyperglycemia and glucose uria of diabetes.

But mature red blood cells have a slightly different sugar transport system which doesn't react to insulin. Those same red blood cells, however, are insulin-sensitive when they originate in the bone marrow as stem cells. Somewhere along the line to maturity, adult red blood cells lose their sensitivity to insulin.

Maynard tried to find where in their development red blood cells lose their original sensitivity to insulin; that information might give a clue to the loss of insulin sensitivity in diabetes patients.

Why use cancer cells? The cells he studied, from a leukemia patient, are red blood cells in the making, but locked in an immature stage of development. The researchers needed to know whether these cells still had the ability to react to insulin.

The experiment involved painstaking work, said Maynard. "I had to set up the kinetic assay for measuring glucose entry into the cancer cell and also measuring exit from the cell."

Although the results were inconclusive, Maynard said his work turned up some interesting facts for further study. And it confirmed his love of research.

"I'd done research before in industry and as an undergrad," he said. "But the summer project really stimulated my interest."

Maynard carried on his project the next year when he was awarded the Dean's Research Fellowship. That meant postponing med school for a year, but to him it was well worth it. First, he made progress toward the combined M.D.-Ph.D. degree he wants. When he presented his work in January at the annual student research competition, he was chosen top student and awarded a trip to a national meeting in Galveston, Texas.

And his extended project, which took a different direction from the

summer work, resulted in a patent application currently in the works.

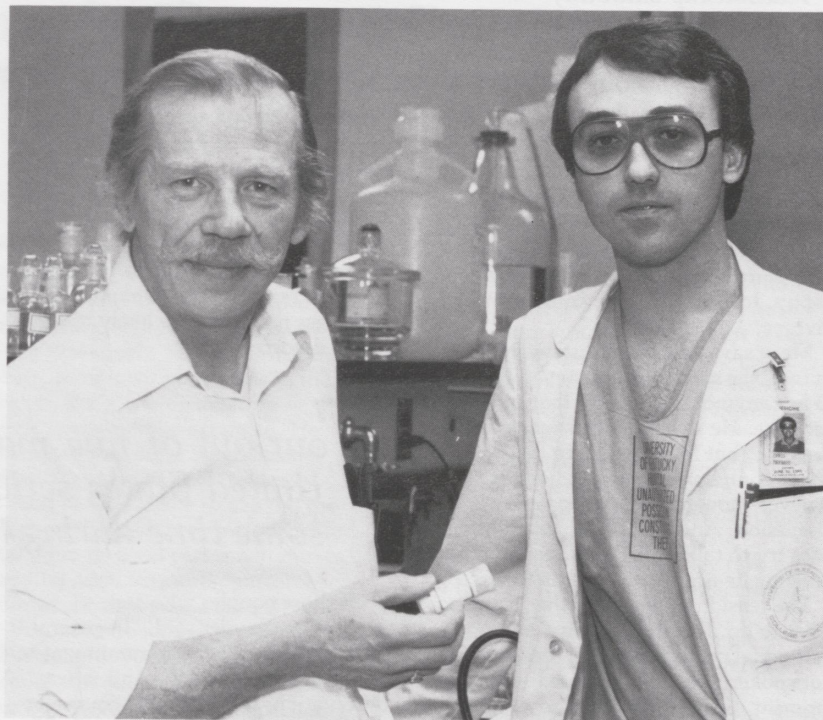
Research, Maynard concludes, is "a lot of hard work and frustration but with a lot of rewards, too."

"When you are finally able to accomplish something and your results will possibly help patients in the future, it's really exciting and most enjoyable. That year made me feel that I'm at least going to have to give academic medicine a try."

Diedrich, who advised Maynard.

Diedrich has had eight students working for him on summer projects and all, he said, have done something significant that contributed to his ongoing research.

"I've been very high on the whole program," Diedrich said. "There are enormously important benefits a medical student can experience in a research environment over a summer rather than just digging into his books."



Medical Student Chris Maynard and Pharmacology Professor Don Diedrich have continued their research collaborations since Maynard's summer in Diedrich's research lab.

If Maynard indeed enters teaching and research, he'll be in a small, select group of UK grads. About seven percent of the University's medical graduates since 1964 have pursued careers in academic medicine. Since research for students is not the primary emphasis here, that seven percent speaks well for the medical school and the research opportunities it provides, said Jarecky.

An enthusiastic supporter of the summer research program is Dr.

If nothing else, curious students can find out from a stint in the lab that pursuing science is not for them.

As confirmed researcher Chris Maynard noted, students who experience summer research "get an idea of what's taking place in the literature, how slowly research progresses, what goes on in the lab and what goes into writing a paper."

"It puts things in perspective for the med students who don't pursue an academic medicine career."

How Can This Marriage Be Saved?

By Tawny R. Acker

"Seldom or perhaps never, does a marriage develop into an individual relationship smoothly and without crises; there is no coming to consensus without pain"—
Contributions to Analytical Psychology

Sam and Mary have been married for three years. They have a nice home, challenging careers, and money for leisure activities. They should be happy. Instead, they are considering divorce.

Mary says Sam never listens to her. In fact, she says he doesn't even talk to her anymore. Sam says that isn't accurate. He says he listens when he has time, but Mary wants to talk about complicated things when there is never enough time for a proper discussion. And, Sam says, when he does try to talk to her, she keeps insisting he isn't really talking to her.

The tension mounts. Neither is sure what to do. Divorce is at first an individual consideration, a thought not spoken. Then, in a heated moment, the word erupts and divorce becomes a potential reality, rather than a fantasy solution.

Neither really wants to consider divorce as the only solution—not yet, anyway. They decide to seek marital counseling.

This hypothetical couple is representative of the four out of five married couples in the United States who seriously consider divorce at some time during their marriage according to recent statistics, said Dr. Douglas K. Snyder, University of Kentucky psychology professor.

"These couples have undergone a protracted period of distress, which makes them consider divorce or another alternative—marriage counseling."

There are no comparable statistics which show how many of those

couples seriously considering divorce choose the alternative of counseling, but Snyder said he doesn't think it's the majority.

"In society today we are finding that fewer and fewer persons are willing to tolerate an unhappy marriage. The diminishing social stigma attached to divorce, more financial resources for women, and the possibilities of sexual fulfillment without fear of conception are all partly responsible for the increased divorce rate." Snyder quickly pointed out that he does not think that these things are responsible for the increased rate of unhappy marriages, but rather are some reasons why unhappy marriages may be more likely today to end in divorce.

Four out of five married couples in the United States seriously consider divorce at some time during their marriage.

Of those couples who seek counseling, Snyder said, "In general, they have made some commitment to saving the relationship. And, after observation, it is up to the counselor to decide upon the best way to help the couple with their problems."

Snyder's research, in conjunction with Dr. Robert Wills of Wayne State University, Detroit, Michigan, is attempting to determine what approach works best with a particular type of couple. Their study focuses on two main approaches used by counselors in marital therapy: behavioral marital therapy and insight-oriented marital therapy.

Behavioral therapy focuses primarily on the couple's communication problems. This approach assumes that a couple has failed to learn good communication skills or they have actively learned bad ones. An example of actively learning bad ones is if the husband learns that by using the "silent

treatment" he can always get his own way. The therapist then teaches the couple good communication skills such as active listening and non-coercive problem resolution skills.

Insight-oriented therapy emphasizes the individual's emotional concerns which may be creating problems in the relationship. A wife may consciously know she cannot expect her husband to fulfill all of her needs, but subconsciously continues to expect that he should. Another example is a husband who has certain sexual needs, but is afraid to express them for fear of rejection. Rather than addressing communication skills, this approach attempts to examine and sort out the personal dynamics which are interfering with the relationship.

The counselor or therapist, using a variety of diagnostic tools, such as videotaped interactions, attitudinal scales, self-reporting, and live observation, must determine which is the best approach. Current literature appears to support the behavioral approach, but no guidelines exist which compare the two approaches and offer information concerning which approach works best with what type of couple.

"It would be helpful for the couples and the therapist if the best treatment procedure could be determined at the onset of the sessions, not simply by professional judgement, but from a combination of scientific data and professional judgement," Snyder said. "Our research will look at 90 couples seeking marital therapy and follow them throughout the sessions and with a six-month follow-up period. During

continued on page 17

this time, each couple will be given a formal assessment as well as the continual reassessment that takes place during therapy. By examining several classes of variables, including the couples' demographics, family histories, personalities and areas of conflict, and then looking at the type of therapy used, we will be able to make a determination."

In many instances, both types of therapy may be appropriate. However, Snyder said, "It is reasonable to me that there are couples who do not have conflicts deriving from unconscious needs, but who just can't communicate with each other effectively. And it is also sensible to me that communication skills are not necessarily the only

problem, but that individual dynamics may be interfering."

Snyder speculates that an overall positive outcome will be found for behavioral therapy. "Whatever the data indicate will be helpful. We (therapists) need to be aware of some of the predictors which influence the way a couple responds to a particular marital therapy approach."

A Talking History of Medicine in Fayette County

By Maria Braden

Dramatic changes in medical care in this century signal what amounts to a cultural and technological revolution: The basic relationship of patient and doctor has been altered and medical treatment has moved into the nuclear age.

Where does one go to trace the changes that have occurred in Fayette County? Not the library.

"Even the (University of Kentucky Albert B. Chandler) Medical Center doesn't have documents. Physicians have not kept diaries or written letters to each other about what it was like in 1926 being a (medical) practitioner," said Terry Birdwhistell, oral history coordinator for the University's King Library.

So, at the prompting of Dr. Peter Bosomworth, chancellor of the Medical Center, the Library and the Fayette County Medical Society agreed to develop and record an oral history of medicine in Lexington and Fayette County during the twentieth century. The Kentucky Oral History Commission awarded the library a grant to carry out the project.

"You've got tremendous changes, but nowhere to look at them," said Birdwhistell. "This lets the physicians tell in an interview situation what it was like . . . Oral history goes back as far as their memories go."

Some 57 interviews have been conducted under the direction of Dr. Tom F. Wayne Sr., former assistant vice president of the Medical Center and associate dean of the UK College of Medicine. Wayne has been guiding the project since 1981, and has

conducted about 20 of the interviews.

The purpose is to develop a history that may be useful in scholarly research, and which could form the basis of a written history of medicine in Fayette County, Wayne said.

He first sought to interview the older, prominent physicians in the region. But a few died before interviews could be arranged. He estimated that 30 to 50 additional physicians should be interviewed.

And he would like to expand the scope of the project to include 50 to 100 other medical personnel: nurses, hospital administrators, pastoral counselors, and physician's wives.

Bosomworth said that when the University of Kentucky Medical School was started 25 years ago, the number of board-certified specialists was very small in the eastern part of the state, and very high in Lexington. "I doubt that there were more than

three or four pediatricians in all of Eastern Kentucky," he said.

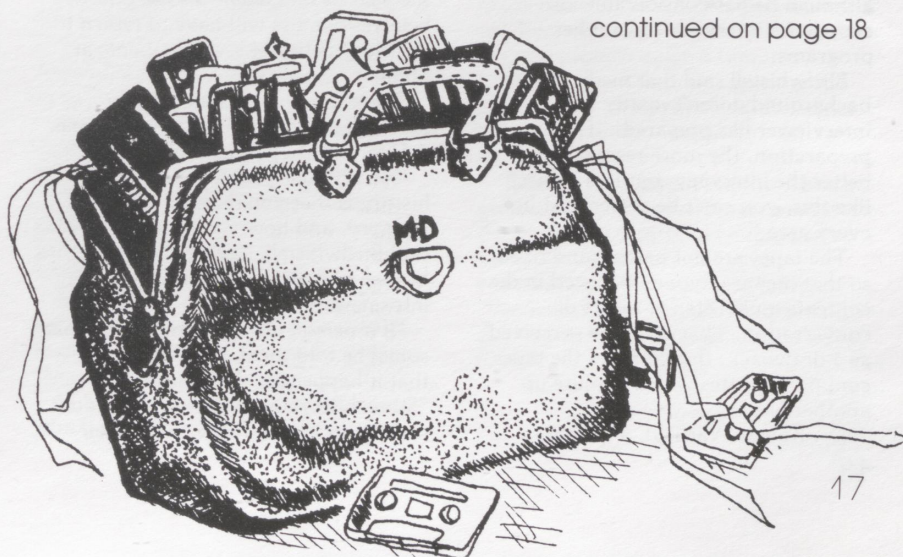
Today, Lexington is a "very highly specialized community." And because of the medical college, there are now many more specialists out in the state.

The interviews have tried to get at what the practice of medicine was like before the age of specialized medicine, Wayne said.

"We wanted to find out about the types of patients — how Lexington began to be the regional referral center for the eastern part of the state," Wayne said. "How did they take care of them? What was the significance of the referral? What was the relationship with those out in the field? It seemed important to get this together."

Each interview lasts one to two hours, usually beginning with a brief biographical sketch. Major topics

continued on page 18



A Talking History of Medicine in Fayette County continued

covered are general and specialty medical care; development of the hospital health care delivery system; the impact of government on the practice of medicine in the county, and development of allied health professional fields such as nursing, pharmacy, physical therapy, clinical psychology and social work.

Other topics covered include development of medical education; the impact of politics on medicine; development of the public health system, and the role of spouses.

Some interviews are more structured than others. Some are like being invited into someone's living room for a chat. With some physicians, "everything flows," Wayne said. "Other people answer in short answers. It's like pulling and prodding. You soon learn not to ask yes and no questions."

Wayne had no formal training in interviewing but didn't consider himself at a disadvantage. After all, he said, physicians use interviewing skills daily in dealing with patients. "Every physician, including me, has taken literally hundreds of patient interviews."

His technique for a successful interview is simple: "I have tried to make every interview a conversation between two friends — enjoyable."

Dr. Carl Fortune, retired from the Lexington Clinic, and Richard Smoot, a graduate assistant in history, have also conducted interviews. Smoot, whom Birdwhistell credits with doing a great number of the interviews, does not have a medical background although he has considerable experience interviewing in other programs.

Birdwhistell said that medical background doesn't matter if the interviewer has prepared. "The more preparation, the more research, the better the interview, but in a project like this, you can't be a specialist in every area."

The tapes are not being transcribed, so that means anyone interested in the contents must listen to hours of conversation. That could be perceived as a drawback. But many of the tapes contain vignettes which conjure up another age.

Dr. Robert Warfield, a retired

pediatrician, remembers what it was like to practice medicine in Lexington shortly after World War II. After leaving military service, doctors had to complete their residencies before they could enter practice. And of course there was a baby boom. So for pediatricians like Warfield, with a solo practice, it was a busy time.

"I would work all day, come home for dinner, and make house calls in the evening."

Warfield said he felt compelled to give up his practice at age 65 because he couldn't keep up with all the reading. "There's been more progress . . . in the period when I was practicing medicine than there ever was in a like period in history," he said.

Dr. George Greene, an obstetrician-gynecologist and medical historian who still serves as voluntary professor of medicine at UK, said the chief change he has noticed over the last 20 years is increased emphasis on lab work. And he doesn't think it's so good when it replaces a physician's personal observation of the patient.

Greene said reliance on laboratory tests as the primary diagnostic tool reflects the training medical students are getting, adding, "this is something that shouldn't be going on." Greene said lab tests should only be an adjunct to a physician's personal assessment of a patient.

He also sees the increased emphasis on money as another perturbing change in the practice of medicine, and predicted that the pendulum would soon swing back, as patients make fewer visits to doctors because of high fees.

Citing statistics indicating that there will be an oversupply of doctors by the year 1990, Greene also said he believes doctors will have to return to the old practice of seeing patients at home.

Those are opinions and highly personal recollections of another time.

How can they be called history?

"An obvious problem in oral history is that you're dealing with memory, and how valid is memory?" said Birdwhistell. "You collect oral history and weigh it against other information."

"If a person tells you something that someone told them, that's evidence that it happened," he continued. "Some historians who would discount oral history would love to get their

hands on a Civil War diary, which also might shade the truth."

Birdwhistell noted that in some cases, little or no documentation is available to historians. That's the case with medical care in Fayette County or the history of blacks in Lexington — another project undertaken by the Library's Oral History Program, he said. "You can't read the *Lexington Herald* and find out about the civil rights movement."

"My job as an oral historian is to gather information, let (others) look at it. It's not better than other sources. It's just another source," he said. "The recollections of those who were students in the 1930s is not better than reading the *Kentucky Kernel*. You have to do both. It adds a different dimension, a little something extra."

The oral history of medicine in Fayette County is just one of several projects underway at the University. Oral histories are being compiled on other important political figures such as former U.S. Sen. John Sherman Cooper. Another project in its early stages is an oral history of Vietnam veterans in Kentucky. Birdwhistell said some of the interviews are being videotaped for use in a special one-hour television program.

"These projects continue for several years," he said. "There's always going to be another person you'll find. We always announce a beginning — but you never know when you'll find someone else (to interview)."

A good example of that is the Alumni-Faculty project, which burgeoned into interviews with more than 200 people all over the country. Birdwhistell calls that project "as interesting as any I've ever done" because of the diverse personalities and recollections of those interviewed.

Birdwhistell traces the origins of oral history in Kentucky to the efforts of Alice Lloyd College students, who interviewed people in the mountains of Eastern Kentucky in the late 1960s. "Because of the efforts of these people, we can do projects we couldn't do otherwise," he said.

Although Kentucky is a leader in the oral history field, with the only state-mandated Oral History Commission in the nation, Birdwhistell said there's still a lot to do.

"It's frustrating when you see the number of projects to do and the limited time and finances."

Detecting Cancers Sooner

By Maria Braden

He is a magnet for graduate students in medicinal chemistry. His enthusiasm and energy are contagious. And George Digenis is that rare breed in the sciences, a man whose research spans many areas.

So diverse are his interests that one of his most promising projects — a procedure that has the potential for

mice were treated with an inhibitor that blocks the synthesis of putrescine, one of the polyamines. Then the animals were injected with radioactively-tagged putrescine molecules.

The tumors absorbed the radioactive molecules at a much greater rate than 13 other major

cancer cells would be labeled with a gamma-emitting radionuclide. The radioactive molecules would then be traced or scanned by a special gamma camera.

UK's College of Pharmacy is the only one in the nation using its own gamma camera for animal studies, a \$180,000 piece of equipment fondly known by UK researchers as "Fat Albert." Digenis said it puts the College "at the cutting edge" of research.

The camera, its head about the size of a microwave oven, is hooked up to a computer and television monitor. It provides continual and cumulative pictures of radioactive emissions on magnetic tape. Pictures taped to the wall show the movement of a radioactively-marked tranquilizer through the body of a baboon. The target area is the brain, but the camera shows that the drug goes first to the lungs, and takes two hours to diffuse into the brain.

"Not only do we know about the distribution of the drug, but also we know about how the drug is distributed as a function of time," Digenis said. "The value of this machine is that you have the entire study on a continual magnetic tape. Then the whole thing is played on a color television. You can play all the events from the first second back, and select regions of interest."

The camera will also be able to show researchers whether polyamines can be used as scouts in a search and destroy mission against tumors.

That's where the next aspect of the research fits in: synthesis of molecules designed not only to find but also to destroy cancer cells.

Tumors have been shown to have a greater need for polyamines, so the theory is that they could be tricked into sucking up polyamine-like molecules which would poison them. "We hope that it would cause more damage to the tumor than to the other tissues," Digenis said.

continued on page 20

The key to Digenis' research is a molecule known as a polyamine, which occurs naturally in the body. Polyamines are found in relatively large amounts in young tissues or in other rapidly growing tissues, such as tumors.

use in early cancer detection — is, he said, "a totally new area for me."

The procedure has been used in mice to detect cancer cells at a very early stage. "We don't expect we are too far away from doing this in humans," Digenis said in an interview at his small office in Research Building #1.

He and his team have been working on the project for two years, and last spring the National Cancer Institute awarded him a \$178,000 grant. The research grew out of his work in another area, tumor uptake of amino acids, financed by a National Institutes of Health grant.

The key to Digenis' research is a molecule known as a polyamine, which occurs naturally in the body. Polyamines are found in relatively large amounts in young tissues or in other rapidly growing tissues, such as tumors.

Digenis has theorized that if animals with tumors are deprived of their supply of polyamines, cancer cells would be most affected. Like a dry sponge, the tumor would suck up new polyamines at a rate greater than normal cells.

The theory worked. Tumor-bearing

normal organs. And radioactive uptake by tumors in pretreated mice was four times greater than by tumors in the control animals. That seemed to confirm Digenis' theory, at least in mice.

"We hope that this will be repeated in humans," Digenis said. "This would be a new form of diagnosis, because in general, you administer a diagnostic drug and trace it in the body."

"Here you prepare a patient by giving enzyme inhibitors which alter the biochemistry of the tumor, which will now accept the diagnostic agent more avidly," he said. "We hope that it will result in more refined diagnostic procedures to help diagnose the cancer as early as possible."

Could the procedure be used to detect a tumor even if it were composed of only a few cancer cells? "That's what we're hoping," Digenis said. "It's been shown on mice very early and very nicely, but not in humans."

It might be "two years, roughly," before the procedure could be used on humans, Digenis said, quickly adding, "Maybe this is optimistic."

In humans, the putrescine molecules which Digenis hopes will hone in on

Detecting Cancers Sooner continued

He likened the poisonous molecule to a bird that could fly up to the tumor without causing alarm. The chemical functions that would destroy the cancerous tissue would be hidden in the bird's legs.

The only problem Digenis sees in synthesizing gamma-emitting radionuclides is that UK lacks a cyclotron to produce them. He said he is using NIH grants to buy cyclotron time from other institutions.

This stage of the project is just beginning, and Digenis said the procedure must be tested on larger experimental animals before it can be used on humans.

"His ideas are intriguing . . . The potential is there. What he's doing is conceptually exciting," commented Dr. Jack Olson, an assistant professor in the College of Pharmacy who is also studying the role of polyamines.

"It does look like it will have a potential application," said Dr. James Chaney, one of Digenis' postdoctoral fellows, who helped develop the project.

Chaney, who left the College of Pharmacy earlier this year to take a job as staff scientist with Nova Pharmaceutical Corp. in Baltimore, Maryland, said it was hard to leave because the project was interesting. And he praised his mentor.

"He's very motivated to go after things," Chaney said. "He is well-known as an outstanding scientist . . . he gets into a lot of different things. His diversity is a rare attribute. He has a way of bridging what is sometimes a gap between research and application."

Dr. Peter Crooks, a colleague of Digenis' in the Division of Medical Chemistry since 1981, said he is unusual because he is interested, and

Digenis as dynamic, and said he was both a great researcher and teacher.

"In his research he is very imaginative," Swintosky said. "He has great confidence and skill. And he excels as a teacher. He knows his subject so well, presents it with so much professionalism."

The dean said Digenis is able to attract outstanding graduate students. He has served as major professor for 27 students working for their Ph.D.

Tumors have been shown to have a greater need for polyamines, so the theory is that they could be tricked into sucking up polyamine-like molecules which would poison them.

excells, in so many different areas. "He's a very curious scientist . . . Anything that interests him he sets out to find a solution to."

Born in Athens, Greece, Digenis was educated at the University of Beirut, where he later spent three years on the faculty. He joined the College of Pharmacy in 1967, after receiving his Ph.D. in organic pharmaceutical chemistry from the University of Wisconsin.

Joseph Swintosky, dean of the College of Pharmacy, described

and for 16 postdoctoral fellows from the United States and abroad.

At times, Digenis has had as many as 11 graduate students, and still teaches a course each semester. Pictures of those students cover the walls of his office.

Digenis said he puts teaching and research first, and sees no conflict between them. "A good researcher is a good teacher," he said. "The best teachers I had were the best researchers."

Black Poetry to the Neighborhoods

By Becky McVeigh

"O Black and Unknown Bards of Long Ago,
How Came Your Lips to Touch the Sacred Fire"

—James Weldon Johnson, *Black and Unknown Bards*

John Townsend used to think there was no interest in black poetry.

That was more than a year ago — before "Poetry to the People" was presented in Lexington.

"I thought nobody would come," he confided recently.

But now Townsend knows there is an audience for black poetry.

And he knows that, as the poem by James Weldon Johnson sums up so well, black poetry has a contribution to make. It speaks truth, or "the sacred fire," to the people. It helps people, black and white, understand the black experience, an experience that has influenced every person's life.

"For a long time, black poetry was considered a bastard child of American literature. It was regarded as not intellectual, or not as poetry at all," said Townsend, assistant to Lexington mayor Scotty Baesler.

"I used to think: Can black poetry be as intellectual as Whitman? Can they (black poets) contribute to society?

"People may ask, Why should we study (black) poetry? It helps not only blacks, but also whites, understand the black experience.

"And there is an audience, I learned that."

Hundreds of people came out to experience "Poetry to the People," and heard such well-known American poets as Pulitzer-Prize-winner Gwendolyn Brooks, Haki Madhubuti, Nikki Giovanni, Al Young, Melvin Dixon, and Lucille Clifton. Each of the six poets visited one of Lexington's six neighborhood centers, the entire program lasting from January to June 1984.

The concept of the program developed out of conversations between two friends — Townsend and Dr. Robert Hemenway, chairman of the Department of English at the University of Kentucky and a widely-



Haki Madhubuti

recognized scholar of Afro-American literature.

Townsend said there were repeated demands for more cultural programming from people in Lexington. While the University of Kentucky has a number of scholars doing research in the humanities, there was no systematic attempt to bring that knowledge to the people of Lexington.

"The problem is that often the University hasn't delivered its expertise to the community," Hemenway said. "Academicians tend to go to the library and teach classes. There aren't any opportunities to share their knowledge in the community."

Townsend also thought that people would be reluctant to go to a poetry

program at the University because "people feel threatened by poetry. They think of it as some esoteric thing or as too intellectual. But it's not. It's a part of everyday life."

Hemenway and Townsend decided that the solution was to develop a "town-gown" project, where university professors shared their knowledge with people at their level and on their own turf by using already existing community centers.

"We wanted to take it (poetry) out to the community where people actually live," Townsend said.

The response was terrific.

"We had huge crowds," Hemenway said. About 400 people went to hear Nikki Giovanni, and about 300 heard Gwendolyn Brooks. "We had 85 people on a night when there was not only a UK basketball game, but the roads were a sheet of ice," Hemenway said.

The response was from people of "all ages, all varieties, rich and poor, black and white," Hemenway said. "It was a community kind of thing."

At each community center, three sessions were planned. The first evening, people were exposed to a talk on the history of black poetry, led by Ann Grundy. Charles Rowell and Edgar Tidwell, UK English professors and specialists in Afro-American literature, led the second session and discussed the themes and language of black poetry. During the last session at each center, one of the six poets read from his or her works, discussed the poems, and talked about how one becomes a poet.

"We kept it flexible," Hemenway said. "We had a few instances where people read their own poetry. One woman got up to sing a spiritual."

continued on page 22

Black Poetry to the Neighborhoods continued

Townsend said that the program provided an important service to blacks who are rarely exposed to black literature. "Many Kentuckians, because of the educational system and because of the textbooks used, are not

that you can find in a large city, people are drifting. They don't have anchors to get them in touch with their roots."

One of the written evaluations of the program addressed exactly this problem. The anonymous writer wrote: "It is really good to touch base with your roots which is difficult to do in this part of the country."

"In a place like Lexington where there is no black radio station, where there aren't the services generated by black agencies that you can find in a large city, people are drifting. They don't have anchors to get them in touch with their roots."

John Townsend

exposed to black literature. In a place like Lexington where there is no black radio station, where there aren't the services generated by black agencies

Another response was simply: "More! More! More!"

Hemenway said that 95 percent of the responses to the program were

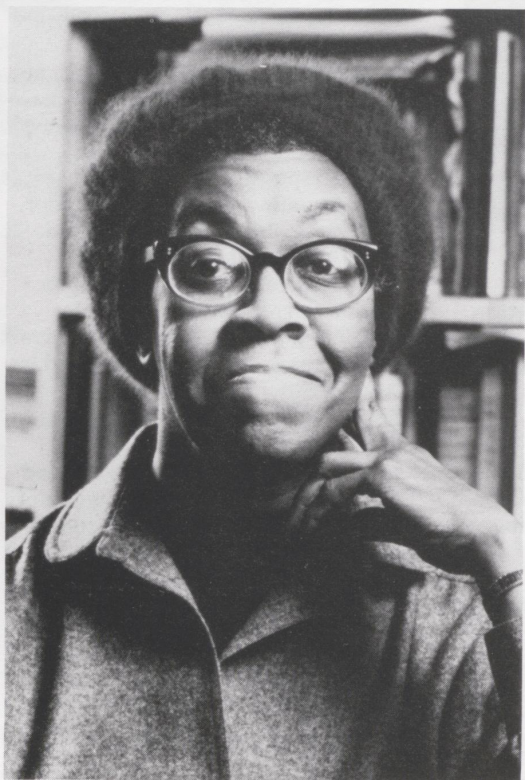
positive, and he received no negative feedback.

The poetry readings had quite an effect on one boy, Alex Hicks, who attended all of the sessions. Townsend said Alex asked a lot of questions during the sessions, and Hemenway said he heard that Alex is now writing poetry.

"My theory is that if you can change one person's life so they can appreciate art and literature, then you have altered Lexington," Townsend said.

"When people look back on this experience I think they will have fond memories. I think they'll know a little more about history, they'll know a little more about the black experience, they'll know a little more about poetry, and I think they'll know a little more about themselves."

"Poetry to the People" was funded in part by a grant from the National Endowment for the Humanities.



Gwendolyn Brooks



Nikki Giovanni

A Pathway to Understanding Cell Growth and Cancer

By Tawny R. Acker

The same cell-growth enzymes which allow an egg from a human ovary to develop into a fully functioning human being are also the enzymes involved in the uncontrolled cell growth known as cancer.

Chemotherapy, chemical agents incorporated in anti-cancer drugs, is directed at killing or stopping malignant or uncontrolled cell growth. It is currently used alone and in conjunction with other treatments, in treating approximately 30 percent of the cancers in the United States.

The main problem with existing chemotherapy is that the drugs usually have only a limited effect on the cancerous cells, while often causing toxic side effects on the body's normal cells and tissue.

The resulting side effects are partially caused by the lack of knowledge about the growth process of the cell—what chemical or enzyme in the cell produces the uncontrolled growth—and what chemical could stop or reverse that abnormal growth, without altering normal cell growth.

Researchers now know enough to inject drugs that will have a limited effect on the cancer, but not enough to do that without potentially harming other cells. If they can continue to unlock the mysteries of cell growth, presumably they could halt or reverse the process and cure or control cancer, preferably without any intolerable side effects.

Dr. Jeffrey Davidson, University of Kentucky professor of microbiology and immunology, is attempting to do just that in his study of how cells produce certain chemicals or enzymes required for cell growth. His research focuses on six enzymes which compose the pyrimidine biosynthesis pathway. This pathway is present in the cells of things as simple as microorganisms and as complex as humans and makes substances essential for cells to grow.

Other researchers discovered that the pathway involves six enzymes in

all living things, including humans. Davidson played a central role in demonstrating that the first three enzymes are linked together as part of a single structure in higher organisms. For example, the first three enzymes are linked in humans and hamsters; whereas, in self-growing bacteria the first three are separate.

"I'm trying to understand why the enzymes are linked together in certain cases and how they are similar and different from those in bacteria," Davidson said. "If I can understand how they are regulated and how to control them, eventually we might be able to control cancer."

Brain and liver cells do not grow a great deal after a certain point. However, in liver cancer, the liver cells grow profusely. Davidson says that if scientists could learn the information necessary to make such cells stop growing, it should presumably reverse or halt the growth of the cancers.

For example, only certain cells in a normally functioning body are in active cell division — including blood, sperm, and intestinal cells and in certain cases, skin cells. Brain and liver cells do not grow a great deal by the time one is an adult. However, in liver cancer, the liver cells grow profusely. Davidson explains that if scientists could learn the information necessary to make such cells stop growing, it should be possible to reverse or halt the growth of the cancers.

But Davidson cautions that it is not as simple as it sounds. If researchers continue to develop chemotherapeutic methods to stop cell growth, they will be able to stop the spread of cancer within a person's body. However,

injecting poisons that completely block all of the enzymes involved in cell growth could have lethal side effects.

"More specifically," Davidson says, "researchers need to learn how to allow enzymes to work in normal cells, but to block their activity or production in abnormal or cancer cells."

Davidson's research uses normal and abnormal cells from the ovaries of hamsters and from human skin fibroblasts—cells acquired by scraping a healing cut. He uses these cells because they multiply quickly and geometrically when grown on plastic

dishes in the laboratory. He also uses white blood cells which are transformed virally so that they will grow rapidly outside of the body.

The similarities between human and hamster cellular structures which Davidson found in his work have led him to consider its ramifications in terms of the theory of evolution. The theory of evolution follows along the lines that all life forms evolved from a single cell microorganism. Hence, all life forms should share some cellular similarities. In one experiment, Davidson took normal genetic information encoding an enzyme of

continued on page 24

A Pathway to Understanding Cell Growth and Cancer continued

the pyrimidine pathway of a hamster and implanted it into a bacterium cell defective in this enzyme. The bacterium accepted the genetic information and used it to make the hamster enzyme which then corrected the bacterial defect. "This particular enzyme is highly conserved between

bacteria and hamsters. The conserved nature of this enzyme is a direct result of the fact that it is essential to cell growth," Davidson said. "And this finding is consistent with the theory of evolution because these enzymes are similar from micro-organisms to higher organisms. This pathway must be one of the oldest biosynthetic pathways."

Davidson is optimistic that studying this pathway will help provide

valuable information needed to better understand cell growth. "As a result of the research being done in this area, scientists are looking at enzyme inhibitors, as one form of chemotherapeutic drugs to treat cancer," he says. "They may provide a more effective and potentially less harmful, way to control specific cell growth than currently available drugs."

Bach to Basics with Computers

By Tawny Acker

The computers are alive with the sound of music — in the listening library of the University of Kentucky School of Music, that is.

Four microcomputers, capable of producing four-voice harmonies, and simple chords, are an integral part of an innovative method for teaching freshman and sophomore music theory.

Richard Domek, associate professor of music and dean of the College of Fine Arts, and Charles Lord, coordinator of UK's Music Theory Division, conceived a technologically-assisted modular teaching program funded by a grant from the U.S. Department of Education. Assisting in the design and implementation were music professors Kate Covington and Peter Simpson.

"What we did, basically, was to take the material covered in beginning and intermediate music theory courses and divide it into four tracks, each with twelve modules of information," Domek said. "The computers were then programmed with corresponding, complementary courseware."

The results of the shift in instructional style is already evident—in the rise in student grades. "Our overall grades in the modular theory courses have a much higher proportion of As and Bs now," Domek explained. "We feel this is not grade inflation, because the material and the instructors are the same as they have always been—the material is just organized differently."

The object of the modular teaching

format is student mastery of the material without the rigid time limitations employed by traditional teaching methods. The modular program allows students to work at their own pace in completing each module before advancing to the next—the students can decide when they are ready to be tested on the material in each module. In order to successfully complete the courses, they must eventually pass all of the modules.

Simpson, who teaches the modular music theory courses, is "very pleased" with the method. "I think it's very beneficial for the instructors and the students," he said. "These courses require the learning of conceptual, aural, notational and physical skills in a steady progression. If students get behind in one area, it's very hard for them to catch up. Using the modular system has helped define specific goals for both the students and me. It also provides a good structure for monitoring student progress."

"Our students come from very diverse backgrounds," Dr. Domek said. "Some may have had several courses in music theory; others, none. The use of computers as teaching aids allows the students as much practice time as they need. They (the computers) provide a one-to-one teaching tool and they have infinite patience."

Domek hastened to add, "Computers are a fine tool, but they are no panacea. And, you have to be careful that students think of them not

only in terms of doing particular assignments, but also in terms of a learning resource that they can continue to use indefinitely."

Using computers to teach music theory is not a new idea. According to Domek, they have been in use for about ten years. But a unique aspect of UK's system is that some instructional devices have been invented and new responses to computer language have been created to meet the particular needs of the students and faculty.

For example, in order to strike the key to correspond to particular musical note values on the computer's alphabetical keyboard, students had to memorize a complicated set of letters corresponding to note values. To simplify matters, the UK faculty programmers designed a keyboard overlay with the actual symbols for notes on them, so when a student wants to hit an eighth note, he simply strikes that symbol on the computer's keyboard overlay.

Another major problem was that of creating a way for the computer to respond to commands in order to produce sound. Although BASIC, a standard and relatively unsophisticated microcomputer language had been used to produce sounds from microcomputers, PASCAL, the more advanced and flexible language used by the UK project faculty, had not. It was Professor Covington who, after long weeks of experimentation finally developed a way for the PASCAL



language to activate the sound boards within the computer. The discovery of this method of sound production is quite a pioneering step in the world of music and microcomputers, according to Domek.

Although the computers are helpful, they are not quite yet able to be used in the manner Domek and his collaborators would like. "It really took us much longer than we had anticipated to program for them and consequently, we did not have the time or really even the resources to implement some of the programs we wanted," Domek said. "For the

computers to function as more than an optional aid for students, the programs must include an automated recordkeeping device, showing who spent how much time doing what and how well, and an internal security system to insure students are doing their own lessons."

Dr. Lord is particularly interested in the possibilities of expanding the use of the computers for voice and pitch recognition. He is presently working on a system which will enable a microcomputer to recognize and analyze the pitch a student sings into the computer. "The application of this

system will cover a wide spectrum," he reports, "from college level music theory to elementary music classes to choral groups in schools, churches, and the community."

Silicon Solar Cells

By Erik Kirkhorn

Technology progresses so rapidly that most of us don't realize how certain changes could have occurred within five or ten years. A commonly-cited example is the calculator. It is a fact that calculators which performed the most basic of functions cost hundreds of dollars in 1975. It is now possible to buy them for under ten dollars.

There are calculators which operate on light rays from the sun or any other strong energy source. Utilizing tiny silicon chips, they are ready to use as soon as opened, providing there is any light at all. This type of technological advancement is the impetus for what is now a multi-million dollar industry.

It is also the basis for the research of three engineering professors at UK. Dr. Oscar Dillon, from the engineering mechanics department has joined forces with Drs. Robert DeAngelis and Todd Gross, who teach metallurgical engineering. They have been assigned a difficult task from the Jet Propulsion Lab at the California Institute of Technology.

other was rectangular and appeared striated. They were both flat and didn't appear capable to perform the enormous task they were produced for—to absorb sunlight and convert it into usable energy.

"They look the same, don't they?" Dillon said, pointing out the rectangular one as being the result of a newer and less expensive process of production.

"That's the problem which has been identified and what we're working on—specifically, what process parameters can be changed to increase the perfection of the silicon ribbon? How can you vary temperature in the manufacturing process to yield high quality material?" Dillon added.

Gross said the new silicon is able to convert about nine or ten percent of the sunlight into usable energy, whereas the more expensive method is able to convert about 18 or 19 percent.

"It's our objective to keep the stresses and the defects down in order to increase efficiency," he said. "We are aiming for complete purity

DeAngelis and Dillon have worked together for about ten years now on various projects while Gross has joined them in recent years, and it's clear that friendship and open communication are as much an asset to their research as is their expertise.

"It's really a matter of being able to marry these two disciplines," Dillon said. "I'm a specialist in stresses and they are interested in materials. To solve the problem we're faced with, we had to know both thermal stresses and material science and to be able to work together. There's too much to deal with here, though. We're a small part of a bigger program."

The researchers are hindered somewhat by a lack of materials. They are not actually able to produce silicon in their labs at UK, but they work via "computer modeling" according to DeAngelis. "No university really could produce silicon—that's why we work with industry."

"We computer-model the ribbon growth process. We take the ribbon through each step of the growth process and monitor its progress with the computer. We look at the solidification process. We work toward developing better and better equations to use in solving the problems. It's an analytical model, but we're able to identify problems this way. It's really a question of what kind of equations do you put in the computer to solve these problems," DeAngelis said.

The three men indicated that there is some urgency involved with the research. The Department of Energy has poured a lot of money into the solar program and there are projects around the United States designed to test, on a limited basis, the viability of using solar cells as an auxiliary source of power.

Without some refinements, such as those the three are working on, solar power is still not economically feasible. In an experiment at Sacramento, California, 40 acres of

One of the silicon wafers was circular and perfectly smooth, the other was rectangular and appeared striated. They were both flat and didn't appear capable to perform the enormous task they were produced for—to absorb and enhance sunlight to the point of converting it into energy.

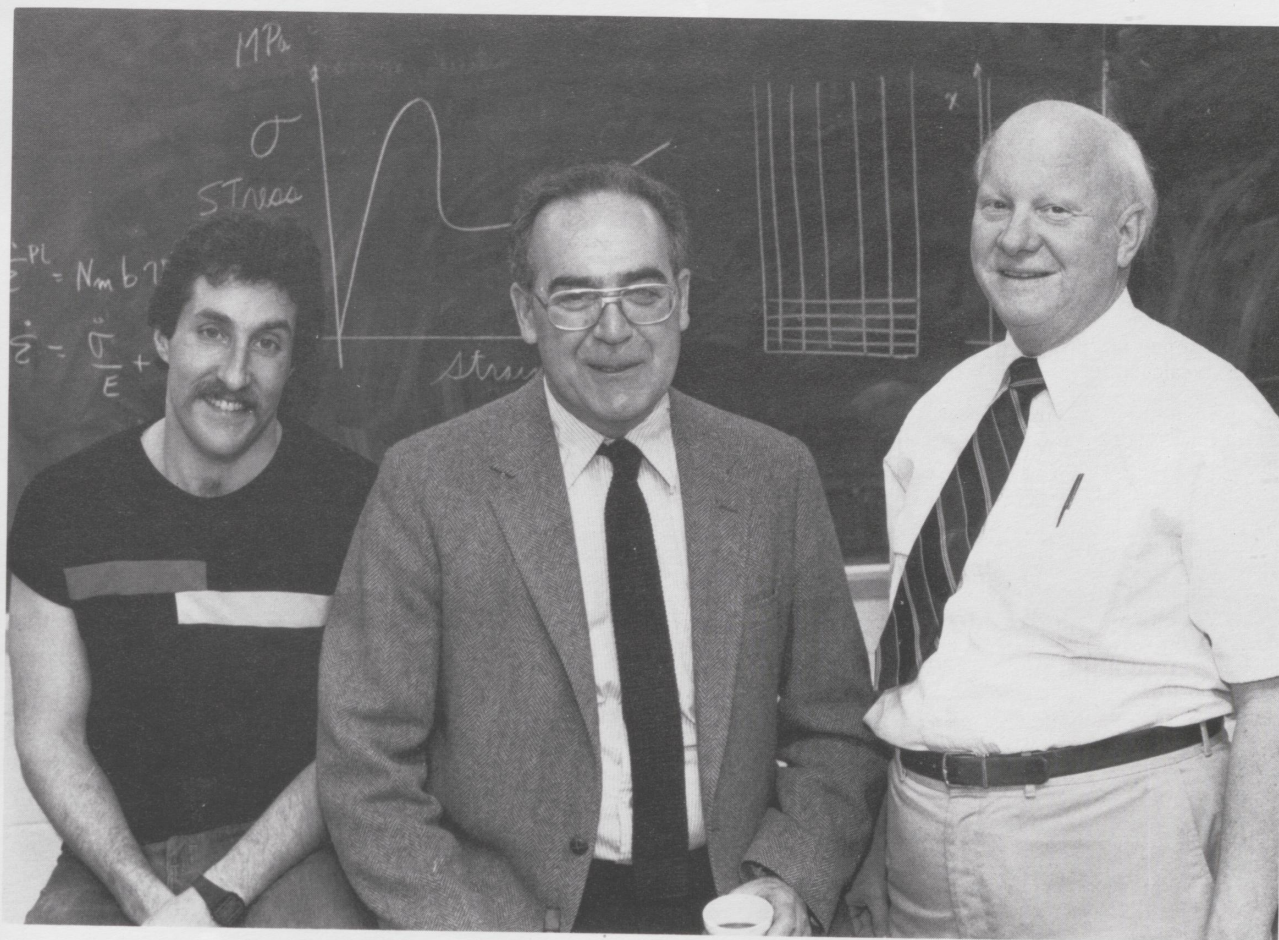
"We are exploring problems concerned with the great deal of time and expense involved with the traditional method of producing individual silicon wafers from single crystal ingots," said DeAngelis, holding two examples of silicon which looked almost identical.

But they weren't. One of the wafers was circular and perfectly smooth, the

combined with low stresses. These ribbons have to be nearly defect free."

"We're trying to put the ribbon growth process on a scientific basis," Dillon said. "What we're looking at here is something which could replace nuclear and coal energy down the road. We're trying to help establish a brand new industry which could have a tremendous impact on everyday life."

continued on page 27



Gross, DeAngelis and Dillon's research is sponsored by the Jet Propulsion Lab at the California Institute of Technology

panels covered with silicon are enabling a power plant there to use the sun as a power source. Full-scale power plant production is years ahead and depends on progress made in the area right now.

"In Sacramento, the experiment is helping to supply 'peak power,' when it is hottest and people turn on their air conditioners. There is a huge investment involved with building new power plants. The cost and efficiency of production must be considered economically before it is used extensively," Dillon said.

"It can be done now, but it can also be done better. Some companies are very conservative and don't want to take the risk. The projected markets are bigger than the automobile industry," he added.

It is also possible that silicon technology would be rendered useless

***I**t is also possible that silicon technology would be rendered useless in five years and replaced by another if the imperfections are not worked out.*

in five years and replaced by another if the imperfections are not worked out. "The government would develop an alternative in five years, something else could take over," DeAngelis said.

"It's a completely new industry and is in its infantile stages right now. It could boom or it could stay infantile. These problems have to be solved. Solar energy is actually cheap if it works. It's still debateable, though," Dillon said.

He added their findings have had an impact on the budding industry, involving better temperature profiles during the manufacturing process, and has already had an effect on the ribbon development process.

For now though they will continue to spend hours between classes in front of a computer terminal in Anderson Hall, trying to discover the right equations.

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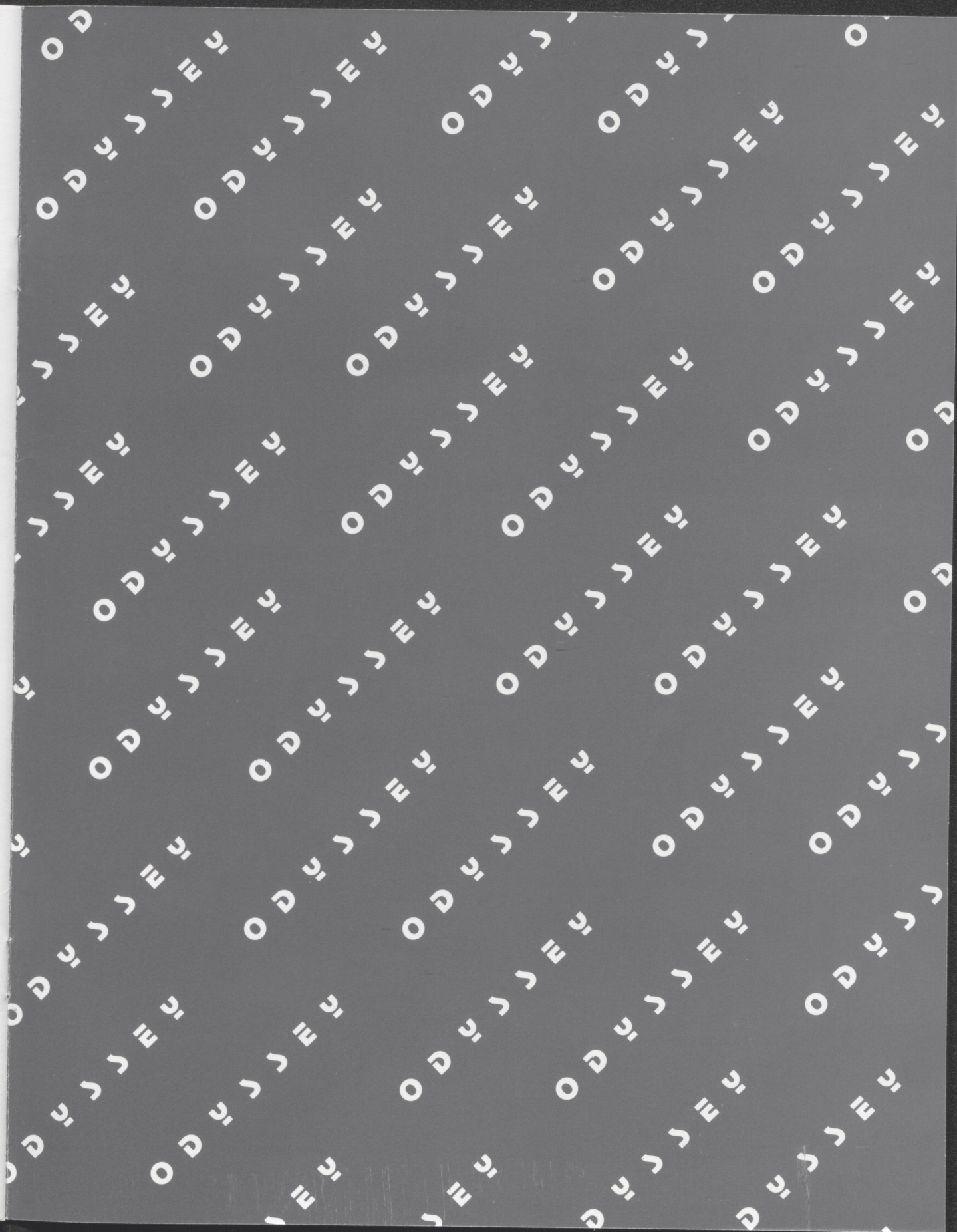
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In This Issue:

- The Hibernation Trigger
- Acres of Soybeans in a Test Tube
- Safer Mines
- Research Summer Helps Decide Career
- Detecting Cancers Sooner
- Black Poetry to the Neighborhoods
- A Pathway to Understanding Cell Growth and Cancer