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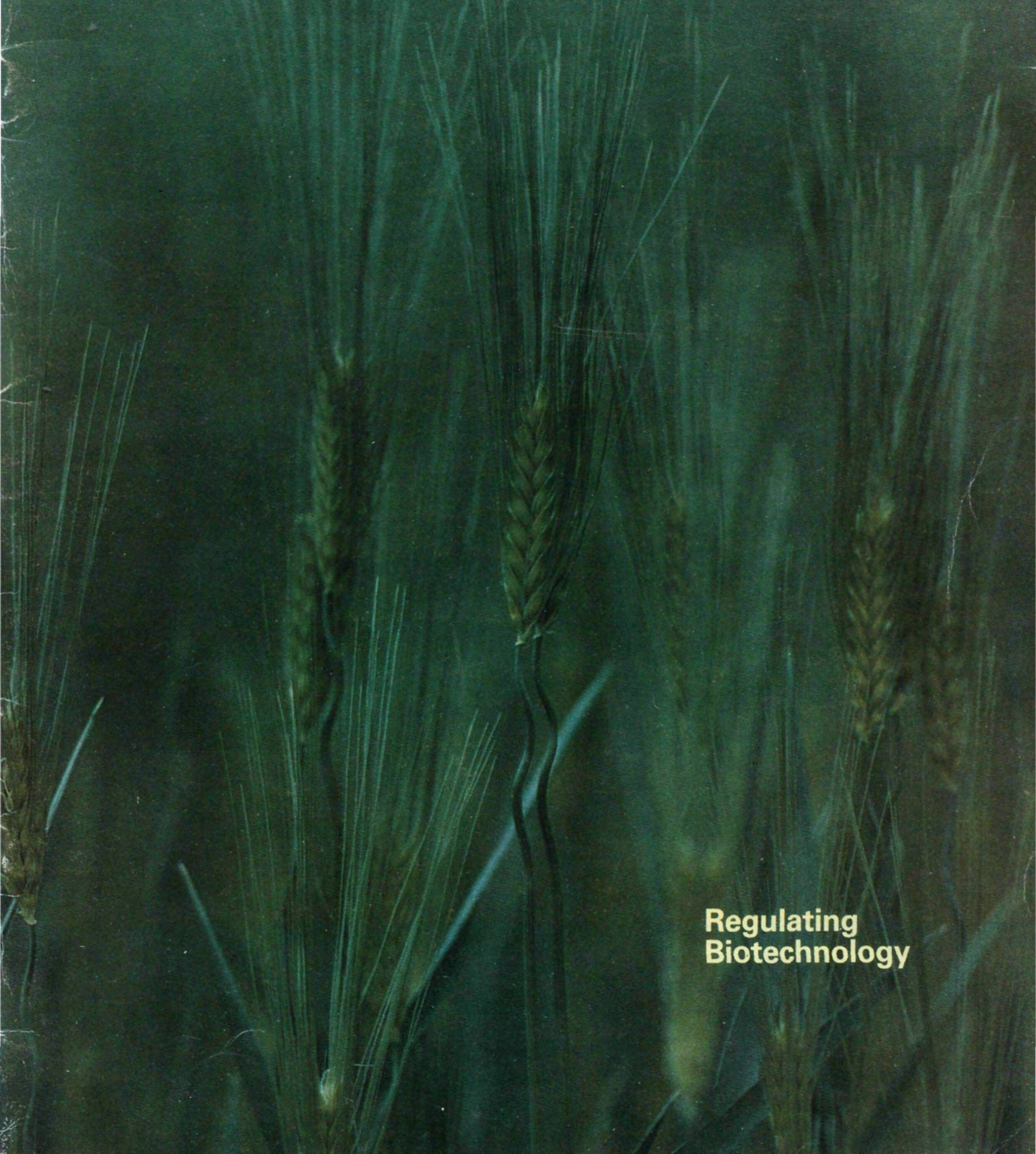

Regulating Biotechnology

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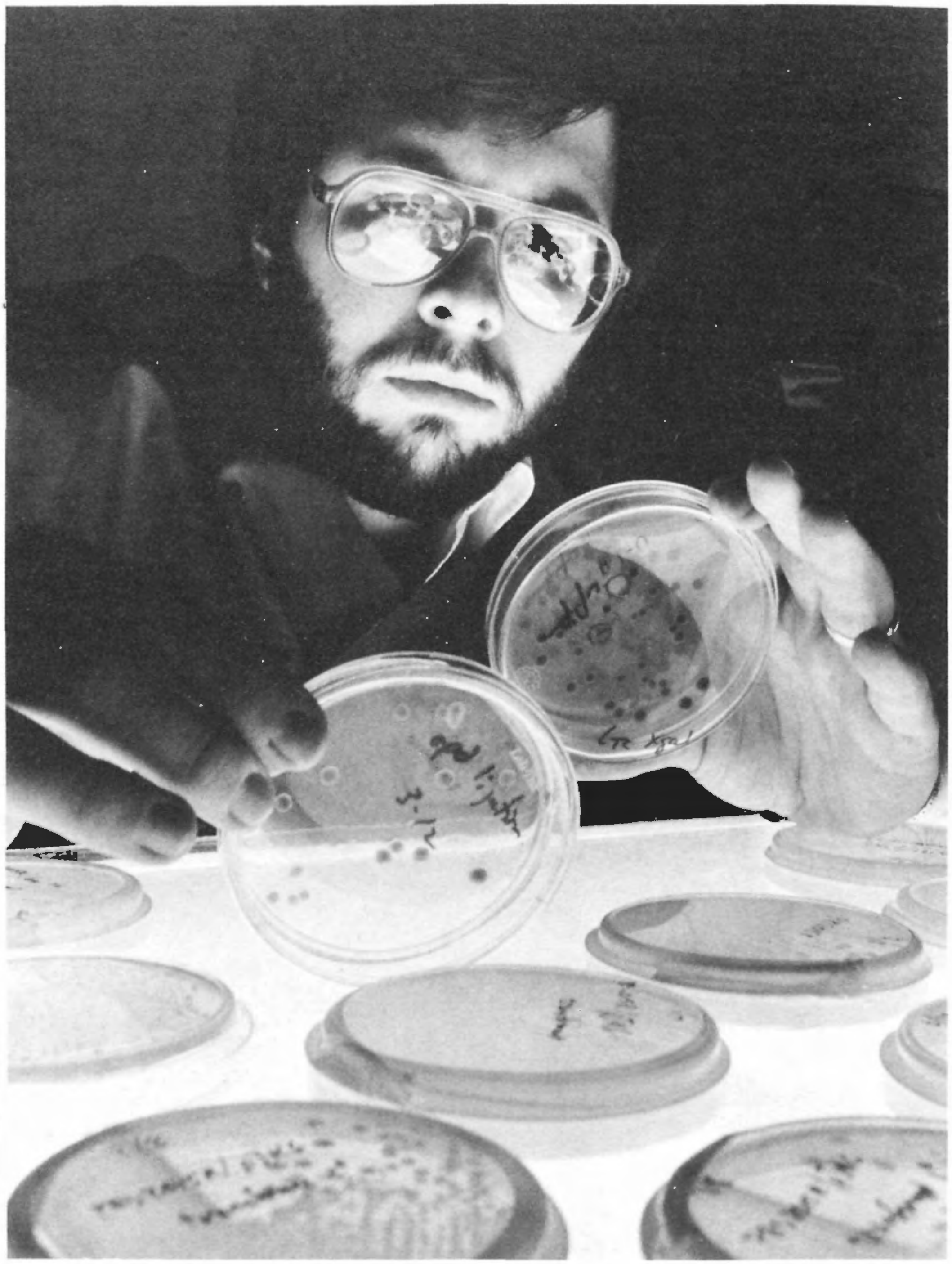

Agricultural Research Service, USDA

At an Agricultural Research Service lab in Maryland, a microbiologist examines bacteria growing in petri dishes. Using DNA-cloning techniques, scientists will genetically alter the bacteria to help speed the breakdown of certain pesticides.

This issue of *EPA Journal* concerns the Agency's role in insuring the safe and productive use of biotechnology, one of the newest and most controversial scientific developments in modern society.

Dr. John A. Moore, the Agency's Assistant Administrator for Pesticides and Toxic Substances, responds to questions about EPA's responsibilities to regulate biotechnology. Dr. David Kingsbury explains the White House policy regarding the development of biotechnology. Kingsbury was a key architect of the White House plan to coordinate regulation in this field.

Two expert observers give their views regarding the future of biotechnology and what the federal government's role should be. Dr. Winston Brill, research director of a biotechnology firm, explains the potential of this new science to help society. Jack Doyle, an associate of a national public interest group, raises some concerns about biotechnology's possible impact.

Concluding this issue's look at biotechnology is a feature reporting on EPA's preparations to regulate this new science and exploring its potential to help clean up the environment.

Also featured this month are articles on a mobile classroom to train asbestos cleanup workers, the practice of the art of "biomonitoring" to measure water pollution in EPA's Region 8, and a retrospective look at a close call with a pollution disaster on the Mississippi River 25 years ago. A photographic essay explores environmental meanings in life on Tangier Island in the Chesapeake Bay.

The issue concludes with two regular features—Update and Appointments.

Coming up next month in *EPA Journal* are articles on how the nation will finance the next generation of municipal wastewater treatment systems, which is also the subject of an Agency conference scheduled for November 18-20 in New Orleans. □

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EPA is charged by Congress to protect the nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

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Front Cover: Unripened wheat. Biotechnology holds promise and poses potential problems in agriculture and some other activities. Photo by John Keith. Folio, Inc.

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Developing Confidence in Biotechnology:

An Interview with John A. Moore


Steve Delaney

What are EPA's responsibilities and plans to regulate biotechnology? To find some of the answers, EPA Journal interviewed Dr. John A. Moore, Assistant Administrator for Pesticides and Toxic Substances, who is playing a major role for the Agency in the regulatory task. The interview follows:

Q What do you see as the greatest risk in the emerging field of biotechnology?

A The greatest risk we face right now is failure to develop public confidence in the process that leads from the laboratory to the marketplace.

Q Is there any way for biotechnological experiments to proceed without the public feeling threatened by them?

A I think so. But an educational process has to take place first, so that the public can develop a perspective on the benefits of biotechnology and can identify the checks and balances that will be in place to prevent undesirable effects from occurring. Hopefully, the community will conclude that its initial fears were unjustified, and that a process does exist to safeguard its interests. Then these experiments can go forward.

This is what happened in the early days of recombinant DNA research about 10 years ago. People who lived in communities where experiments were to take place voiced objections. Scientists worked to inform them fully about the experiments. As a result, today this kind of research is "business as usual" in communities such as Cambridge, MA.

Q Then you're saying that it's possible for biotechnology to be developed safely?

A No question about it. It already has been developed safely.

Let me give you some examples. The Commissioner of the Food and Drug Administration (FDA) recently anounced that FDA is licensing for marketing a new vaccine against the hepatitis B virus. The new vaccine is believed to be vastly superior to the vaccine currently on the market.

Human insulin is being produced by bacteria grown in fermentation vats.

Blood components are being produced using biotechnology.

The U.S. Department of Agriculture (USDA) has permitted the testing and sale of a pseudorabies virus vaccine. Although there were concerns about the review procedure, the vaccine is safer than the virus and, on balance, society is better off having it available.

Q Does biotechnology have a big future as a component of our economy and our health care system?

A That depends. As a society, we have a double challenge. We have to find ways to exploit biotechnology in a whole sphere of activities. But we also have to think about the consequences of applying biotechnology, so that we don't make serious errors.

Q Will EPA have a major role in regulating the biotechnology industry?

A Yes. EPA is probably going to regulate under two statutes.

Under FIFRA (the Federal Insecticide, Fungicide, and Rodenticide Act), EPA will regulate biotechnology in the development of pesticides. Under TSCA (the Toxic Substances Control Act), the Agency will have a role in reviewing the development and commercialization of products that involve non-pesticidal or non-agricultural usage, with the exception of drugs. For example, we could look at the development of microorganisms that can degrade certain chemical pollutants. Or we could look at bacteria engineered specifically to concentrate precious minerals or commodities of one sort or another that currently exist only in extremely low quantities or concentrations.

Our role is to be sure that the new organisms do only what they are supposed to do. If a microorganism is supposed to degrade a certain chemical, we need to be sure that it doesn't also attack some other type of life, or chemical substance, or that it doesn't produce a new chemical substance worse than the one it set out to destroy.

As the field evolves over the next decade or so, some legitimate concerns may also arise under RCRA (Resource Conservation and Recovery Act), as well as under some of the water statutes. EPA will need to make certain that companies in the biotechnology field don't end up with byproducts that they can't safely dispose of.

Q How is EPA going to make sure that its regulations are effectively enforced?

A Enforcement is the challenge with any set of regulations. Biotechnology will be no different.

First we must identify *exactly* what needs to be regulated, and come up with a clear set of guidelines so that all parties understand what is expected of them. Then we have to identify milestones that determine compliance with the guidelines in an objective fashion. Where people fail to comply, we will take them through enforcement action.

Q The Administration has developed a coordinated plan for oversight of biotechnology. What is EPA's part in this plan?

A Along with other agencies, EPA has a major role in developing a common approach to assessing biotechnology products. The goal is to

U.S. Department of Agriculture

Idaho potatoes ready for harvest. EPA approved a genetic engineering experiment to improve frost resistance of potatoes, but the experiment cannot proceed until settlement of pending litigation.

agree on a single review process so that, in cases of joint jurisdiction between EPA and other federal agencies, the review can at least proceed on parallel tracks. This should avoid undue delays for the person seeking to develop and sell a product.

I think we've made good headway in identifying which agency should have lead responsibility in such cases. We've also developed common definitions that are keyed to some of the regulatory actions.

Also, along with USDA, EPA is co-chairing a subcommittee to develop guidelines for testing in greenhouses. These guidelines will help scientists who are testing new products, as they move from the research phase in a laboratory to the development phase in a greenhouse.

Q How many reviews has EPA conducted to date on biotechnology products, and how many of these products has the Agency actually approved?

A If someone wants to do a biotechnology experiment in the environment, he first consults with EPA. The agency determines whether or not a formal, experimental use permit application will be required.

As far as formal requests for reviews are concerned, we have received nine so far, all of them in the pesticide program. To date we have ruled that an experimental use permit will be required for three of these.

We have acted on all three. We approved two ice nucleation bacteria experiments. One of these involves the field experiment of Dr. Steven Lindow of the University of California using the bacteria on potatoes. The other involves an experiment of Advanced Genetic Sciences, Inc., also in California, using the bacteria on strawberries. In the third instance—a Monsanto proposal for an experiment involving bacteria which live on the roots of corn plants—we've deferred making a final decision pending the development of additional data.

In other instances, we've determined that experimental use permits are not required and have allowed the experiments to proceed. A couple of formal requests are still pending.

Q Were you dismayed when you learned that Advanced Genetic Sciences, Inc. had actually tested its product outdoors before the agency granted it a permit to do so?

A Yes, of course. In that case, the Agency found that something improper and illegal had indeed been done. But we were convinced that the company's motive was characterized by unwitting error in judgment rather than a conscious and blatant disregard for regulations or law. The case has been closed, and the company has been fined.

Q Did EPA learn anything from this experience that it can apply to the future?

A We know that we really have to evaluate the clarity of our communications, so that this kind of misinterpretation can be minimized in the future.

Q Do you think that Agency personnel have kept abreast of advances in biotechnology and that they will continue to be able to do so in the future?

A Yes, I do think so. This obviously involves a bit of speculation on my part, since I don't know what's coming in the future. But based on proposals we've received to date, I'm confident that we

Agricultural Research Service, USDA

In greenhouse studies, a plant geneticist removes pollen from a drought-resistant petunia to cross with a new petunia (right), created through microinjection of chromosomes. EPA is helping to develop guidelines for genetic testing in greenhouses.

can keep up with what's coming.

Of course, we've relied heavily on outside scientific expertise in reviewing every formal inquiry we've received to date, and we will continue to do so in the future. The scope of science involved in these early laboratory and field trial ventures is so broad that there's no way EPA could anticipate all the eventualities and hire an adequate stable of resident experts. So peer review by outside experts is, and will continue to be, a key to our ability to keep pace with the anticipated workload.

Q What steps does EPA take to insure that genetically altered products are reviewed confidently and effectively?

A One key step, as I just mentioned, is peer review. Before EPA grants permission to do an experiment involving biotechnology manipulations, we assess the adequacy of information about the experiment, as well as the data generated for the experiment. We form a tentative interpretation of the proposed study.

We then share all that information with the appropriate experts, both inside the federal government and outside, usually from academia. These experts look at the original data, form their own conclusions, and match their conclusions against those of the Agency. The more significant issues usually involve a meeting where everyone can talk out perspectives and viewpoints. If there is concurrence among everyone, we feel reassured that the judgment is correct and that errors of oversight have been avoided. EPA can then make a risk management decision about what will be allowed to go forward, and under what circumstances.

Another key step is our insistence that results of all approved experiments be made available to EPA. Following some experiments, a company may decide to abandon development of a particular product because it doesn't see any commercial value in it. But the data the company has come up with may still be of value to us. When we look at that data, we can find out if our judgment, and the judgment of the peer review groups, was correct.

The more data we have, the better off we are when it comes to dealing with future proposals. By requiring that data be given to EPA, we will build a better data base, and our judgments will become more and more objective.

Q What are the potential benefits of biotech products versus existing pesticides and toxic substances products?

A Biotechnology allows us to develop products that function with great specificity. This means we can look forward to a marked reduction in undesirable side effects of certain products.

For example, many of the early pesticides were indiscriminate. They not only killed the insects they were supposed to kill; they got rid of every other insect as well. Another problem of those pesticides was that they persisted in the environment. Other organisms would consume these pesticides, with undesirable consequences all the way up the food chain. In the case of DDT, every creature in the food chain magnified levels of the pesticide, and the eagle, at the top of the food chain, ended up with huge concentrations of DDT.

Today we're developing products that work at a molecular biochemical lesion level, and have great specificity as to the number of organisms affected. Biotechnology gives us strong tools to develop pesticides that are more and more specific.

Q Does it surprise you that an agency formed just to clean up the air and water now finds itself in the center of the most advanced science in society?

A No, I think it's an appropriate place for us to be.

Let me give you an example. Some people follow this line of reasoning: pesticides are poison; therefore, they are bad; therefore, EPA shouldn't be involved in any process that allows them to be used.

This same line of reasoning could also be applied to biotech products. In each case, I think it is faulty reasoning. It is important that someone be able to assess both the benefits and the detriments of biotechnology products, or pesticides, or whatever. Indeed, that's what environmental protection is all about.

Q Is there any particular comment you would like to add concerning biotechnology?

A I would like to underscore the statement I made at the outset: it is essential that we develop a clearly outlined approval process that everybody can understand. "Everybody" includes the general public. We've got to be very open with the public as we look at specific cases, so that the public can feel assured that our judgments protect public interests. Anything short of that will portend a very rocky road for the development and commercialization of biotechnology products. □

Regulating Biotechnology: The White House Policy

by David T. Kingsbury

Plant geneticists with the Agricultural Research Service determine the structure of a soybean DNA segment that resembles the "jumping genes" first discovered in corn. The scientists are trying to learn how genes control traits in soybeans so that they can help breeders design better crops.

Agricultural Research Service, USDA

A framework to guide and coordinate federal regulation of biotechnology was developed recently as a White House policy. The policy was issued by the Office of Science and Technology at the White House. The leader in developing this policy was Dr. David Kingsbury of the National Science Foundation. The following article by Kingsbury explains the policy:

On June 26, 1986, the federal government's final policy for a "Coordinated Framework for the Regulation of Biotechnology" was published in the *Federal Register*. The framework invokes new regulatory requirements and establishes two basic principles:

- to the extent possible, government agencies involved in regulating biotechnology will use consistent definitions of "genetically engineered" organisms;
- all agencies will base decisions on comparably rigorous scientific reviews.

We believe this policy will protect human health and the environment and, at the same time, provide the flexibility necessary to deal with a new and rapidly developing industry.

Biotechnology has broad applications in many diverse aspects of industry and commerce, and most observers expect that it will affect the U.S. economy substantially. One recent analysis predicted that the sale of biotechnology products will rise to several billion dollars in the 1990s and to as much as $40 billion by the year 2000.

Anticipated major products will include pharmaceuticals, agricultural chemicals and pesticides, growth-promoting hormones for animals and plants, and a line of very valuable industrial chemicals. Biological waste treatment processes and specially engineered microorganisms to degrade pollutants are also probable products for the relatively near future.

Although the U.S. is currently the world leader in this field, our lead is not unbeatable. Japan and many European countries have the technical sophistication to develop biotechnology-based industries, and these industries have been targeted for special financial support from their governments. They can be expected to receive special regulatory treatment from their governments as well.

That is why the framework is so important. Without a consistent, rational approach, some observers are concerned that non-scientific issues may play a dominant role in the future of biotechnology development and implementation in the U.S. They fear that an irrational or burdensome regulatory climate could fatally impede the eventual introduction of products now under development and lead to future disinterest in this area. There is also worry in the financial community about the long-term stability of businesses in environmentally regulated fields. This worry may reduce the economic capability of many enterprises to continue needed product development and testing.

Thus, a major goal of the "framework" agencies is to educate the public about the true risks and benefits of biotechnology. The public has legitimate concerns about the introduction of some products, and it's our job to establish principles that ensure their safe environmental use while allowing research to proceed. The interagency committees that worked on the current policy are very confident that existing regulations cover the present and near-term biotechnology industry. We are also confident that we will be able to monitor and absorb changes as the technology develops. We are proud of our coordination policy, but we recognize that it is only the beginning. □

Biotechnology: Its Potential

by Winston J. Brill

Not a week goes by without another headline or TV bulletin on the emerging benefits of biotechnology, especially applications of genetic engineering. In most cases, the focus is on human health care with promises of safer vaccines, more sensitive diagnostic tools, and new cancer treatments like targeted monoclonal antibodies. Meanwhile, biotechnology is also being applied to agriculture, and there is even some activity in mining, oil recovery, and toxic waste removal (the latter topic is discussed on page 10 of this issue by EPA writer Roy Popkin). Biotechnology also holds out the hope of safe substitutes for toxic chemicals.

The non-medical applications presuppose the release of genetically engineered organisms into the environment, and that brings EPA into the picture. The task of EPA and also of the U.S. Department of Agriculture is to regulate released organisms without inhibiting the advance of biotechnology as a whole.

The genetic engineer can take a gene from any organism and add that gene to the chromosome of another organism. The recipient cell does not have to be related to the donor. Scientists are adding bacterial genes to plants, plant genes to bacteria, animal genes to plants, etc. This work is teaching us a great deal about the pathology and development of organisms. Industry is swiftly applying what is learned to new and improved products with enormous potential to improve the quality of life.

Plant Agriculture

Traditional plant breeding just randomly mixes tens of thousands of genes from each parent, with the following disadvantages: a) the breeder almost never can predict the exact characteristics of the progeny from a standard cross, b) the breeder has to hunt among the progeny for the few offspring with the desired properties, and c) painstaking reverse breeding is necessary to dispose of undesirable characteristics. Thus, the process of breeding and backcrossing is very labor-intensive; it can take 10 to 12 years to develop a new variety. By comparison, genetic engineering adds one or two well-characterized genes to the tens of thousands of genes in the recipient organism. Thus, a breeder working with genetically engineered plants: a) can easily predict the characteristics of the modified plan, b) does not have to hunt for the rare combination of desirable traits, and c) does not need to spend a third of his life backcrossing since no undesirable genes have been added. Faster production of new and better characterized varieties will result.

Biotechnology does hold out the hope of safe substitutes for toxic chemicals.

Laboratories have already achieved major advances. A viral gene has made plants resistant to attack by that virus. A yeast gene has made plants resistant to a bacterial pathogen. A bacterial gene has made plants resistant to certain caterpillars. These resistances breed true from one generation to another. The "pesticide" is built into the plant and is non-toxic to man and other non-target species. Unlike chemical pesticides, it is unlikely that the pests will become resistant to the pesticidal action of the plant, except perhaps over thousands of generations. This technology is clearly going to cut the use of toxic pesticides in our environment.

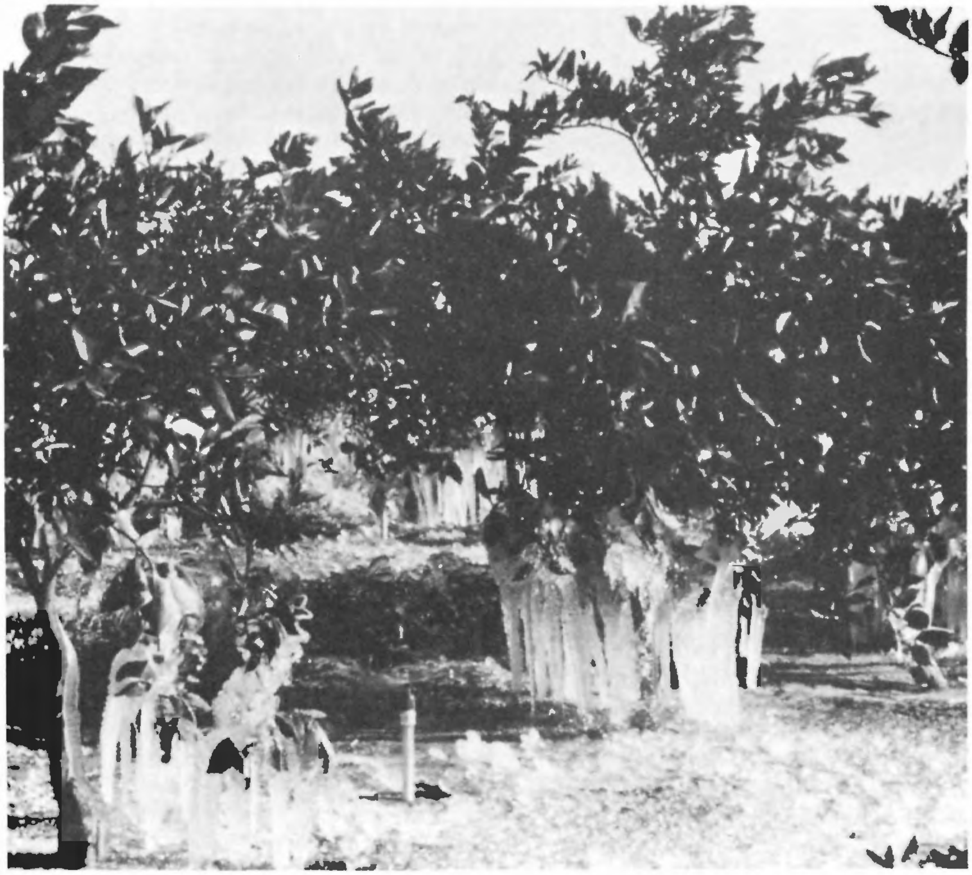
Several groups have used genetic engineering to obtain plants that survive application of a chemical that kills weeds. This advance will allow farmers to be more selective in their weed-killing methods. While herbicide resistance in plants may seem, at first, to make possible continued use of toxic chemicals in the fields, it should actually obviate them. Through genetic engineering we should be able to choose herbicides with minimal health and environmental effects. Chemical companies will be able to market herbicides that are safer, more beneficial, better targeted and ultimately less expensive than any available today.

Another approach will utilize microorganisms that kill or damage weeds. The disadvantage here is that microbial herbicides are usually specific for a single weed. However, a mix of microbial herbicides may come on line to kill a variety of weeds at some point in the future.

Research is also being focused on genetically modified microorganisms that will improve a plant's ability to utilize fertilizer. The farmer wouldn't need to use as much and run-off after a heavy rain would carry less fertilizer into rivers, lakes, and streams. Bacteria have been modified to protect plants from early frost damage, a development that could prevent huge economic losses. Laboratories are genetically engineering bacteria and fungi to protect plants from diseases, too. Such bacteria would be added to seed or soil or sprayed on the growing plant. Again, all these methods should greatly diminish the use of toxic chemicals.

Simple diagnostic kits are being developed to detect extremely low levels of disease-forming microorganisms. Farmers will be able to detect pathogens in their fields before

(Dr. Brill is Vice President of Research and Development, Agracetus, an agricultural biotechnology firm in Madison, WI. He has written frequently on the subject of biotechnology.)



Dr. John Attaway & Dr. Larry Parsons

During a freeze in January 1985, ice forms on two-year-old Florida citrus trees. The ice is actually a form of protection. Microjet sprinklers like the one in the foreground spray water directly on the lower trunk. When water freezes, it releases heat. The freezing water will protect the trunk at a temperature near 32°F. Today, geneticists are trying to create plants that are naturally frost-resistant.

plant symptoms become visibly apparent. With this early-warning test, farmers will be able to be much more selective in deciding the quantity and type of pesticide to prevent damage by disease.

Mining and Oil Recovery

Bacteria have been used for many years to leach metals from ores; biotechnology should give us microorganisms with very effective mechanisms for accumulating specific metals. Such organisms could be added to a crude ore and then, full of metal, harvested. Uranium, molybdenum, tungsten, gold, silver, and copper may be mined by such methods.

Oil wells that are no longer active usually have large amounts of oil remaining, but the internal pressure of the well is not sufficiently high to raise it to the surface. Organic materials that could help push the oil out of such wells are being examined. For instance, a material that clogs rock pores or materials that expand when water is added has potential value. Many bacteria synthesize such materials (e.g., polysaccharides) and genetic engineers are examining ways to modify bacteria to produce large amounts of polysaccharides in an oil well, thus pushing the oil to the surface.

Concerns

Some people have expressed concern about releasing genetically engineered organisms into the environment, fearing that genetically engineered crop plants could become problem weeds. In fact, the likelihood of forming problem weeds through genetic engineering (adding one or two characterized genes to an organism) is much smaller than the chances of forming a problem weed through traditional breeding (randomly mixing tens of thousands of genes). As with any technology, however, we should be alert to possible problems. A plant engineered to be resistant to one pathogen may unintentionally become susceptible to another. These types of problems are the kind that breeders have traditionally been on the lookout for, and they are routinely detected during extensive field testing before a new variety is marketed.

There is more concern about the release of genetically engineered microorganisms because they are associated in the public mind with disease. But thousands of different microorganisms, added to many types of environments in amounts of billions per acre, have been used experimentally and commercially in agriculture and mining for the past 80 years without any health or environmental side effects. The evidence is rather persuasive that a deleterious pathogen

It is improbable that adding one or two genes to improve a safe microorganism will render that organism dangerous.

cannot be formed by genetically modifying a safe microorganism. A pathogen is a problem not because it contains a single "patho-gene," but because it contains many genes all finely tuned and integrated, representing natural bacterial selection over many millions of generations. Thus, it is improbable that adding one or two genes to improve a safe microorganism for agriculture, mining, waste removal, etc., will render that organism dangerous.

Conclusions

Genetic engineering is one of the many techniques being applied to improve products, develop new services, and help us get a grip on environmental and health problems resulting from heavy use of man-made chemicals. Farmers and miners will be utilizing organisms modified by genetic engineering just as they have used organisms modified by traditional techniques. Farming, in the future, will be based more on biology than chemistry. Biotechnology means going "back to nature." In this light, any advantage the U.S. now enjoys in biotechnology can easily be eroded. Pointless regulation will impose a burden on an inherently safe technology and delay the phasing out of undesirable chemical products. □

Biotechnology: Its Possible Dangers

by Jack Doyle

"Gene splicing" is no longer an exotic technology of the far future; it is here today. And despite what newspaper headlines might suggest about postponed field tests and progress, biotechnology is a going business, rapidly becoming an established part of every major industry based on biology or genetics.

Genetically engineered organisms are currently being field-tested, new products are being sold, and millions of dollars continue to be invested in biotechnology research as major industries "re-tool" for the Age of Biology. American Cyanamid, for example, one of the nation's major chemical concerns, now defines itself as "a research-based biotechnology and chemical company which develops proprietary medical, agricultural, chemical and consumer products . . . "

In medicine, genetically altered insulin and interferon have been approved by FDA and are on the market. In agriculture, a number of new genetically engineered livestock vaccines are currently in use, including the first live virus to prevent pseudorabies in hogs. Genetically altered crops are also being field-tested.

Wall Street, meanwhile, has been very receptive to biotechnology. In recent months, the "biotechnology index" has outperformed the Standard & Poors 500. In July, the first public stock offering by Calgene, a California biotechnology company, sold out in one day, with 2.25 million shares selling at $14 per share, a price more than three times the company's book value. In addition, some unlikely corporations, such as Kodak, have turned on a dime to launch major in-house biotechnology R&D programs, while others, such as Bristol-Meyers Co. and Eli Lilly, have gobbled up promising new biotech companies (Bristol Meyers acquired the Seattle-based Genetic Systems for $295 million last October, while Lilly paid $350 million in March to buy up San Diego's Hybritech.)

But the business boom in biotechnology does not mean that all the questions about ecological risks have been adequately answered. Nor does it suggest that there is an adequate regulatory system in place, or that the public is well informed about this new technology. Quite the contrary.

(Doyle is with the Environmental Policy Institute, a nonprofit organization working on environmental and natural resource policy in Washington, D.C. His book on the subject of agricultural biotechnology, Altered Harvest, was published last year by Viking Press.)

Ecological Risks

Only since 1983 have government agencies and scientific institutions begun to think in-depth about what genetically altered organisms might do in the environment *outside* the laboratory. And only as recently as June 1985 did molecular biologists and ecologists, meeting in Philadelphia for the first time on the question of deliberate release and ecological risks, begin a scientific dialogue on the subject. But in the last three years, as more and more ecologists have participated in the debate, more questions have begun to be asked and more uncertainty and data gaps have begun to appear.

In February 1985, the Cornell University Ecosystems Research Center issued one of the first comprehensive overviews of what was possible and what was lacking in the way of assessing the environmental risks of new biotechnology products. The findings of that report are fairly astonishing and underscore how little we know about microorganisms—how they survive, why some grow and others do not, and how they disperse in the environment.

But the clincher in the Cornell study is what it said about our ability to make predictions about the behavior of organisms in the environment. "Methods for predicting the likelihood of survival and proliferation of a given organism in the environment are crude," says the report. "Methods are available for assessing some potential effects, but there are many deficiencies in current knowledge and theory. Generally, we lack any true data base against which to compare test results or predict environmental consequences."

EPA's Scientific Advisory Board released a January 1986 study that echoed some of the same concerns about data deficiencies and the present state of ecological knowledge. In addition, a growing list of ecologists, entomologists, population biologists, and evolutionary biologists continue to raise new concerns independently of official government bodies.

Some scientists estimate that as many as 80 percent of soil microbes have yet to be cultured in the laboratory, and perhaps as many as 90 percent don't even have names. Of those that are named, we don't know much about their relationship with other microbes. Scientists are unable to prove conclusively that a given organism has completely "died out." We can measure when organisms have "died back," only down to a certain level, beyond which we can't measure them accurately or even detect them.

Although EPA has so far approved one field test for the much-maligned "ice-minus" bacterium (currently blocked by litigation in California) as well as a few other laboratory-mutated and killed microbials, it has called for more information in the case of a Monsanto soil bacterium combined with an insect toxin gene from bacillus thuringiensis.

As the Administration's current multi-agency regulatory scheme wends its way through a court challenge and a public comment period, it is unclear what regulatory scheme will finally emerge, and how effective the new regulations will be. Congress has yet to take a clear position on the matter, and there is some sentiment running in favor of EPA having more authority in reviewing release experiments, and USDA and FDA having less.

In any case, the issues of risk assessment and scientific uncertainty are sure to figure prominently in all future debates in Congress and elsewhere. Yet, the most immediate need is for publicly funded research to tackle some of the data shortcomings and upgrade assessment tools.

But, assuming for the moment that these problems will be overcome, there are still other issues surrounding the application of biotechnology that have more to do with side effects, economic impacts, and the setting of social priorities than they do with microbes running amuck.

Promises, Promises

In agriculture, for example, biotechnology offers some very interesting and promising opportunities,

U S Department of Agriculture

Wheat piles up near a grain elevator in Rosalia, WA. The author is concerned that use of biotechnology on the farm may only worsen problems related to current agricultural surpluses.

from genetically engineered cereal crops that "fix" their own nitrogen to the development of safe biological pesticides that could replace toxic insecticides and herbicides. But, as with all new technology, what is promised is not always what is delivered.

In the agrochemical industry, for example, companies such as Monsanto, Ciba-Geigy, Stauffer Chemical, W. R. Grace, and others have teamed up with biotechnology companies and university scientists to develop all kinds of new "farm inputs." Some of these companies, to their credit, are working to exploit molecular and cellular mechanisms of disease and insect resistance *within* crops, a development that could save farmers money while cutting the use of pesticides.

However, at least 26 companies are also engineering crops to make them *genetically resistant* to the damaging side effects of herbicides, raising concerns about further ground-water contamination. In addition, some universities, USDA researchers, and chemical firms are also fashioning a new generation of fine-molecule chemistry for agriculture, developing chemical plant growth regulators designed to "turn on" or "turn off" the genes of field crops in order to set more flowers, capture more sunlight, or produce stronger stalks. These "new" products—essentially in the pattern of the same "old" agricultural chemistry, but tied more closely to plant genetics—will extend the pesticide era rather than end it, continuing the health and environmental risks associated with pesticide use.

Biotech & the Ag Surplus

In quite another vein, biotechnology's awesome powers of productivity on the farm may very well prolong and increase the current agricultural surplus—not only in the U.S., but worldwide—bringing further management headaches to both farmers and government planners; creating pricing and market instabilities; inviting agricultural trade and subsidy wars; and ultimately forcing more farm consolidation and the further demise of the family farm.

Bovine growth hormone (BGH), a projected $1 billion product being pursued by several major chemical and pharmaceutical companies for use in the dairy industry, will increase milk yields per cow by 20 to 40 percent, reduce the need for about a third of the present U.S. dairy herd, and squeeze out of business an equivalent number of farmers, most of them small-to-medium operators. This new yield-enhancing, genetically engineered product (and there are others coming for hogs, sheep, and cattle) will come on the market precisely when Congress must again grapple with a new farm bill in 1989-1990, against a backdrop of mountains of stored dairy products and a darkening economic picture for family dairies.

If agricultural biotechnology simply adds new increments of pedigree improvement to the high-yield system already in place, with the same crop varieties and the same livestock breeds currently in use, we will continue to overproduce, driving more farmers off the land and pushing more shaky rural communities to the brink of bankruptcy. But there are choices with this technology, and there is an opportunity to be "smart" with the new knowledge that is coming to agriculture every day. Biotechnology can be used to broaden the mix of crops and livestock, reduce production costs for farmers, and help eliminate the use of pesticides and other supplements that have had negative environmental and public health side effects. The choices, it would seem, are ours to make.

The Vulnerable Thoroughbred

Our agricultural system is very much like a thoroughbred race horse: it is a system fully capable of achieving very high yields, but, like the pampered and sensitive race horse, it must be maintained and supported by all manner of artifices. Today's hybrid crops and pedigree livestock must be sustained and nourished by heavy inputs of energy, water, fertilizer, pesticides, medicated feeds, hormones, antibiotics, and capital. In short, ours is a high-strung agricultural system, capable of yielding surplus, but one which is also vulnerable to the whims of nature and technological "quirks."

Biotechnology may be used to isolate and amplify the thoroughbred genes in agriculture, creating a system that is made to "run faster," but one that is also genetically locked in to chemicals, capital, and big equipment to keep it performing at peak levels. In the long run, that could be a dangerous and vulnerable deployment of biotechnology, producing a "house-of-cards" system in which one unforeseen mutation or errant gene could bring down the whole system.

And beyond agriculture, of course, biotechnology is already being used in the forest products industry, and will certainly be used for mining, enhanced oil recovery, toxic waste cleanup, and various marine applications. Virtually every natural resource industry will be affected, as well as the resources themselves, from ground water to the air we breathe. Economic and environmental questions will surely emerge in all of these uses, as well as new ones not yet envisioned. So it behooves us now to move ahead with deliberate caution and measured forethought in fully assessing the risks we will face, as well as making some hard choices as to what we want from this "new fire," and how we want to apply it. □

Keeping Ahead of a New Technology

by Roy Popkin

"Now here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that.

-The Red Queen in *Through The Looking Glass*

As biotechnology moves "somewhere else" into the era of genetic engineering, the Environmental Protection Agency finds itself running at least twice as fast to stay ahead of this burgeoning new technology. But, unlike Lewis Carroll's Red Queen, EPA also has an unprecedented opportunity to make haste slowly and to anticipate the problems—and benefits—that might come with genetic engineering and other recombinant DNA breakthroughs.

Proponents of genetic engineering say that it has potential application to every facet of modern life, particularly medicine, industry, agriculture, and pollution abatement or prevention, and they hold out promise for:

- microbes that remove specific pollutants from ground water, wastewater, and soil;
- plants bred "to order" for nutritional composition and drought-, salt-, and pest-resistance;
- improved mining and oil extraction methods; and
- low-cost manufacture of medicines and various proteins, enzymes, and hormones used in medical treatment.

Opponents of widespread use of genetically engineered organisms, on the other hand, fear that assessment of their possible risks has been inadequate. They charge that introducing changed organisms into the environment has enormous potential for medical or environmental catastrophe; they cite the already alarming increase in bacterial resistance to antibiotics which has occurred because of widespread use of antibiotics in animal feed as an example of the impact on the environment or human activities.

(Popkin is a writer-editor for the EPA Office of Public Affairs.)

Other opponents raise concerns about social impacts of biotechnology—for example, will farming with genetically engineered products eliminate all but a handful of farmers?

In this charged atmosphere, EPA is running hard to stay ahead of the game. And the game may, in fact, be a lot longer and harder than was first expected. In an early study sponsored by the National Science Foundation and the Carnegie-Mellon Institute, a panel of experts was asked to predict the major developments in genetic engineering that would take place between 1980 and the year 2000. As reported in the April 1981 issue of Futures magazine, the experts were very optimistic. By the early 1980s, they expected biotechnology to have developed nitrogen-fixing and predator-resistant crops, one-celled edible proteins, bacteria for use in wastewater and pollution control, techniques to isolate genes causing birth defects as well as gene therapy to correct monogenic diseases such as sickle-cell anemia, and increased knowledge of immunological processes, aging, and cancer.

"This time, we're doing the worrying up front."—Dr. Elizabeth Milewski.

This ambitious agenda has not been fulfilled. Few of the expected breakthroughs have occurred even in the laboratory, much less in the real world of hospitals, farms, and waste treatment plants. In addition, legal challenges to the release of genetically engineered organisms have also served to slow commercial development. As one trade magazine commented several years ago, " . . . the expectation that 'two geneticists and a pair of white rats make a business' seems now . . . behind us."

But, while industry may be marking time for the present, EPA is putting this slowdown to good use, seeking to develop a framework to regulate this new industry without stifling it.

The Agency's scientists generally believe that most current and future products of genetic engineering will not threaten the environment or human health. But they want to be sure that each product's possible risk is adequately considered, that no accidents inadvertently create a deadly virus or a crop blight.

Dr. Elizabeth Milewski, formerly in the Office of Recombinant DNA Activities at the National Institutes of Health and now Special Assistant to the EPA Assistant Administrator for Pesticides and Toxic Substances, puts it this way: "This is one time we are attempting to evaluate the down-side of a new technology before it is widely applied. When the automobile was introduced, people said the machines would frighten horses and could cause accidents, but no one envisioned the impact cars and the fuel they used would have on the air we breathe or that they would cause lead poisoning in children. At the start of World War II, when shipbuilding increased rapidly, no one stopped to think about the asbestos poisoning that would affect shipyard workers in the years to come, even though the impact of asbestos on the human lung was known at the time.

"This time, we're doing the worrying up front. We're trying to determine what problems genetic engineering might create, and how we can monitor the technology and use of its products so as to prevent problems before they occur. We want to know what the risks are, so we can regulate them properly, from a base of scientific knowledge rather than fearful conjecture."

At a treatment plant, a worker adds microbial products to wastewater. These naturally occurring microorganisms help destroy certain organic compounds in the wastewater. Proponents of genetic engineering hold out promise for development of "designer bugs" that can degrade toxic chemicals in ground water, wastewater, and soil.

Polybac Corporation

In some ways, she says, the future of genetic engineering will be like that of any other new technology, but EPA feels that "we must know more about and be sure of the safety factors before our regulations can be seen as credible by those who may need reassuring that the new microorganisms are useful and aren't to be feared."

So far, EPA has only been asked to license or otherwise approve a handful of experimental applications of genetically engineered microorganisms—or potential "superbugs"—in the environment.

But there is no doubt that the Agency will receive scores of applications in the future. Milewski believes that an important future exists in genetic engineering of "designer bugs" (microbes that can degrade specific toxic chemicals at their source in toxic waste dumps or in ground water). While microbes have been used to treat waste for many years, their use has largely been confined to bacterial contaminants. The big challenge now is to find a way to treat toxics with microbes.

A step in the direction of producing such bugs has occurred at EPA's laboratory in Ada, OK, where microbiologists John and Barbara Wilson have encouraged the growth of microorganisms that gobble up and detoxify chlorinated hydrocarbons such as EDB and TCE. (These organisms will be tested in wells next year in conjunction with the Air Force, which is a major user of TCE.) The Wilsons and their colleagues are now seeking to develop organisms to work on other chemicals such as dioxin and PCBs.

A similar effort at the Lawrence Livermore Laboratory could remove selenium from the polluted waters of the Kesterson Wildlife Refuge. Biochemist Robert Taylor and geneticist Emilio Garcia are working to combine the genes of one bacterium that absorbs selenium with the genes of another that chemically detoxifies it. If they succeed, Kesterson's 2.3 million gallons of water could be filtered for a few hundred thousand dollars annually, rather than the $1.1 million to $145 million estimated for other methods.

EPA today has a multi-million dollar research program in place. Coordinating these activities is Dr. Morris Levin, Biotechnology Program Coordinator in the Office of Environmental Processes and Effects Research of the Office of Research and Development (ORD).

"At this point in time, we are ahead of the curve insofar as genetic engineering is concerned," Dr. Levin says. "The steady growth of commercial research and development has led to a parallel growth of government concern and activity."

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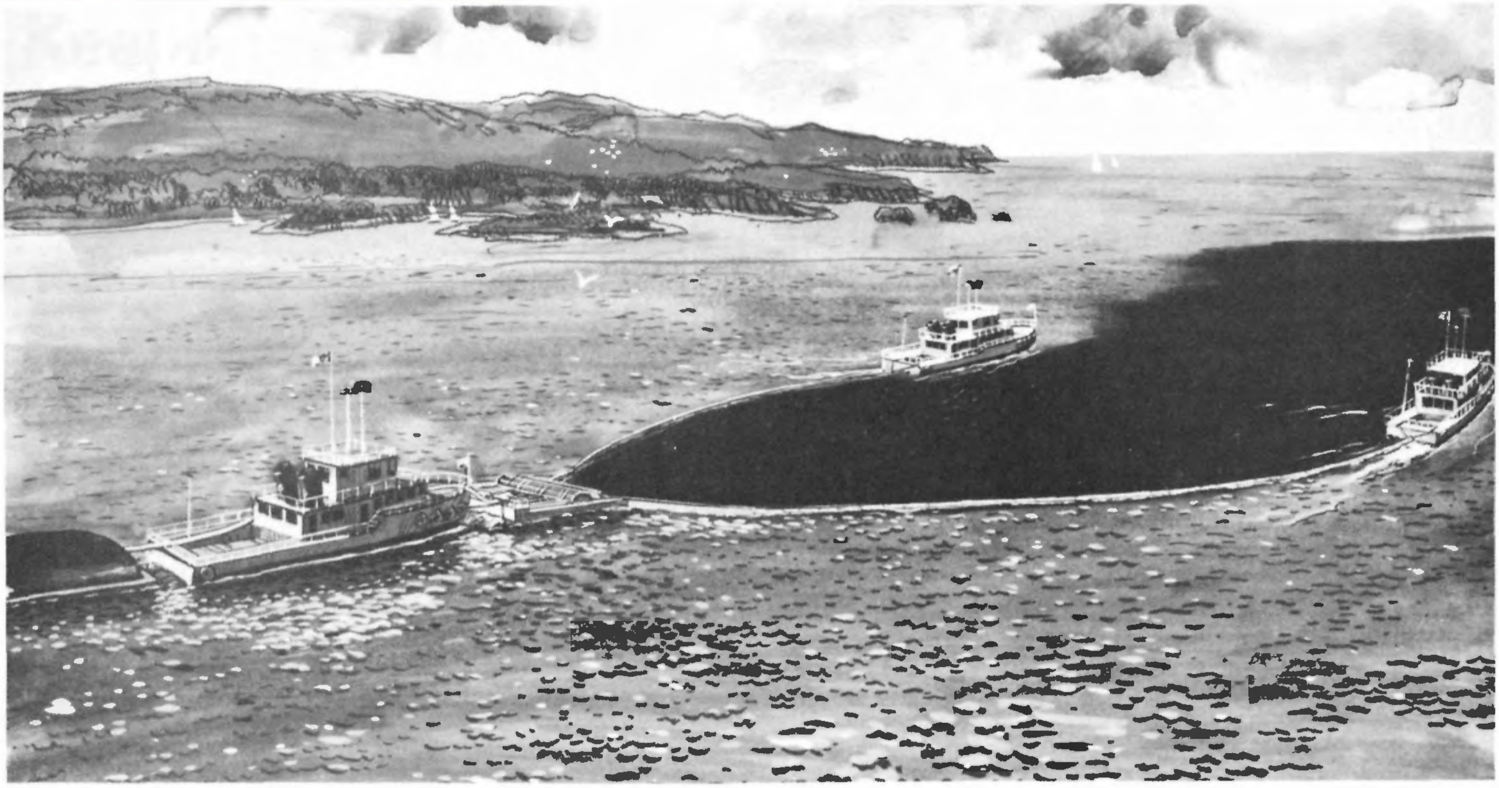


American Petroleum Institute

Artist's rendition of the use of booms to contain an oil spill. Researchers are seeking to engineer bacteria that will be able to control oil spills biologically.

EPA's research efforts are focused primarily on developing methods and protocols for assessing the impact of releasing genetically engineered microbes into the environment, with particular emphasis on the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Toxic Substances Control Act (TSCA). The Agency's research program began with a series of workshops in 1978, 1979, and 1980, at which industrial, academic, and government scientists looked at EPA's potential role in relation to the rapidly growing biotechnology industry. They recommended that EPA:

- Examine sewage systems and aerosols as vectors for the dissemination of genetically engineered microorganisms.
- Evaluate the potential for engineered organisms to create harmful effects.
- Develop a plan for studying the release, survival, colonization, potential for genetic exchange, dissemination, and effects of releases of such organisms.

Following up on these recommendations, ORD surveyed biotechnology's emerging industrial and agricultural applications, and initiated preliminary research in the recommended areas. At the same time, Agency capabilities and needs for research related to FIFRA and TSCA and genetically engineered products were identified. This effort culminated in a 1984 conference at which panels organized by the American Association for the Advancement of Science reviewed the proposed research plans. The panels recommended an overall research program concentrated on environmental effects and how to estimate them, and a case-by-case approach to evaluating the release of specific microorganisms. (The case-by-case approach is currently being used by EPA to review applications for approval of experiments in real world testing areas.) Funds allocated for the research program were $1.5 million for fiscal year 1985, $4.5 million in fiscal year 1986 and $4.8 million for the coming year.

The program now being carried out in a number of EPA and university laboratories is built around risk assessment. It includes development of methods and protocols for laboratory studies, evaluation and modification of methodology in laboratory microcosms, comparison of equivalent data from field studies, and the preparation of risk assessment guidelines. Eighty percent of the funds are being used for environmentally oriented research because of the uncertainty regarding the effects of manufactured superbugs on the environment.

Research at EPA's Corvallis, OR, laboratory is on terrestrial ecological assessment problems. The Gulf Breeze, FL, lab is focusing on the aquatic equivalent of those problems. The Health Effects Research Lab, Research Triangle Park, NC, is seeking ways to estimate health effects and to develop risk assessment guidelines. In Cincinnati, OH, Agency scientists are looking at the problems of accidental release, containment, and decontamination. In addition to research at its own facilities, EPA has cooperative or related studies going on at more than a dozen universities and at the Battelle Memorial Institute Northwest.

These scientists are a collective equivalent of Alice's "Red Queen." They're running twice as fast so that before a product is ready for release into the environment, the world will know it is safe. When genetically engineered organisms arrive, EPA intends to have in place a credible, well-founded regulatory program with which to meet the superbugs and see that they are properly introduced into the environment. □

Some Possible Uses for Biotechnology

Here is a partial list of pending or potential environmental uses of genetically manipulated organisms.

- **Using killed bacteria as a pesticide**
  The delta-endotoxin gene from *Bacillus thuringiensis* (Bt) is cloned and inserted into a species of *Pseudomonas* which is cultured to produce large amounts of the protein that acts as a pesticide. The bacteria are then killed, their cell walls fixed, and the resulting "poison capsule" administered as an insecticide. Small-scale field trials by the developer, Mycogen, San Diego, CA, are under way. The Monsanto Co., St. Louis, MO, is working on a similar product involving the use of live *Pseudomonas fluorescens* containing the Bt gene.

- **Ice minus**
  Strains of *Pseudomonas syringae* and *Pseudomonas fluorescens* from which the ice-nucleation gene has been deleted will be applied to strawberry blossoms to see if the "ice minus" bacteria will make the strawberries frost resistant. EPA approval of small-scale field testing by the developer, Advanced Genetic Sciences, Oakland, CA, is pending.
  A similar experiment by the University of California at Berkeley involves manipulating bacteria to confer increased frost resistance on potatoes. Although approved by EPA, field testing has been delayed because of legal challenges against the university and the State of California.

- **Cell fusion product for fungus control**
  A Cornell University scientist has received EPA approval to field test genetically altered strains of the fungus *Trichoderma harzanium* to determine if these new strains are effective for controlling fungi responsible for such plant diseases as damping off and root rot. The strain was produced by fusing cells of two closely related strains of the fungus. The hybrid fungus will be applied to pea and cucumber seeds.

- **Fungus strains altered by ultraviolet irradiation**
  Four strains of the fungus *Sclerotinia sclerotiorum*, genetically changed by ultraviolet radiation, are being field tested by Montana State University to determine their efficacy as herbicides against the weeds Canada thistle and spotted knapweed.

- **Baculoviruses as pesticides**
  By manipulating the organization and expression of viral chromosomes, researchers at universities in Florida, Texas, and Idaho, and at Genetics Institute, Cambridge, MA, hope to increase the usefulness of baculoviruses as pesticides.

- **Engineered marine algae**
  Protoplast fusion techniques are being used by scientists at Northeastern University, and other recombinant DNA techniques are being used in Australia to increase the efficiency of marine algae in producing beta-carotene, agar, and other useful algal by-products.

- **Toxic waste disposal**
  Researchers are seeking to engineer bacteria to metabolize specific toxic wastes such as PCBs or PBBs, dioxin, and oil spills. One such bacterium, developed by EPA distinguished visiting scientist Dr. Ananda Chakrabarty, is a *Pseudomonas* strain capable of metabolizing several crude oil components. This may improve the possibilities of biologically controlling oil spills by combining in one bacterium functions that now must be performed by several.

- **Toxic waste disposal—heavy metal recovery**
  Bacteria are being experimentally engineered to extract or concentrate heavy metal contaminants from land fill or mine tailings to minimize toxicity problems and allow future agricultural use of reclaimed land, or more efficient recovery of mineral resources. Similar applications are being developed in relation to wastewater and industrial effluent treatment.

- **Plants engineered for increased tolerance to environmental factors**
  Plants can be genetically engineered to increase their tolerance to such limiting environmental factors as salinity, drought, sensitivity to heavy metal toxicity, pests, etc. This artificial expansion of ecological niches could be exploited to bring marginal lands into use or to decrease problems of deforestation and erosion. Such developments could also reduce dependence on environmentally harmful pesticides.

- **Pollution control**
  Phosphorus removal, ammonia oxidation, and flocculation are three significant problems in municipal water purification systems that could be dealt with through use of engineered bacteria. Developing the potential for using genetically modified microorganisms created at EPA's Ada, OK, laboratory for use in removing toxic chemicals from underground water supplies and wells also represents a potential widespread application of the new biotechnology. □

"Hands-On" Training for Asbestos Control

by Dave Ryan

"Asbestos" and "hands-on" would seem to be mutually exclusive terms these days, but not to the folks at the University of Kansas National Asbestos Training Center. Using a retrofitted tractor trailer, the first of its kind in the country, they've built a mobile training unit for people who work with asbestos. Their clients are contractors, schools and building owners, and workers; their mission is to provide a real, but safe, experience in working with asbestos.

Asbestos is a proven human carcinogen, causing as many as 12,000 cases of lung and other cancers in the U.S. every year. Since the early 1970s, EPA has taken steps to reduce the risks of asbestos to the public, most recently proposing to phase out all asbestos use in new products. But while these actions will help to eliminate problems in the future, EPA estimates that millions of people still live, work, and study in buildings that hold friable asbestos-containing materials. (Friable materials are those that can be crumbled under hand pressure and are therefore likely to release fibers when disturbed. EPA considers asbestos potentially hazardous when it is in friable material.) In their concern over the presence of asbestos, many building owners have inadvertently hired untrained contractors whose poor removal efforts have sometimes made exposures worse than had the asbestos been left in place.

Aside from providing grants to states to establish contractor certification programs, EPA is providing contractors and workers with training in proper methods of asbestos abatement. Since 1985, the Agency has helped set up and partially fund five asbestos information and training centers: Tufts University in Boston; the Georgia Institute of Technology in Atlanta; the University of Kansas at Lawrence; the University of Illinois at Chicago; and the University of California at Berkeley. In the last 18 months, these five centers have trained over 7,000 participants in correct methods of identifying and abating asbestos.

(Ryan is a Press Officer in EPA's Office of Public Affairs.)

At the University of Kansas Training Center, however, officials were not content with just letting people come to the Center for training. Instead, they decided to take the training via the mobile training unit—to the people. "Asbestos control, done properly, is complex, difficult work," says Dale Grube, Director of the Kansas training center. "It allows little margin for error. Whether performed by a contractor doing a major removal project or a maintenance man repairing a leaking ceiling, asbestos abatement requires an understanding of the procedures, techniques, and equipment needed to protect employees, building occupants, and the public from exposure to dangerous asbestos fibers. The mobile van was designed to fully impart this understanding in the closest real-world simulation possible."

Outfitted with pipes, valves, hot-water tanks, duct work, flooring, walls, ceilings, and plenum spaces, the van can simulate a complete asbestos abatement operation from preparing the work area to disposing of asbestos waste. Its facilities include realistic asbestos substitutes to work with, as well as state-of-the art abatement equipment, such as respirators, negative air units, vacuums, and decontamination chambers.

The training van itself is an 8' x 40' semi-trailer with three sections. The first and second sections are "clean areas," where students become familiar with personal protective gear and learn how to thoroughly decontaminate themselves and the abatement equipment. The third and largest section is designed to resemble asbestos removal sites. This is where the bulk of the training takes place. Students are taught how to maintain or remove pipe and boiler wraps, and repair or remove ceiling materials. They also learn to use sophisticated removal equipment.

Training programs in the mobile van accommodate a group of six to 18 students at a time and last two days. In addtion, the center also offers customized training to meet the needs of specific sites and workers. Several groups are targeted for hands-on training. The primary target for the mobile training unit, of course, is those who actually work with the asbestos—workers and supervisors in contractor firms, as well as maintenance workers in public and private buildings, particularly schools. In other programs, the Center reaches architects, engineers, and consultants who develop asbestos removal plans. Finally, the center wants to reach decision makers, such as building owners and school administrators, who must choose among various abatement options and costs.

Though it has already served such diverse clients as Michigan State University, the Nebraska Deferred Building Task Force, and the Leavenworth Federal Penitentiary, the University of Kansas mobile unit is still just a prototype. Another trailer is nearing completion, and two additional designs are under study. Newer training units, for example, will be housed in converted moving vans to take advantage of their better suspension systems and smoother rides. In addition, future units will have larger training areas.

The mobile unit not only provides training for safety, it also provides contractors with hands-on training experience which is an important component of many state certification programs. Such certification programs are functioning or under development in 25 states already; several other states have legislation pending to set them up. The University of Kansas Training Center has worked with Kansas and Iowa officials to develop a training course that covers both states' requirements.

The mobile training van, as well as the five training centers, were established through funding under the Asbestos School Hazard Abatement Act of 1984. Funds are distributed to each training center over three years: $250,000 the first year, $200,000 the second year, $100,000 the third year. Centers are expected to become self-supporting by the fourth year.

"Most people think of EPA as some sort of stern regulator," says Grube, "but the mobile van gives high visibility to another aspect of the Agency, that of a positive helper in meeting environmental goals.

"Moreover," she adds, "the van and the Kansas Training Center, as well as all the other centers, are an excellent example of how a federal government agency and universities can work together to make a positive impact on a significant problem. With a relatively small amount of government funding and a lot of federal and academic ingenuity, we've come up with something that fulfills a real-world need in protecting all Americans from the hazards of asbestos." □

Practicing the Art of Biomonitoring

by David Wann

Loys Parrish, an EPA aquatic biologist, studies organisms from the stream bottom of Denver's Cherry Creek, searching for signs that will indicate the quality of the creek's water.

Some of the techniques currently used by environmental scientists seem to be as much art as science. Biomonitoring is a good example. By growing "indicator" species such as fathead minnow, crustaceans like daphnids, and algae in selected water samples, scientists can quickly determine if a given stretch of waterway should be studied in more detail. The artistry lies in deciding exactly where and how to use the indicators.

According to Del Nimmo, an aquatic toxicologist with Region 8 of the Environmental Protection Agency in Denver, "The advantages of this sort of testing are its simplicity, cost-effectiveness, and quick results. This technique can be used as a first line of defense in the protection of our surface waters."

There's no doubt that plant and animal species have served as reference points for environmental quality throughout human history. One of the first *formalized* uses of biomonitoring was the canaries which miners took with them into the coal mines to forewarn of lethal gases. When the canaries died from accumulating methane, the miners got out fast. In recent years, biomonitoring techniques have become so finely tuned and reliable that they are now being built into the regulatory process.

The Clean Water Act specifically refers to biological testing for assessing environmental hazards, especially in conditions where the mix of potential pollutants is complex. Instrumental techniques such as atomic absorption spectroscopy, which have become astonishingly sensitive in recent years, can detect concentrations as small as parts-per-trillion, but they can't effectively demonstrate the interaction of chemicals with each other, and with variables such as acidity, hardness, solubility, and exposure time.

Biomonitoring integrates these variables and can definitely tell us when chemicals have reached the toxic level. It can also help us trace contaminants back to such sources as hazardous waste facilities, since it can quickly reveal where the hot spots are.

Del Nimmo and his colleagues Jim Lazorchak and Tom Willingham have been working with bioindicators for years, all over the U.S. and even as far afield as Egypt. But their recent work has been focused on using tiny crustaceans to monitor water quality in the generally pristine streams and lakes of Montana, Wyoming, Colorado, Utah, and North and South Dakota.

Sometimes they work out of Region 8's Environmental Services mobile lab for several weeks at a time, but when flexibility and a quick turnaround are called for, they can pack an entire field laboratory into a briefcase and an ice chest. The most crucial equipment is the crustacean itself, hundreds of which can be carried in a container no bigger than a canning jar.

In function, these organisms are similar to well-trained hunting dogs or falcons, except that their repertoire of skills is limited: they dart around, eat a specially prepared diet, and, after only four days, produce their first brood. If the water sample is clean they live; they die if it's not. If the water quality falls

(Wann is a writer with EPA's Region 8 office in Denver.)

somewhere between the two extremes, a "chronic" test to observe the number and vigor of offspring will yield valuable information about the degree of toxicity. In some cases this information can be used to calculate the dilution necessary to reduce the toxicity of a given discharge to acceptable levels.

One of the biggest advantages of being a test crustacean is that the food is good. Trout chow, the entree, is concentrated into highly nutritious "soup" by being gently bubbled for a week. The soup is kept chilled until use. The second course is a tea prepared from powdered rye grass or dried alfalfa usually obtainable at a local health food store. An equal serving of baker's yeast rounds out the menu.

But lest this begin to sound like a Julia Childs' luncheon buffet, it should be emphasized that these platoons of daphnids are on very critical assignments. Like the rest of the country, Rocky Mountain and High Plains states are experiencing water contamination from both point sources like wastewater discharges and nonpoint sources such as agricultural, urban, and mining runoff. Since nonpoint source contamination can result in a wide range of potential toxicants, biomonitoring is very effective in homing in on the troublespots in large stretches of waterway. The technique is also a natural for detecting the relative toxicity of treatment plant and industrial effluent.

Biomonitoring is being carefully looked at both regionally and nationally as a means of meeting the objectives of the Clean Water Act: to restore and maintain the natural biological balance of the nation's waters, and prevent the discharge of toxic pollutants in toxic amounts. Biomonitorinng techniques can also be very effective in the proper assessment of risk, and the setting of appropriate toxic effluent limits.

In fact, the nation's first official industrial application of biomonitoring is now on line at the Ciby-Geigy chemical plant in New Jersey. The state's Department of Environmental Protection has required that the plant continuously monitor a colony of mysid shrimp, an organism smaller than the tip of a pencil point and extremely sensitive to contamination. Biomonitoring is especially valuable in this case because the company uses hundreds of chemicals in its manufacturing processes, and determining the impact of each interacting chemical would consume a lot of time and money.

The role of "Toxic Busters" seems to suit the EPA crew of water quality experts, who are often accompanied in their efforts by state and local employees. Their detective work has already uncovered many cases of toxicity with serious environmental and health impacts.

The most crucial equipment is the crustacean itself, hundreds of which can be carried in a container no bigger than a canning jar.

For example, late in 1985, EPA worked with the Colorado Water Quality Control Division and the Denver Metropolitan Sewage District on a thorough profile of the South Platte River. Acute 48-hour tests and chronic 7-day tests revealed that one of Denver's major wastewater treatment facilities was in far worse shape than previously realized. The results were unequivocal: above the treatment plant, 100 percent of the tiny crustaceans survived, whereas directly below the plant's discharges all perished.

For 16 miles downstream from the plant's effluent, survival and reproduction of the bioindicators was markedly reduced, which demonstrated that a complete range of testing was necessary. Region 8's Environmental Services lab took over at this point, running fish bioassays and the whole spectrum of chemical tests.

Another discovery resulting from the South Platte study was that one of the river's tributaries, the prairie-born Cherry Creek, had high levels of contaminants in it. At the confluence of the river and the creek, right where Denver had first been settled, there was something in the water that didn't appeal at all to the daphnid crustaceans. A later, more in-depth, biomonitoring of Cherry Creek pinpointed several sources of toxicity of both point and nonpoint origins.

Included in the Cherry Creek profile was an evaluation of invertebrate life in the bottom level of the streambed. The quantity and type of organisms present in a given square foot of stream bottom can yield valuable information about how clean the water is. In general, as water quality decreases, one observes a higher population of midge larvae (a mosquito-like insect), more caddis flies and snails, and fewer mayfly and stone fly larvae. Though the biologists wading through Cherry Creek seemed to be panning for gold as Denver's pioneers had done, actually they were in search of something even more valuable: signs of the kinds of living things proving that the water was clean and safe.

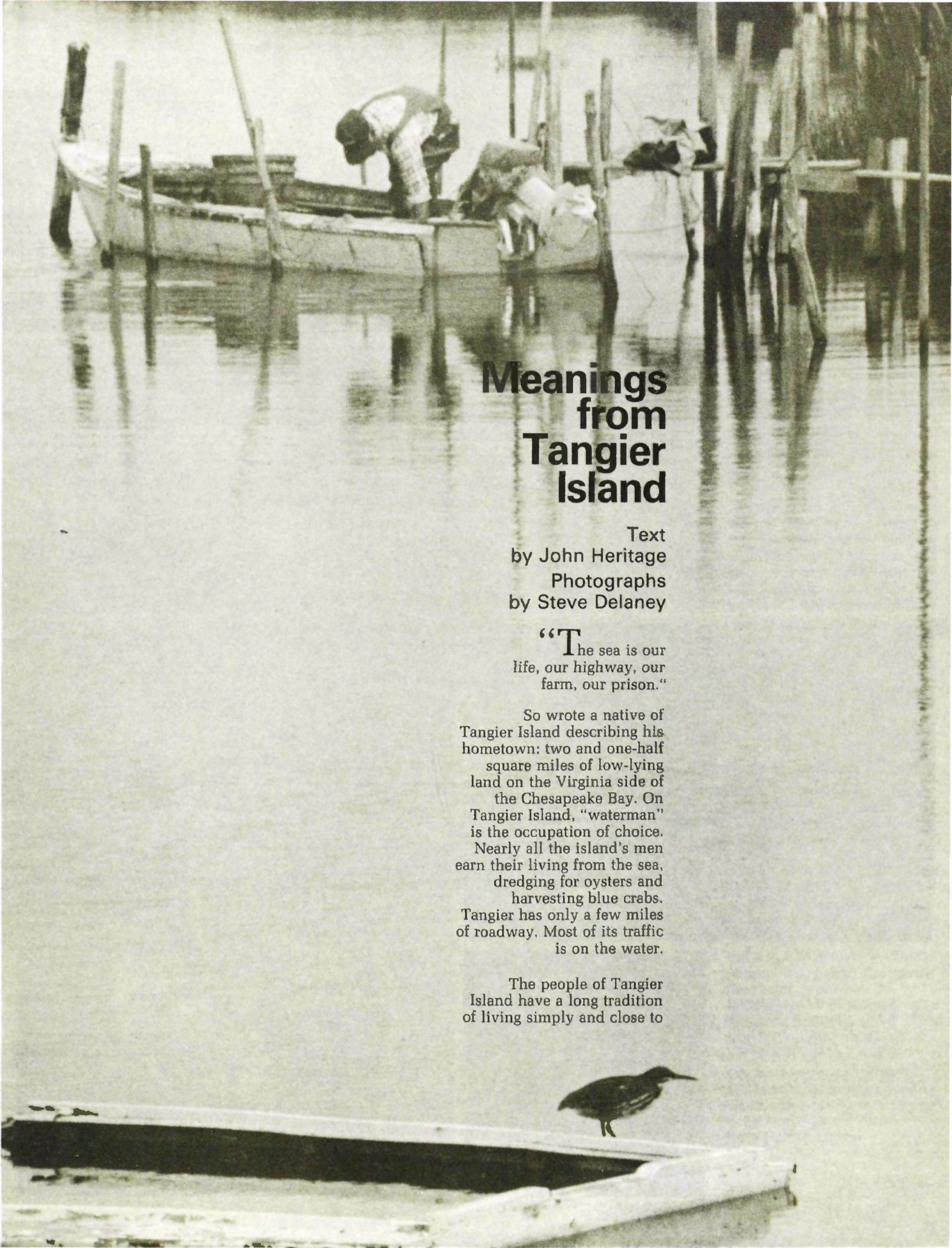
"There are a whole lot of variables here," Nimmo remarked as he looked up from his microscope. He was evaluating the results of an acute toxicity test which he and personnel from the Colorado Division of Wildlife had performed on water samples taken upstream from the Chalk Cliff fish hatchery just east of the Continental Divide. The facility and a sister hatchery supply many of the trout stocked in the state's cold-water streams. But in recent years, during periods of high runoff, substantial percentages of fingerling trout transferred from Mt. Shavano to Chalk Cliff had not survived the move. When the transfers were made experimentally to other receiving waters, the die-off didn't occur. Apparently there was something odd about the water in Chalk Creek, especially in the springtime.

Biologists observed the transferees closely and noticed that as soon as they arrived they would start jumping. At first they thought the fish had too much darkness en route and were just reacting to the light. But within 24 to 48 hours many of the trout were dead.

Extensive testing was performed on Chalk Cliff's waters for heavy metals, dissolved oxygen, pH, ammonia, hardness, etc., but the problem could not be pinpointed. Among the many possible causes were the amount of runoff during a given year, the presence of septic leach fields and greenhouse operations along the creek, the routine pesticide spraying nearby on national forest lands, and the interaction of various compounds under differing pH and temperature conditions. Finding the exact source of the fish-killing contaminants was about as easy as juggling tenpins in a space station.

Yet, biomonitoring gave quick and conclusive results. In water collected upstream from two abandoned mines, the daphnids were thriving, but water directly below the mine tailings was 100 percent fatal to the crustaceans.

"I'm proud of these critters", remarked Del Nimmo. "It looks as if they've once again saved us a lot of time, expense and aggravation." □



Meanings from Tangier Island

Text
by John Heritage
Photographs
by Steve Delaney

"The sea is our life, our highway, our farm, our prison."

So wrote a native of Tangier Island describing his hometown: two and one-half square miles of low-lying land on the Virginia side of the Chesapeake Bay. On Tangier Island, "waterman" is the occupation of choice. Nearly all the island's men earn their living from the sea, dredging for oysters and harvesting blue crabs. Tangier has only a few miles of roadway. Most of its traffic is on the water.

The people of Tangier Island have a long tradition of living simply and close to

Continued from page 17

the environment. A man checking his crab pots on a quiet summer morning; a bird flitting through the marsh grass — these are everyday scenes on Tangier. Life here is very different from the urban life with which most of us are familiar. But the island triggers reflections that might help us rediscover the meaning of our own daily efforts to improve environmental conditions, including the waters where the Tangier Island crabs flourish.

There has been in recent years a national awakening to the complexity of life and the fragility of the environment, and a growing willingness to respect and adapt to the natural scheme of things. This change in attitude represents a new reverence for basic natural values and the interrelatedness of living things, a change that reaches from salt marsh to corporate board room, from crab harvest to Congressional hearing. When we think about it, perhaps Tangier Island and the rest of the country aren't so far away from each other after all. □

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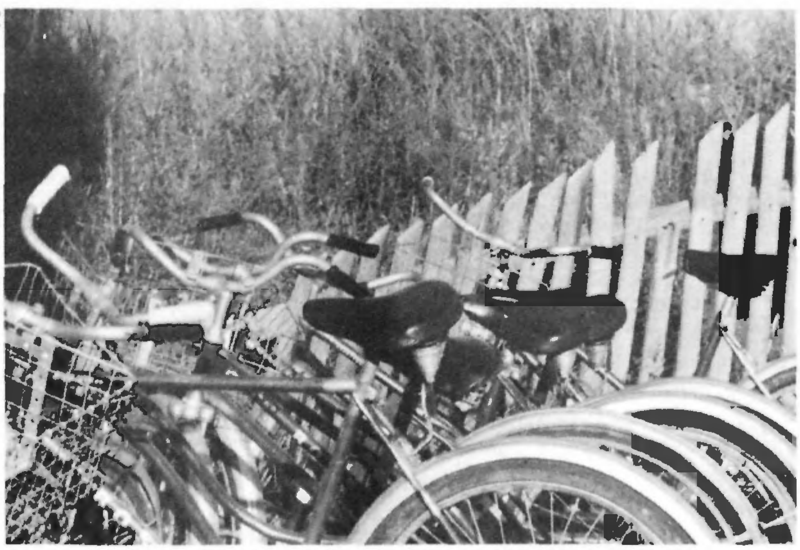

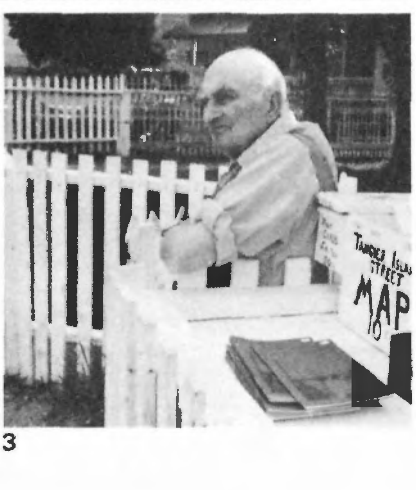

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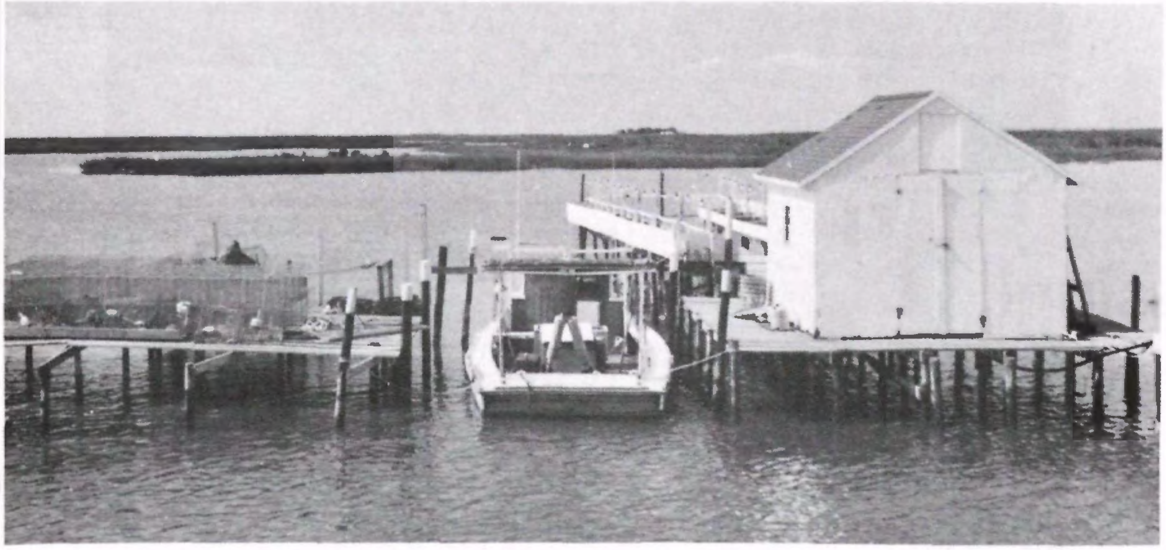

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1 *As clean laundry flaps out a beat on his backyard line, Nanner Pruitt works on the construction of a flat-bottom skiff. He will use the small boat to shuttle back and forth from shore to the crab shanties where fishing gear is stowed. The boat will also ferry him to nearby salt marshes to hunt the ducks and geese that migrate there every winter.*

2 *Bicycles lean against a backyard picket fence. Most people get around Tangier Island's few miles of narrow roadway by bike. In fact, a recent visitor to the island observed a half dozen or so trucks, golf carts, and mopeds, but not a single automobile.*

3 *A front yard entrepreneur sells his own publications to tourists. The history of Tangier Island sells for a dollar; the map, for a dime.*

4 *Looking like a character out of Huck Finn, a youngster paddles his skiff, the Sweet William. On Tangier Island, "You've just got to have [a boat]," a native once wrote: "skiffs for the little ones, outboards for the youths, and work craft for the breadwinners."*

5 *Crab traps, boats, and shanties: the essentials of life on Tangier Island. Fish bait placed inside the traps lures the crabs. A single fisherman may set out more than a hundred traps each day.*

6 *A youngster holds the prize he has just scooped up with his crab net: a peeler. This is a crab nearly ready to shed its hard exoskeleton and turn into the Chesapeake Bay delicacy known as a soft-shell.*

7 *Generations of islanders have found a final resting place in the raised graves of this cemetery on Tangier's main street. High land — nowhere more than five feet above sea level — is at a premium here. As a result, many islanders bury their kinfolk in raised graves in their front yards.*

8 *White clapboard houses of Tangier Island overlook this abandoned workboat, rotting away in the grass of an adjacent salt marsh.*

A Close Call on the Mississippi

by Roy Popkin

Slow and squat, the river barge *Wychem 112* hardly looked like the cause of a major emergency, and thanks to good luck and creative improvisation, she wasn't. But 25 years ago, she could have been the world's first synonym for a disastrous airborne chemical release.

On the morning of March 23, 1961, the *Wychem* was being towed north in the flood-swollen waters of the Mississippi River. Seven and a half miles south of Natchez, MS, and Vidalia, LA, the barge was swamped by waves, snapping the towlines and sinking the barge into the muddy river bottom. The Master of the towboat radioed the U.S. Army Corps of Engineers, reporting that the *Wychem* had sunk with a load of caustic soda.

He was right about the sinking, but very wrong about the cargo. The *Wychem* was carrying four large steel tanks containing liquified chlorine gas—enough to make more poison gas than was used in all of World War I.

Sunken barges on the Mississippi are not that unusual, and the lost vessel posed no apparent threat to river navigation. But the *Wychem's* cargo was of considerable concern to the federal government, which is responsible for the safety of the nation's navigable waterways. It was not any threat to other tows that worried government officials; it was the chlorine gas. Should the tanks or their valves be damaged, or eventually rust through, the chlorine could bubble up to the river's surface, becoming a deadly, uncontrollable cloud.

Many people think of chlorine as a water purifier, a household cleaner, something you pour into a swimming pool to kill bacteria. And it is those things. But chlorine is also a poison, causing acute, delayed, and chronic health hazards,or even death, if inhaled. Its symptoms may include burns to the skin and eyes, severe irritation of the nose, throat, and eyes, severe coughing, difficulty in breathing, congestion, and other problems.

One book describes the use of chlorine in World War I this way: "spread as a gas by the Germans—then they called it mustard gas—it wafted over allied lines, almost unnoticeable at first, just a faint metallic odor. Then there was a stronger stench. A vile yellow fog crept evilly along the muddy ground of battlefields like Ypres. Pushed by the wind it climbed the bunkers and over walls. Heavier than air, it filled the trenches, the ditches, and ravines. First the soldiers' eyes began to water, then their throats tightened. The yellow gas flooded their lungs, searing them, leaving the soldiers gasping for oxygen. They vomited, writhed into unconsciousness, and died. Even small doses left thousands crippled with respiratory diseases for life. It doesn't take much. As little as 50 parts per million in the air is enough to cause quick, horrible death."

In the National Guard armory, a large jug of chlorine was marked, "Take a sniff. Know your enemy."

The U.S. Public Health Service, responsible for air quality problems at that time, had this history in mind when it estimated there could be as many as 50,000 casualties—half of them fatalities—if the chlorine in the barges's tanks leaked and a gas cloud subsequently spread over nearby cities and the surrounding countryside.

Despite these worries, more than a year later, the *Wychem* and its lethal cargo were still at the bottom of the river. The cargo owners, their insurers, and the Corps of Engineers had all tried with no success to locate the sunken barge. In September of 1962, President John Kennedy asked the Office of Emergency Planning to look into the matter. The Corps of Engineers was assigned to find and salvage the barge, while the Public Health Service was given responsibility for public safety.

The decision taken in September set up a unique barge recovery task force. In today's lexicon, what the task force did would be called an "emergency removal."

The task force had three big jobs ahead of it: finding the hulk; raising it and its cargo safely; and devising an evacuation plan that could move some 80,000 people out of range of any toxic cloud that might be released.

Using a U.S. Navy hurricane hunter plane and an electronic probe used by oil companies to locate sunken pipelines, the Corps found the *Wychem* in a few days. It was largely buried in the mud, its "back" broken and tilted in two directions. Divers immediately began investigating the condition of the barge and the cargo, but all operations were halted when the Mississippi director of civil defense said his state was not adequately prepared for an emergency evacuation. Not until October 14 were the evacuation problems resolved and salvage work resumed.

The plan was to raise each of the four tanks individually. This was considered less risky than raising the entire barge at once, transferring the chlorine to other containers while they remained underwater, or gradually bleeding the chlorine out of the tanks to the surface.

Under the leadership of the Public Health Service, the Red Cross and various state agencies had put together an evacuation and shelter plan keyed to a special warning system and ready to go around the clock until the tanks had been safely raised and removed from the area. The federalized Mississippi National Guard on one side of the river and the Louisiana State Police on the other were responsible for carrying out any evacuation. The Public Health

Army Corps of Engineers, Vicksburg District

A chlorine tank from the sunken barge Wychem is moved by derricks onto a transport barge.

Service recommended total evacuation within a thirty-mile radius of the salvage site. The area, which included Natchez, Vidalia, and a number of smaller communities, as well as isolated fishing camps and farms, had a population of 80,000. All these people would have to be warned and moved beyond the thirty-mile limit as soon as a leak occurred. Why thirty miles? A Red Cross disaster administrator who participated in the planning meetings recalls that "we had to go by what was known about chlorine gas at the time . . . and a lot of that came from battlefield experience."

Using supplies from its own and government sources, the Red Cross established 133 temporary shelters and supporting logistical facilities in communities outside the proscribed danger area. These were manned by key personnel 24 hours a day; until the last tank was raised, many of these people had to be close to a designated telephone at all times. Hospitals, clinics, and other facilities were given special training and supplies for use in treating chlorine exposure victims.

Natchez, a riverport city and tourist attraction because of its many fine antebellum homes, was the largest city involved. National Guardsmen were posted at every street corner, day and night, to sound an alarm and assure the evacuation of everyone in adjacent homes. In the National Guard armory, a large jug of chlorine was marked, "Take a sniff. Know your enemy." Evacuation drills were held in all schools, bringing the average time it took to empty a school, tag the kids, and get them on an outbound bus down to under two minutes. In fact, because it was easier to manage the city's children while they were in school, all the tanks were raised during school hours. When raising the third tank took longer than expected, school hours were extended.

Those buildings that couldn't or shouldn't be evacuated on short notice, such as the telephone company central office and the local hospitals, were fitted with collective protectors, compressed air units that looked like giant tarantulas hanging outside the buildings. These units kept a higher than normal air pressure in designated inside areas to prevent the entrance of chlorine-laden air. Individual gas masks were issued to everyone.

During the salvage period, no sirens were used by emergency vehicles or local fire alarm systems. The populace knew that a siren meant just one thing—chlorine gas was loose. Whenever a tank was being lifted from the bottom, activity in Natchez seemed to come to a halt. Everyone listened to live radio broadcasts from the riverbank. And each time the "play-by-play" reporter on the Natchez radio station announced that a tank had been secured on a special barge and was under way, the city seemed to come back to life with a collective sigh of relief.

Tense as the situation was, it was not without humor. On Halloween, kids painted their gas masks weird colors and wore them when they went out to trick or treat. The Coast Guard, which was responsible for controlling river traffic during the operation, tried to prevent a riverboat from bringing a group of clubwomen into Natchez for a tour of the mansions. When the women persisted in touring, they were ordered to wear gas masks at all times.

At the site of the salvage operation shortwave radio operator was on duty constantly to relay word of any leak. The National Weather Service released balloons regularly to monitor wind direction, and a helicopter sat on the levee, ready to follow a gas cloud and to warn hunters, fishermen, and isolated farmsteads. Scientists in small boats circled the salvage area, ready to spray ammonium hydroxide on any tell-tale bubbles and to signal even the smallest sign of a chlorine leak. This, too, went on night and day. All salvage workers wore protective gear, and special wind machines were imported from Hollywood film studios to blow any escaping gas away from the salvage crews and emergency operations.

Under the water, after practicing in pitch black darkness, divers had to first clear away the accumulated mud and silt—in some places 14 feet deep—from the barge, than carefully remove the deck structure so they could get at the individual tanks. Then, ever so delicately, they had to remove the fastenings holding the tanks in place and just as delicately attach new straps to hooks lowered from giant derricks on the salvage barge above them. The crane operators, directed from beneath the river, had to inch each tank into a level position from its canted posture on the broken barge. Once this was done, the derricks raised the tanks—slowly—until they broke through the river surface up to 50 feet above the *Wychem's* resting place. From there, they were hoisted onto a barge and closely examined to make sure the valves were intact. Then, at last, each tank was towed to a depot in Geismar, LA, where the liquid chlorine was transferred to safe storage tanks.

The last tank was raised on November 5. All that remained of the operation were the after-action reports, and they have long since disappeared into files and libraries.

The story of the sinking of *Wychem 112* will never be the subject of country ballads, for no one died and the salvage operation plan went off without a hitch. But the potential for such incidents has increased. A report for the Federal Emergency Management Agency published early this year cited nearly 300 evacuations because of chemical accidents —more than one a week—in the United States from 1980 to 1984. The average involved one thousand people. The largest, in which 30,000 were evacuated, took place in downtown San Francisco after a piepline carrying PCBs was broken.

The largest chemical-caused evacuation on record occurred in Canada in 1979, when a freight train derailed outside the city of Mississauga in the province of Ontario.

The force of exploding chemicals tore a large hole in a tank car containing liquid chlorine, letting the chemical leak out in the form of a dangerous gas cloud. And the continuing fires not only created a danger of further explosions, but delayed efforts to seal the leak. What's more, the problem of sealing the leak turned out to be much more difficult than expected; the personnel involved had to work not only on the exterior of the tank car but had to get inside it, an extremely risky business at best. It took six days to close the holes and extinguish the fires.

Initially, only the industrial area immediately surrounding the wreck was evacuated. Then, as the escaping chlorine formed into yellow clouds, the evacuation was expanded to include everyone living within five miles of the accident site; ultimately, almost 250,000 residents, four hospitals, and all commercial establishments in the area were evacuated. It was not until five days later that the authorities permitted people to return on a sector-by-sector basis.

Army Corps of Engineers, Vicksburg District

Officers of the Mississippi National Guard instructed local residents in how to use the gas masks that were distributed in case one of the Wychem's chlorine tanks leaked.

Again, good luck and effective action by public authorities prevented another candidate for the "first" Bhopal. Fortunately, the wreck had occurred between two heavily populated areas under wind conditions that blew the gas clouds away from the population long enough to get people out of harm's way.

Events like the 1962 chlorine barge sinking or the Mississauga trainwreck would be handled much differently in the United States today. For the one thing, much more is known about the behavior of leaking chlorine and chlorine gas clouds. Federal criteria for emergency actions recommend a much smaller evacuation area than the 30-mile radius specified in 1962. It probably would be in keeping with the five-mile radius used by the Canadians, or possibly a smaller area, although Joseph Lafornara of EPA's Emergency Response Training Center in Edison, NJ, says "if I thought that the amount of chlorine they had under the Mississippi was going to be released all at once, I might urge a much larger area be cleared out."

But the major difference today is EPA's automatic presence on the scene in any situation that presents an imminent threat to human health or the environment. Chemical releases today are generally reported o the National Response Center (NRC). The NRC then contacts EPA to respond to the emergency. Although the state and local officials are responsible for carrying out evacuations, EPA's experts provide the technical leadership on decisions about the extent of danger and the area to be evacuated. EPA's computer models, for example, can test hundreds of different scenarios from an incident, thus giving emergency response agencies a quick fix on what needs to be done and how soon.

In addition, EPA has access to a multitude of quick response information systems on topics such as toxic effects of chemicals, medical treatment, identities of chemical manufacturers and transporters, and an inventory for locating response equipment.

Finally, one other important difference is the availability of guidance to help communities prepare for such incidents. EPA's Chemical Emergency Preparedness Program, activated in the aftermath of the Bhopal incident, provides information on preparing contingency plans; criteria for identifying chemicals that can be acutely toxic under certain conditions and a list of chemicals that meet these criteria; and technical training for emergency response officials. If state and local governments use EPA's assistance, future emergency operations won't be stymied by the lack of an adequate evacuation plan. If the EPA goals are achieved, every river-front community will not only know what cargoes are moving by, but also what to do if something goes wrong. It would be a wonderful legacy for *Wychem 112* to leave behind. □

Update

A review of recent major EPA activities and developments in the pollution control program areas

AIR

Chrysler Recall

EPA ordered Chrysler Corporation to recall about 93,000 cars that are exceeding the federal oxides of nitrogen emission standards.

The affected models are the 1981 Dodge Omni and 024 and the Plymouth Horizon and TC3 equipped with a 1.7 liter engine and manual transmission.

Once a remedial plan has been approved by EPA, Chrysler will notify owners of the affected vehicles by mail.

The average oxides of nitrogen emissions from vehicles tested at EPA's lab was 1.4 grams per mile (gpm). The current standard is 1.0 gpm.

1987 Gas Mileage Estimates

The Chevrolet Sprint ER tops the list of vehicles tested in EPA's gas mileage figures for the 1987 model year vehicles.

The Sprint, rated at 54 miles per gallon (mpg) for city driving and 58 on the highway, was followed by the Honda Civic Coupe HF with a 52 city and 57 highway mpg ranking. The Sprint, which has a three cylinder engine, is made for Chevrolet by Suzuki in Japan.

The top domestic models are the Ford Escort and Lincoln-Mercury Lynx diesels rated at 37 city and 45 mpg highway.

HEALTH

Guidelines for Risk Assessment

EPA announced that it will publish risk assessment guidelines setting out the approach EPA will use to evaluate the public health risk of environmental pollutants.

The guidelines will be used by agency scientists to assess the risk of given pollutants in five areas: carcinogenicity (cancer-causing effects), mutagenicity (genetic damage), developmental toxicities (birth defects), chemical mixtures, and exposure.

EPA expects that data and methodological uncertainties identified in the guidelines will spur future research in this area.

PESTICIDES

Dinoseb Pesticide

EPA has warned that pregnant women exposed to the pesticide dinoseb during its application in the field may pose a risk of birth defects to their unborn children. Women of child-bearing age are cautioned to avoid exposure to dinoseb during application. The Agency believes that dietary exposure to dinoseb is not of concern.

EPA Deputy Administrator A. James Barnes, said, "the warning is primarily aimed at making sure that the agricultural community in particular understands the health risks associated with the exposure of women to dinoseb."

Dinoseb is primarily a contact herbicide used to control broadleaf weeds. It is highly toxic to humans by exposure through the skin as well as inhalation, and label directions require protective clothing for applicators.

TOXICS

Lead in Plumbing

EPA Administrator Lee M. Thomas has formally notified the governors of the 50 states of significant new limits on use of lead in the installation and repair of public drinking water supply systems.

Thomas stated in the letters to the governors that "I recognize that you may already have instituted or be considering similar prohibitions and requirements. You are to be commended for your action."

Extensive studies have shown that lead in drinking water can cause damage to the central nervous system in humans, and that children are especially vulnerable to the toxic effects of this metal. □

Appointments

Dr. Vaun A. Newill has been nominated by President Reagan to become the new Assistant Administrator for Research and Development at EPA.

Dr. Newill, is a veteran of many years in environmental medicine both in government and in industry. He previously served with EPA from 1970-74, including 18 months as special assistant for health affairs to the Administrator, and later on assignment to the Office of Science and Technology and the Office of Energy Research and Development, both in the Executive Office of the President.

Prior to his service with EPA, Dr. Newill was with the National Center for Air Pollution Control from 1967-68 and the Division of Air Pollution, U.S. Department of Health Education and Welfare, assigned to Japan, from 1965-66. He was on the faculty in the Departments of Preventive Medicine and Medicine, School of Medicine, Western Reserve University, from 1955-1967. Dr. Newill has worked with the Exxon Corp. since 1974. He currently is regional medical director and head of the Occupatonal and Environmental Health Department, Exxon Europe, London, a post he has held since June 1985.

He received a bachelor of science degree in chemistry from Juniata College in 1943, an M.D. from the University of Pittsburgh in 1947, and a master's degree in hygiene epidemiology from Harvard University in 1960.

Frank M. Covington, Director of the Water Management Division in Region 9, has been selected to become the new Deputy Regional Administrator for Region 5, EPA.

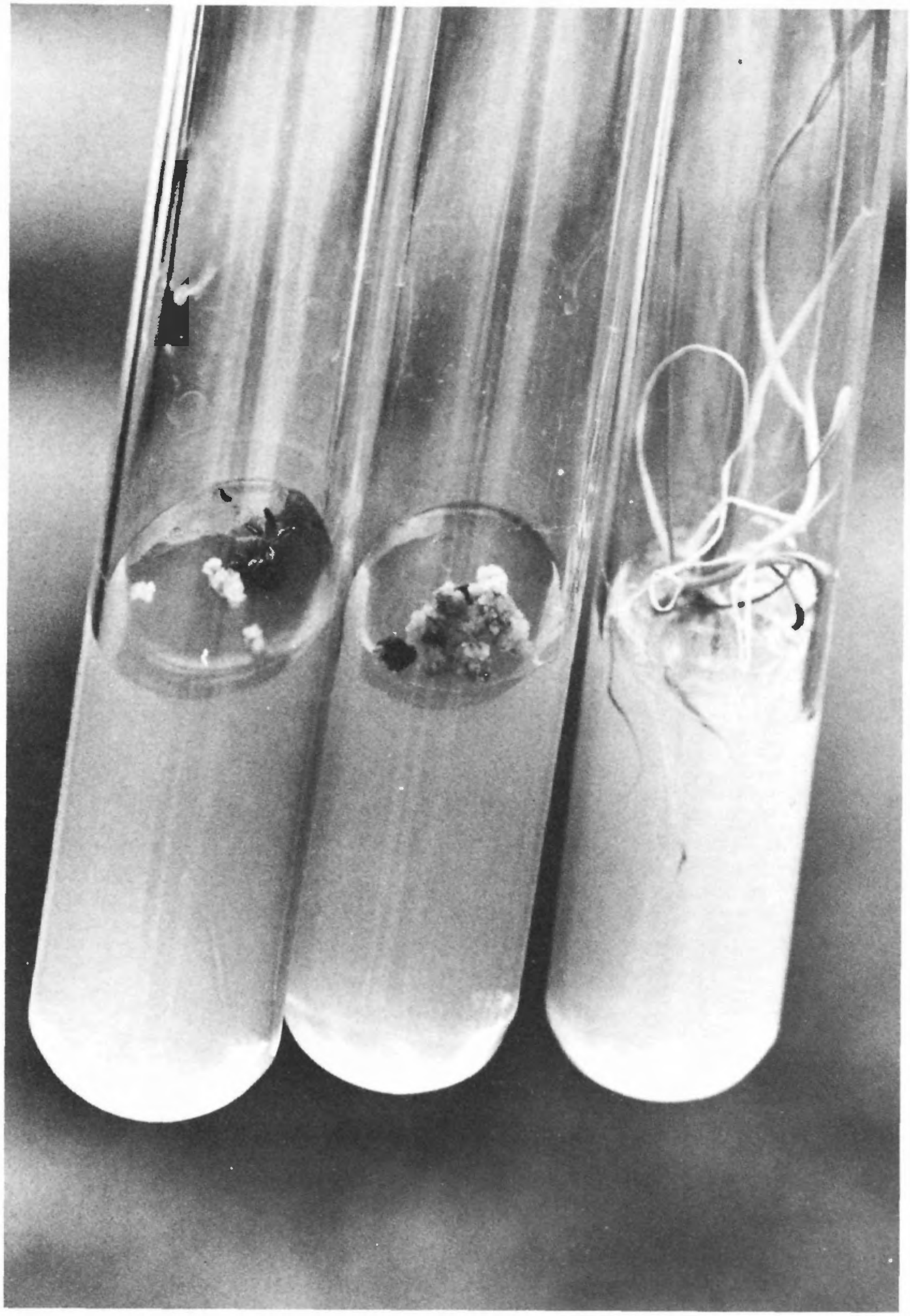
Covington brings to this position a wide range of environmental experience. He has been with Region 9 since 1971 in various capacities, including Director of the Air and Hazardous Materials Division, Director of the Enforcement Division, and Director of the Air and Water Division. In 1977, he was Acting Deputy Regional Administrator in Region 7. Prior to joining Region 9, he occupied the position of Director of Planning and Interagency Programs at EPA Headquarters. He also worked at one of EPA's predecessor agencies as Executive Assistant to the Commissioner of the Federal Water Quality Administration.

Covington received his bachelor's degree from San Francisco State University and his master's degree in business administration from Golden Gate University.

Sheldon Meyers, formerly the Deputy Assistant Administrator of the Office of Air and Radiation, will become the new Director of the Office of Radiation Programs in the Office of Air and Radiation at EPA.

Meyers, who has been with the agency off and on since its existence, has held many positions in the Agency. From 1969-77, he directed the Federal Solid Waste Program and the Federal Activities Program at EPA. From 1978-82 he was Deputy Assistant Secretary of the National Nuclear Waste Management Program at the Department of Energy, and from 1982-83, he served as Director of the Office of Air Quality Planning and Standards at EPA.

Meyers received his bachelor's degree in Marine Engineering from the State University of New York, an M.S. in Mechanical Engineering from the University of Michigan, and a masters degree in Business Administration from New York University. He received the Presidential Rank Award of Meritorious Executive in 1981. □



An experiment in culturing anthers, the male parts of flowers. The experiment bypasses the genetics of sexual reproduction to generate new plants in test tubes from bits of anthers. In this photograph, white clumps in the test tube on the left are cells forming from live wheat anthers. In the center tube, masses of undifferentiated tissue grow from the cells; and, in a special growing medium in the tube on the right, a small plant develops from the cultured tissue.

Back cover: Fall in New Hampshire.
Photo by Cynthia Foster, Folio, Inc.

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