Surgeon General's Conference on Agricultural Safety and Health
FarmSafe 2000 • A National Coalition for Local Action
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ATTITUDES AND RISK BEHAVIOR

By Pamela D. Elkind, Ph.D.
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Dr. Ronald D. Eckoff: Our next presentation will be by Dr. Pamela Elkind on attitudes and risk behavior. Dr. Elkind has a bachelor's degree in sociology from Boston University, a master's degree in sociology from Boston University, and a Ph.D. in sociology from Northeastern University with joint course work at Tufts University. Her special areas of work have been environment and energy, social impact assessment, medical sociology, rural communities, and research methods. Dr. Elkind has held a variety of research and consulting positions and for the past ten years has been at Eastern Washington University in the Department of Sociology where she is a professor of medical sociology, environmental sociology, and a research specialist. Dr. Elkind will be presenting this morning in relation to *Attitudes and Risk Behavior*. Dr. Elkind:

Thank you. Good morning. I have been asked to speak to you today about behavioral attitudes related to hazardous farm activities. To speak to this subject, three questions should be asked.

▸ Firstly, why consider agricultural attitudes?

▸ Secondly, what are the relevant attitudes?

▸ Thirdly, how are these attitudes related to farm health and safety practices?

These are the questions we will consider today.

AGRICULTURAL ATTITUDES

The first question I shall address is, Why consider agricultural attitudes? As in this extraordinary conference, farm health and safety is receiving attention in the early 90's. Coalitions of concerned citizens and organizations are becoming common. OSHA is developing regulations. NIOSH is funding large projects. Kellogg is initiating special innovation projects. Popular magazines are covering the risks of agriculture. Programs and projects that deal with the safety of farm populations are being conceptualized.

Within the framework of the various projects, there appears to be an important assumption. This assumption, simply stated, is that to make agriculture safe for the farm families and workers, it is necessary to motivate them to protect themselves from health and safety hazards.

The assumption further suggests that the way to accomplish this is to educate them about the dangers and possible negative outcomes of hazards. It is assumed that armed with the statistics and the knowledge of the means of protection, the agriculturalist will change behaviors, ultimately diminishing injuries and casualties. I shall attempt to demonstrate to you that these assumptions lack validity.

Principal persons in 206 farm families were interviewed in the State of Washington, in 1988 and 1989. The data were gathered as one of four subgroups in an analysis of farm hazards sponsored by the University of Iowa, Institute of Agricultural Health and Occupational Medicine. Many of you have referred to this as the NCASH study.

> This assumption, simply stated, is that to make agriculture safe for the farm families and workers, it is necessary to motivate them to protect themselves from health and safety hazards...I shall attempt to demonstrate to you that these assumptions lack validity.

There is a good deal of similarity between the four states, data sets, but today we will speak of Washington State. Respondents were asked to compare farming to other occupations in terms of occupational hazards, including health effects and injuries. In our Washington State sample, 80 percent of those questioned believed that farming is at least as dangerous as other occupations, and there is no significant correlation between perceptions of farm safety and gender, occupational longevity, age, education, or outside occupational status. This leads us to conclude that there is a generalized agreement across all categories in the farm population that agriculture is hazardous.

However, the knowledge that farming is dangerous does not necessarily affect the attitudes of the respondents (Figure 1). When asked if they were more concerned about farm safety and health than economic issues, as, for example, farm product prices, only 21 percent were more concerned about health and safety.

Furthermore, when later in the interview we asked if the health hazards in farming are great enough for them to discourage their children from farming, only 6 percent of the sample replied yes (Figure 2). In fact, those who felt farming was most dangerous were more likely not to discourage their children from farming.

	Number of Responses	Percent
Yes	43	20.9
No	140	45.5
Equally Concerned	53	25.7

Figure 1. More Concerned About Health and Safety Than Farm Product Prices.

There is the greatest likelihood that a farm family knows agriculture is dangerous in terms of health and injury, yet parents believe it is an appropriate occupation for their children and are more concerned over the economics of agriculture than anything else.

	Number of Responses	Percent
Yes	11	6.3
No	164	93.7

Figure 2. The Health Hazards in Farming Are Great Enough That You Could Discourage Your Children from Farming.

In an interview, it is difficult to evaluate behavior, since only reported behavior is measured. Yet, some elements may be scrutinized. Respondents were asked about the precautions they take when dealing with agri-chemicals, tractors, machinery, or with grains, feed, and bedding material.

They were asked to choose from among lists of choices, which range from staying downwind and washing one's hands to wearing protective devices and using machine or vehicle safety equipment. Though many of the safety approaches would appear to take little effort, 18 percent did none of these.

Conversely, 82 percent of the sample take some safety precaution, and there is no significant difference in their behavior with respect to the degree they consider agriculture hazardous. Some families practice a good deal of safety. About 40 percent of the sample reported that they regularly practice 5 percent to 10 percent of the safety precautions. Again, there was no significant difference between these behaviors when correlated with diverse perceptions of farm hazards.

This analysis suggests to us that:

▸ First, based on the sample of Washington State farm families surveyed, there is a good deal of knowledge about farm hazards in the population. Farmers perceive agriculture as dangerous.

▸ Second, we might conclude that the attitudes about the importance of those hazards with respect one's own life differ from the knowledge of the hazards. In fact, when weighed against the family's economic well-being or a child's future in agriculture, the hazards are overlooked.

▸ Third, behaviors of taking precautions tend to be unrelated to the knowledge of hazards. Farmers who regularly take many safety precautions do not say that farming is any more or any less dangerous than those who do nothing to protect their families and workers.

Thus, I will argue, based on the Washington State sample, that knowledge about farm-based safety and health hazards is unrelated to deep-seated values and attitudes about what is important in farm life, and it is ultimately unrelated to the behaviors found in farm families with respect to safety practices. I will further argue that if knowledge is, in fact, not related to the reported attitudes and behaviors, one cannot conclude that change in the knowledge about safety will yield change in safety precautionary behavior. There are, I might add, some number of intervening variables within the attitudinal structures of farm families that require understanding in order to discover in what way behavioral changes might take place to increase farm safety practices.

RELEVANT ATTITUDES

Next, we should discuss what the relevant attitudes are that we might consider. Research since the 1930's has demonstrated a consistent value orientation pervasive in rural farm regions. The value set is known as agrarianism. It appears to partially emanate from Thomas Jefferson's anti-Federalist thinking as appropriated from Aristotle, Locke, and Montesquieu.

The pattern is derived from farmers' backgrounds in the class struggles of the 18th century European estate system.

- Agrarianism suggests that rural life is natural and healthy rather than artificial or evil.
- The ownership of land makes the farmer self-reliant and independent.
- Agriculture is nationally important.
- Thus, farming is a virtuous occupation.

The sense of equality and independence in agriculture points to a positive benefit of democracy, and farmers tend to be fierce defenders of democracy.

Sociologists defined rural life, early in the century, as having an habitual character and an even flow. Life rested upon deeply felt and emotional relationships rooted in the steady rhythms of uninterrupted habit.

The intimate relations between persons were based upon their individuality and wholeness. The traditional lifestyle was comprised of friendship groups, neighborliness, and blood relations.

The attitudes of persons involved in 20th century agricultural production result from a lifestyle structured around conflicting values; traditional agrarian and contemporary market values clash.

The social values and ideas had their points of reference within these social groups and organizations. Farm-based economic independence and social equality foster the sharing of problems and activities by collectives engaged in land-based living over time.

However, the deepest problems of modern life derive from the claim of the individual to preserve the autonomy and individuality of existence in the face of overwhelming social forces, of historical heritage, of existence, of external culture, and of the technique and technology of life. Farmers experience these problems more than other groups. Agrarian values stress autonomy and individuality, but agriculture necessitates a great deal of interaction within the economic and political institutions of the society.

Agriculture is a scientific endeavor requiring a great deal of educational background reinforced by practical experience. It involves a knowledge base in agronomy, economic projection, and fiscal management training, personnel management training, and a solid knowledge of both the marketplace and government regulatory policy.

Farming today, at every level, is involved with local, state and federal governments in, for example, subsidies, tax adjustments, and regulations of both crop output and farm practices. Technological development necessitates a constantly changing body of regulation in agriculture.

The agricultural lifestyles, attitudes, and behaviors today are the outcome of the opposing forces of traditional agrarianism against the economic realities of a highly technical, rapidly changing society. The attitudes of persons involved in 20th century agricultural production result from a lifestyle structured around conflicting values; traditional agrarian and contemporary market values clash. The result is a shared pattern of living and thinking, which differs from both the old farm ways and the highly urbanized, post-industrial society.

SAFETY AND HEALTH PRACTICE

Finally, let us consider how these attitudes are related to farm health and safety practices. There is a paucity of research on the question, but I shall use a few of the available studies to suggest some answers.

According to Worwick, everything we know about accidents leads us to the conclusion that faulty habits and attitudes are the prime accident producers.[1]

Murphy, hypothesizing that those farmers who hold different attitudes about health and safety from other farmers would have different accident records, looked at the diversity of attitudes and accidents in Pennsylvania.[2] Using a semantic differential procedure contrasting attitudes in about 500 farmers, he found no significant difference between the attitudes of persons working where accidents had occurred in the previous five years, and those of accident-free farmers. In fact, no differences in safety attitudes or occurrences were found between farmers, when they were grouped by such demographic and structural variables as farm size, number of workers, type of farm, level of education, or hours worked on the farm.

He concludes that other factors are likely to be more related to farm accidents than safety attitudes. His suggestion is that the pressures exerted by society and the low value actually placed upon safety in the decision process is likely to cause more risk behavior and, ultimately, accidents.

Napier, et al., conducted an extension-based analysis of farm risks in the state of Ohio.[3] Their statistically based research also indicated that there were no significant demographic or structural variables that would account for the accident rate differentials on farms in Ohio. Further, they considered a farmer's accident background and decided that social learning or experience with hazards does not make a significant difference in accident rates, since people may or may not repeat their mistakes.

Farm family attitudes may be related to economic well-being, as the Washington study suggests. They may revolve around the problems of agricultural productivity and the various costs surrounding preventive measures; however, the attitudes and ultimately behaviors could also be connected to a range of risk-taking personality characteristics and coping mechanisms.

They are also likely to be related to an occupational culture. An excellent example of occupational culture could be considered that of mine workers. Yount found very definite work culture characteristics in risk behavior associated with mine workers.[4]

The manner in which they treated hazards, the interaction with respect to fear, and discourse while in social settings all demonstrated risk-taking and hazard--coping mechanisms shared by the work culture. These characteristics and attitudes are influenced by the environment of their daily work, and they influence their everyday behaviors. Similar feelings and findings are likely to be found in farmworkers.

Other elements such as ethnic or gender culture may also be related to attitudes. For example, a NIOSH/OSHA safety training story comes to mind. An Hispanic male working with hazardous materials was ordered to wear protective clothing: shoes, mask, and gloves. He wore all of these items except the gloves.

When ordered continuously to wear the gloves for his own protection, he finally responded that yellow gloves remind him of his mother washing dishes. As a strong male, he could not force himself to wear the gloves. When black gloves replaced the yellow ones, the problem was solved. In the case of this worker, there were personality characteristics associated with the cultural statement of masculinity that were outstanding. These stories are pervasive in the occupational safety domain.

What characteristics and attitudes are at play when engineers monitoring construction sites or hazardous waste sites and educated not to enter sealed tunnels beyond four feet continuously take flashlights and go into these areas? They have read the statistics, and they are well-educated persons. If asked, they respond that they have been doing it for years, or it is the only way to get the job done, or they shrug and laugh, according to one OSHA-trained supervisor.

Do each of you use seat belts? I am sure you have read the studies. And how many of you smoke cigarettes despite warnings?

Much as Murphy, Napier, et al., Aherin and others—many others—are suggesting, in order to reduce farm hazards, it will be necessary to undertake a good deal more investigation into the forces behind the formation of attitudinal behavior and far communities.[2,3,5]

The various dimensions of risk-taking behavior and their attitudinal components tend to be at the very heart of this problem. Only through a thorough comprehension of these behavioral dynamics will policy-makers and change agents design successful interventions, which are likely to alter risk-taking in order to reduce farm injuries and health hazards.□

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INDUSTRIAL CROPS OF THE FUTURE

By Daniel E. Kugler, Ph.D.
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Dr. Ronald D. Eckoff: We shift gears a little bit again now. Instead of talking so much about the workers, we're going to talk about some other things that are happening that relate. Our next presentation will be by Dr. Daniel Kugler, regarding industrial crops of the future. Dr. Kugler has a Ph.D. in Agricultural Economics from Michigan State University and works for the United States Department of Agriculture. He led economic and policy studies for soil and water conservation programs with special emphasis on the economic impacts of variable cost sharing and soil depletion on the adoption of conservation practices. In 1986, he joined the Cooperative State Research Service in Washington, D.C., to start up and manage the Department's Kenaf Development Program, a program designed to remove barriers preventing the commercialization of this non-wood fiber plant for manufacture of newsprint. In 1989, he was appointed director for the Office of Agricultural Materials, where he oversees research, development and commercialization of a number of crops, which provide new raw materials and chemical feedstocks to industry. Dr. Kugler will speak, this morning, on the topic, *Industrial Crops of the Future*. Dr. Kugler:

First, I want to thank the organizers for the opportunity to come here to Iowa and address this important conference in the area of issues, which affect the national agenda. It is always important to keep informed of changes that will affect the agricultural industry, which is so important to our country.

Specifically, I want to offer to you a glimpse of an area of agriculture that many of you know nothing about or, at most, may not think about on a day-to-day basis. It is an area that we refer to as industrial crops or agricultural materials—these being crops or materials, which provide non-food, non-feed materials to industry for use in processing and product manufacture and marketing. These materials generally do not enter the food chain either for human consumption or as animal feeds, although there are some notable exceptions in pharmaceuticals and in the area of some by-product meals that are used for animal feeds.

I thought that the best way to illustrate this area would be to provide you seven examples of industrial crops of the future. They have a variety of potentials. Some of them are commercializable now; some next week; some of them may require the remainder of this decade before they can come to the marketplace.

You will find that a number of them are surprisingly common. Others, as I have mentioned before, you may have never seen or heard of before.

ASPEN, SOUTHERN PINE

The first crop is the very beautiful aspen tree. Many of you may be familiar with it. This tree is an excellent source of wood fibers and is harvested mainly from the northern United States and from forest plantations in Canada.

The fiber from this tree is very well suited for the manufacture of dry-formed composites. Aspen, in a dry, refined form—very coarsely refined— resembles shredded wheat.

When you take it and blend it with synthetic fibers such as glass or polyester and add thermal-setting resins, you can create an air-laid, non-woven mat. This particular kind of mat can then be put into a heated compression mold to make a variety of shapes of various angles and depths that can be used in a wide variety of products with which you are very familiar.

Common applications include interior car door panels, dashboards, and the head liner that is over the top of you when you sit in your automobile. So, the next time you're rolling down the window in your car, underneath that vinyl or leather panel there may be an aspen tree.

CORN, WHEAT, RICE, OR POTATO STARCH

The second example is pretty familiar to you folks here in Iowa. Corn is very abundant and well known as a food source in our diets. However, there is more to do with corn than to just eat it.

Corn is a principal source of starch, which is being extensively explored by government, universities, and industry to make degradable thermoplastics or starch polymers. Here in the United States alone we manufacture, on an annual basis, some 60 billion pounds of plastics from petrochemical sources.

There are technologies available right now that can put up to 40 percent starch—and it can be from wheat, potato or other sources—into various kinds of plastic film such as grocery bags and trash can liners. There are other technologies that are in development that will put 85 percent to 95 percent starch into these kinds of plastic materials and use it to make a variety of molded products.

There is one effort that we believe is very significant—the Department of Agriculture and Department of Defense have joined hands with several universities and a major private company to produce degradable starch products, which will satisfy the Marine Plastic Pollution and Research Control Act of 1987. That particular act of Congress requires the Navy to cease the disposing of plastics at sea by the end of 1992, unless they are fully degradable in the marine environment. This is a very, very busy project. It is a very challenging and, we believe, achievable opportunity.

INDUSTRIAL RAPESEED AND CRAMBE

For the next industrial material, you will see a very beautiful slide of a crop in the state of Idaho. It is industrial rape seed. Many of you may know a cousin of this crop, called canola. The canola variety vegetable oil is sold in your supermarket under the Puritan label, from Proctor and Gamble.

The industrial variety of rape seed, however, retains a high content of erucic acid, and that erucic acid can be used to manufacture a number of functional fluids, plastics, and nylons. I have several examples of things we are doing with high erucic acid rape seed.

We have been working with some companies and universities to produce an automatic transmission fluid supplement, which is made from the derivatives of rape seed oil. Tests have shown at this point, when compared to standard factory-fill fluids, that with this particular kind of supplement, wear is reduced 50 percent, oxidative breakdown is reduced 24 percent, and that pentane insolubles are reduced some 60 percent.

In another product, we are producing cutting fluids from rape seed oil. The cutting fluids show longer use. They show extended tool life. In addition to that, there are no halogenated fluids produced, which require hazardous waste disposal.

One other very significant product, which has been made from crambe oil, another crop source of erucic acid, is nylon 1313. Crambe, indeed, is a crop of the future and nylon 1313 is a product of the future because it is very lightweight, has very low water absorption characteristics and shows exceptional dimensional stability. We expect in the near future that nylon 1313 will be used in a variety of aircraft and marine applications.

GUAYULE

My fourth example is another very interesting crop. Guayule is native to the southwestern United States and northern Mexico.

It is a perennial shrub that reaches maturity at about three to five years of age. We extract natural rubber and resins and a variety of other chemical feedstocks from the plant's steno, branches, and roots.

The advanced varieties of this particular plant have about 10 percent high molecular weight rubber, which is very similar to and comparable in performance with the Hevea rubber, which we import mainly from Malaysia, Thailand, and Indonesia. We are currently 100 percent import dependent for our nation's rubber supply, and it costs us a billion dollars a year in export dollars.

Right now we are manufacturing tires made from guayule natural rubber, which will go on the Navy's F18 and A4 aircraft at a Goodyear plant in Virginia. We are also manufacturing light truck tires, which will be used for testing by the Army at a Firestone facility in Illinois. These are very important strides forward in developing a domestic rubber industry.

In addition to the natural rubber in this particular plant, there are some very interesting resins. The most notable one can be used to produce a strippable coating for preservation of machine parts and mothballing aircraft. We are currently seeking work with the Air Force to test out this particular coating.

KENAF

The fifth example is another industrial crop that many of you may know if you have an ornamental hibiscus plant in your yard at home. This is a hibiscus grown for its industrial fibers, called kenaf. It is an annual plant of tropical and semitropical origin, native to east central Africa.

In the cotton belt of the United States, this crop will grow 12 to 20 feet tall and produce six to ten tons of dry matter per acre. The fibers of this particular plant are very interesting. There are two fibers in the plant: a bark and an inside core. They make a very natural mixture for manufacture of newsprint.

The outer fibers are long and tough and strong. The inner fibers are short and flat and make good filler and surfaces. When you take the entire plant and thermomechanically pulp it, you make a very high quality pulp that makes a very high quality newsprint, which has been accepted by the newsprint industry as a real commodity.

Currently in the state of Texas, there are plans to build a $50 million newsprint mill based on kenaf. We hope to see those plans activated this year and to see newsprint in production by the end of 1992 or early 1993.

In addition to newsprint, there are a variety of other products made from kenaf fibers, which show premier. These are composites, packaging, poultry litter, high-grade specialty papers, absorbants and soil amendments.

PACIFIC YEW TREE

The next example of an industrial crop is the Taxus plant, an ornamental yew used as a landscaping shrub all over the country. Bark of the Pacific yew tree and needles and twigs of ornamental Taxus shrubs yield a complex natural chemical called taxol.

According to the National Cancer Institute, taxol is the most important anticancer drug in 15 years and is in the last stage of cancer. The Department of Agriculture has organized an effort to establish immediate, medium and long-term supplies of the tree bark and shrub clippings for extraction of the drug. Agriculture will help provide the renewable raw material for this life-saving drug.

SOY BEAN

The last example, like corn, is another very familiar agricultural plant. But also like corn, there is more to do with soybeans than eat or feed it.

Printer's ink using soybean oil has been under development since the early 1980's and inks with 30 percent soybean oil are in use. Notably, *The Gazette* in Cedar Rapids, Iowa, under the leadership of Joe Hladky, Publisher and Chair of the American Newspaper Publishers Association Technical Committee for Inks, is the pioneer in daily commercial use.

In March 1991, the Department of Agriculture announced a 100 percent soybean oil ink that is completely compatible with newspaper presses. This formulation removes all the petroleum from the ink and shows low rub-off, lower cost, and more environmentally soundness in terms of degradation and recycling of old newsprint. If all newspaper ink were made with soybean oil, it would require 40 million bushels.

RENEWABLE MATERIALS

We are talking about renewable materials from agriculture, and I stress the word "materials." We are looking to make polymers, functional fluids, composites, structural materials, natural fiber products, and pharmaceuticals—all of which are extremely important to the health of our business and industry in this country.

Why do we do this? There is a variety of reasons. There are some very obvious balance-of-trade implications here, where we can reduce the imports of certain commodities, in particular petroleum and rubber. There are opportunities to turn around and export things that we currently import.

There are very obvious areas in which we can improve the competitiveness of our country by utilizing the excess productive capacities of our farmland to produce new crops or to use some of the crops that we are currently producing in excess. All of this, of course, is designed to spur rural economic development, increase our domestic production and add value to our agricultural materials at home, send them to the international market place.

> In addition to that, we are trying to alter the image, to some extent, of agriculture, and to let this country and the world know that agriculture, indeed, is a very high-tech business.

In the area of leadership, one of the things we would like to be able to do in this country is to be a leader in technology development. One thing we have done an excellent job on in this country, for years and years, is research.

We are the pre-eminent research country in the world, but the honest truth is, we have not done a very good job of taking those research results and moving them into the marketplace by doing value-added work. Many other countries come here, take our research discoveries and inventions home with them, make the products and then deliver them back to us. There is no need for that. We can do much of that here in our own country.

How are we going at this? The Office of Agricultural Materials is a very small office. We are working very closely with industry, very closely with academia, and very closely with state and federal government to do something that Washington calls "precompetitive generic technology development." We are trying to enable commercialization, that is, to bridge the gap that currently exists between the research bench and the marketplace.

In addition to that, we are trying to alter the image, to some extent, of agriculture, and to let this country and the world know that agriculture, indeed, is a very high-tech business. We are every bit as sophisticated as and have scientific talent on a par with those that are conducting research on supercomputers, high-performance ceramics, etc.

To close, let us look at this slide that shows the official seal of the United States Department of Agriculture. It has an animal-drawn plow in the front and some shocks of corn in the back. Focus your attention at the statement at the very bottom, where it says:

Agriculture is the foundation of business and commerce.

Industrial crops and many other crops can be and are strengthening and enhancing that foundation.□

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BIOTECHNOLOGY AND AGRICULTURE

By Jane Rissler, Ph.D.
Biotechnology Specialist
National Wildlife Federation

Dr. Ronald D. Eckoff: Our final presenter this morning is Dr. Jane Rissler, who will be speaking about biotechnology and agriculture. Dr. Rissler received her Ph.D. degree in plant pathology from Cornell University and conducted post-doctoral research in fungal physiology at the Boyce-Thompson Institute for Plant Research. She has taught and conducted research in the university setting for a number of years. Since 1983, Dr. Rissler has been engaged in biotechnology science and regulatory policy work. From 1983 to 1988, she was at the Environmental Protection Agency where she was involved in the formulation and implementation of biotechnology policies. She served as a science advisor for and a project manager of the Pile Technology Project that operated under the Toxic Substances Control Act and was a special assistant in biotechnology to the EPA Assistant Administrator for Pesticides and Toxic Substances. In those position, she helped to develop EPA biotechnology regulatory policy and coordinated EPA's activities in the development of the Federal regulatory framework for biotechnology. She currently is a biotechnology specialist with The National Wildlife Federation. As part of her work in the National Wildlife Federation's National Biotechnology Policy Center, she has recently authored or co-authored several documents: *Biotechnology's Bitter Harvest, Herbicide Tolerant Crops and the Threat to Sustainable Agriculture, Natural Resources and Environment, Biotechnology and Pest Control: Quick Fix Versus Sustainable Agriculture* published in the *Global Pesticide Monitor.* She is the co-editor of the *Gene Exchange* a National Wildlife Federation Newsletter that provides a public voice on genetic engineering. This morning, Dr. Rissler will discuss *Biotechnology and Agriculture.* Dr. Rissler:

INTRODUCTION

I was asked to come here today to talk with you about potential farm worker health issues raised by the use of biotechnology products in agriculture. In fulfilling that request, I will briefly explain the technology, where it is likely to be heading in the next decade, and some concerns for worker safety that may arise from the technology. I appreciate the opportunity to provoke discussion of biotechnology and agricultural worker health issues and hope that worker safety experts will consider and evaluate these issues as the technology is developing and before its widespread use.

Before I begin, however, I would like to tell you of my biases that are relevant to this talk. I represent a major environmental group, the National Wildlife Federation, the country's largest conservation, education, and environmental advocacy organization, with over 5.8 million members and supporters and 50 affiliated state groups.

Four years ago the Federation established the National Biotechnology Center, to try to prevent the environmental and human health consequences associated with other technologies, such as the synthetic chemical, fossil fuel, and nuclear technologies. The Center's objectives are to minimize the risks of this new technology and to ensure that the public has a role in the regulation and development of the technology.

I am here, not as a proponent of agricultural biotechnology, but as a skeptic—a skeptic who fears that the technology poses significant risk and uncertainty. Furthermore, from a vantage point of studying the industry for nearly eight years, I seriously question whether biotechnology should or can assume a major role in answering the environmental, human health, and productivity problems facing U.S. agriculture.

WHAT IS BIOTECHNOLOGY?

Broadly speaking, biotechnology refers to the use of living organisms as products or processes for humanity. People have used organisms for food and drink (e.g., yogurt, bread, wine, cheese) for millennia. From early agriculturalists to 20th century plant and animal breeders, humans have manipulated living organisms to improve food and fiber production.

I am here, not as a proponent of agricultural biotechnology, but as a skeptic—a skeptic who fears that the technology poses significant risk and uncertainty.

Advances in molecular biology in the last three decades allow human beings to manipulate organisms in dramatically different ways than are possible with traditional breeding methods. Many of these methods have been developed out of basic research in the 1960's and 1970's and have been adapted in the last 15-20 years to produce commercial products.

These methods, along with the products and processes developed using them, constitute modern biotechnology. The terms are not used precisely or consistently. Sometimes the term biotechnology is used to characterize a small subset of techniques, that is, genetic engineering, gene splicing, or recombinant DNA techniques. Other times it is used in varying degrees to include other techniques.

A Powerful Technology

This is a powerful technology—a technology in its infancy. As an illustration, I use the words from a promotional piece from Monsanto, a company that made a huge investment in biotechnology:

> *A new science destined to take [hu]mankind into technology as a scientific milestone comparable to the realization of atomic energy or the development of semiconductors and powerful computers.*[1]

The power of the genetic engineering—gene splicing—techniques comes from the capacity to combine genes from a wide array of organisms: mouse genes in tobacco plants, human genes in bacteria, or chicken genes in potatoes. Traditional breeding techniques are dramatically more limited in the range of possible gene combinations. Only closely related organisms can be interbred by traditional means. By combining genes from widely disparate organisms, genetic engineers will create a variety of genetically novel organisms impossible by traditional means.

Expected Products

Using genetic engineering techniques, cell and tissue cultures, and other modern techniques, the industry promises transformations in the way food and fiber are produced and processed in this country. Among the products already on the market and that we can expect to see in the near future or within a decade or two are the following:

1. Genetically engineered food (grain, fruit, vegetables, oil) and fiber crops—for example, genes from insects, chickens, mice, fish, bacteria, viruses, and unrelated plants have already been splices into crops; these crops have been field tested in the last two years.

2. Food and food supplements from genetically engineered microorganisms—cheese, yogurt, alcoholic beverages—for examples, a cheese enzyme produced by bacteria containing a cow gene is already in wide commercial use and tryptophan, a food supplement derived from genetically engineered bacteria, was on the market; it was removed because nearly 30 people died and hundreds more became ill with eosinophilia myalgia syndrome as a result of consuming the product; whether the genetic engineering contributed to the toxicity is not yet known.[2]

3. Genetically engineered food animals—cows, pigs, chickens, fish—carp with a trout growth hormone gene are being tested in ponds in Alabama; pigs and cows containing human genes have been produced.

4. Genetically engineered hormones, antibiotics, vaccines—among the products thus far developed, bovine growth hormone, derived from genetically engineered microorganisms, is being used to enhance milk production; a recombinant vaccine against pseudorabies is already on the market; a recombinant rabies vaccine is being tested in wild animals in Virginia and Pennsylvania.

5. Genetically engineered microorganisms to control plant diseases and enhance crop growth—several recombinant microbes have already been field tested.

6. New uses of crops and animals to produce commercially valuable chemicals—cows producing drugs in milk; tobacco plants producing anti-cancer proteins.

While this list is incomplete,[3] it gives an idea of the power of a technology still in its infancy.

BIOTECHNOLOGY COMPANIES

The following are companies that are farthest along—as measured by their progress in field testing genetically engineered plants and microorganisms—in developing novel organisms for use in agriculture:

- Monsanto
- Ciba-Geigy
- DuPont
- Sandoz
- Calgene
- BioTechnica
- Upjohn
- Pioneer HiBred
- Crop Genetics International
- Northrup King
- Rohm and Haas
- Agrigenetics Advanced Sciences
- Agracetus
- Canners Seed
- Amoco Technology
- Boyce Thompson Institute
- Wistar Institute
- Rogers NK Seed
- Dekalb Plant Genetics
- Frito-Lay
- Campbell Institute for Research and Technology.

WHAT FARM WORKER HEALTH ISSUES ARE RAISED BY AGRICULTURAL BIOTECHNOLOGY?

Based on industry predictions about the nature and pace of agricultural biotechnology, it is obvious that farm workers will be exposed to genetically engineered organisms: micro-organisms, viruses, plants, animals.

> I hope that this presentation will provoke a wide-ranging consideration and evaluation of the potential impacts of biotechnology on farm worker health.

Keeping in mind that this is a new technology, one based on a highly artificial manipulation of living things, one that poses significant unknowns and uncertainties, it is time to begin discussing the agricultural worker-health ramifications of biotechnology. The organizers of this conference, is placing this talk on its agenda, recognized this need. I hope that this presentation will provoke a wide-ranging consideration and evaluation of the potential impacts of biotechnology on farm worker health.

The experiences that we have to draw on to initiate this discussion come from genetic engineering research laboratories,[4] the pharmaceutical industry where genetically engineered organisms have been used for some time, and industries and agriculture based on traditionally developed microorganisms, plants, and animals.

A complete discussion of risk[5] would require consideration of both hazards and exposure. This talk is limited to an attempt to identify potential farm worker health hazards that may develop from a large commercial agricultural biotechnology industry. I have not attempted to describe exposure beyond general statements indicating that more farm workers are likely to be exposed to increased numbers of living organisms—both genetically engineered and conventionally bred ones—and their products.

The list of potential hazards I offer may be incomplete; I welcome suggestions. Some are more speculative than others. As the hazards are evaluated by experts, some will be judged as more problematic than others. Some concerns are the same that one would expect with non-engineered organisms.

POTENTIAL BIOLOGICAL HAZARDS

Opportunistic Pathogens[6]

Several factors point to the potential for increased problems for genetically engineered organisms that are opportunistic human pathogens. Developers may engineer microorganisms whose opportunism is unknown. Scientists may unknowingly engineer an opportunistic pathogen for one of two reasons.

- First, they are working with organisms about which little, including opportunism, is known. Splicing genes into an organism requires little or no information about the organism's ecological or pathogenicity traits.

- Second, engineers may have some information on the organism's ecological characteristics but, because of isolation between scientific disciplines, the scientists may not know that the same organism has been classified as opportunistic (or even frank pathogens) by human health experts.[7] The organism may, in fact, have different taxonomic designations in two different disciplines.

1. Farmers and farm workers, as a population engaged in one of the nation's two most hazardous jobs (the other is mining), may often be unhealthy and highly stressed as a result of their occupation[8]—and more susceptible than the population at large to opportunistic infection.

2. In addition to their occupational stress, the farm worker population is likely to show an increase in the number of immunosuppressed or compromised persons as a result of the epidemic of acquired immune deficiency syndrome (AIDS) and related diseases. Persons with suppressed or compromised immune systems are generally more susceptible to infection by opportunistic pathogens.

One example of an opportunistic pathogen that already is the subject of biotechnology research and development is the vaccinia virus—the virus originally used to immunize the human population against smallpox. The vaccinia virus has long been known to cause, though rarely, disease and death, including encephalitis,[9] in immunocompromised/suppressed persons. Recently, three persons infected with AIDS reportedly died after being inoculated with a vaccinia virus.[10]

Work is underway to genetically engineer vaccinia virus to make vaccines against a number of animal diseases, including rabies and rinderpest. To create these vaccines, one or a few genes is taken from the rabies or rinderpest virus and spliced into the vaccinia virus. The genetically engineered vaccinia virus then is used to inoculate animals to prevent rabies or rinderpest from developing.

FRANK PATHOGENS[11]

Generally, we expect that companies will not use and regulators will not permit the use of genetically engineered human pathogens in agriculture. However, a problem arises because of the potential for splicing genes into poorly characterized organisms, some of which may be human pathogens. As noted above, scientists may engineer organisms about which they know little in terms of ecological or pathogenicity traits.

Another question that may arise is whether genetic engineering could transform a nonpathogen into an opportunistic or frank pathogen. Because pathogenicity is generally a complex trait controlled by many genes, it is not likely that splicing in one or a few genes could create a pathogen. On the other hand, there are instances where engineering an organism that is closely related to a pathogen, i.e., already possesses most of the characteristics of a pathogen, might change that organism into a pathogen.[12]

ENDOTOXINS[13]

Greater use of gram-negative bacteria (e.g., pseudomonads and rhizobia) in biotechnology applications may increase the incidence of respiratory problems among farm workers. Some scientists have hypothesized that the endotoxin portion of the gram-negative cell wall may be responsible for the respiratory disorders associated with a number of agricultural industries: grain and silage handling, pork and poultry production in confined facilities, composting, and poultry processing.[14]

ALLERGENS[15]

Allergens, which incite a hypersensitive reaction, include substances produced by plants, animals, and microbes. If biotechnology achieves even a portion of the success promised by its proponents, there will be an increase in the agricultural use of living and novel organisms—and their products.

Consequently, we may see an increased incidence of hypersensitivity—due to greater exposures to living organisms, in general, and due specifically perhaps to changes caused by genetic engineering. Genetic engineering may introduce new allergens, for example, by producing expected secondary metabolites in microorganisms. Foreign genes in crops may produce new allergens in the plants and their pollen.

ANTIBIOTIC RESISTANCE

Many novel organisms are genetically engineered to resist one or more antibiotics. This is a trait added, not to improve the organism, but to confirm that gene splicing has been successful. Splicing in antibiotic resistance is part of standard genetic engineering methodology. The worker health issue that arises is the extent to which the unintentional ingestion of antibiotic-resistant microbes could result in the subsequent transfer of antibiotic resistance to gut microflora and eventually to pathogens.[16]

Transfer of antibiotic resistance to pathogens could make them resistant to therapeutic control by the drugs to which they are resistant. Thus far, most drug resistances used in genetic engineering in this country are antibiotics not widely used clinically.

UNEXPECTED/UNKNOWN HAZARDS

This is a category of hazards whose definition will only be known in retrospect. Generally, what I am proposing is that there may be unexpected and as yet unknown hazards associated with this highly artificial technology—perhaps a new illness or an old one unexpectedly associated with genetically engineered organisms.

Already genetic engineering has produced unexpected effects. Three examples are:

1. Naked DNA from human cancer cells can unexpectedly trigger tumors when the DNA is applied to abraded skin. It was previously thought that DNA had to be transported into target cells by a carrier.[17]

2. Human or bovine growth hormone genes spliced into pigs gave the expected result—leaner pigs. However, the genetically engineered pigs also displayed unexpected deleterious effects: arthritis, gastric ulcers, weak muscles, and lethargy.[18]

3. Experiments with petunias, genetically engineered to alter pigment production in flowers, showed "results . . . completely different form those the scientists expected."[19] Not only was the actual frequency of nonpigmented flowers ten times greater than expected, but the flower pigmentation responses to environmental conditions were totally unexpected.

POTENTIAL CHEMICAL HAZARDS

One of first agricultural biotechnology products to reach the market will be crops engineered to resist herbicides, that is, crops created so farmers can apply more of certain herbicides to obtain weed control and not harm plants. Some of the herbicides for which plants are being engineered for resistance are 2, 4-D, bromoxynil, glufosinate, glyphosate, and sulfonylurea. Increased use of certain herbicides, particularly those like 2, 4-D and bromoxynil, which are known or suspected to be human health hazards, poses risks to workers who apply them or are otherwise exposed.[20]

On the other hand, a potential improvement in farm worker safety may come from genetic engineering for pest resistance, such as splicing insect toxin genes into plants. Pest-resistant crops may provide at least a short-term decrease in the use of dangerous insecticides and fungicides.

WHAT SHOULD BE DONE TO ENSURE WORKER SAFETY IN AGRICULTURAL BIOTECHNOLOGY?

Four actions will go a long way toward enduring the safety of farm workers exposed to agricultural biotechnology products.

1. Evaluate risks. Public and occupational health experts should begin to evaluate the risks that a growing agricultural biotechnology industry poses to farmers and farm workers.

2. Use only no- or low-risk organisms, ones that are well-characterized and thoroughly evaluated, for potential human health hazards. Only these should be approved for agricultural use.

3. Reduce exposure to biotechnology products. Standard approaches, such as worker protection equipment, procedure, and training, should be adopted to reduce worker exposure to biotechnology products.

4. Initiate and maintain medical surveillance. The case for surveillance is best made in a report from a Centers for Disease Control/National Institute for Occupational Safety and Health (CDC/NIOSH) *Ad Hoc* working group on medical surveillance for industrial applications of biotechnology.[21]

Uncertainty provides the strongest argument for maintaining medical surveillance over workers engaged in industrial applications of biotechnology. As is the case for any newly developed technology, there is a lack of information concerning the nature or severity of any acute or chronic health hazards, which might be associated with the industrial applications of this technology. The CDC/NIOSH working group is of the opinion that medical surveillance of biotechnology workers constitutes prudent medical practice. Such surveillance should be aimed at the early detection of sentinel disease events.

The detection of any occupational illness caused by recombinant organisms or their products will have important biological and public health consequences and should be actively sought.□

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4. In the 1970's the major risk associated with the new genetic engineering technologies was the potential for disease among laboratory researchers and the public. Conferences were held and experiments were conducted to evaluate the human health risks (see for example, *Risk Assessment of recombinant DNA Experimentation with Escherichia coli K12*, Proceedings from a Workshop at Falmouth, MA, published in *The Journal of Infectious Diseases*, Volume 137, Number 5, May 1978). Since that time, in the absence of epidemics attributable to recombinant DNA, the fears have largely dissipated. However, as far as we know, there have been no extensive, systematic studies monitoring the health of recombinant DNA researchers—recent disturbing report may cause a reconsideration of the safety of some aspects of genetic engineering research. See, for examples, "Some DNA Lab Work Raises Cancer Risks," *BioWorld Today*, October 12, 1990, page 1; "Cancer Deaths Probed at Pasteur Institute," *Science*, June 27, 1986, page 1597.

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6. Pathogens that do not cause disease in healthy individuals but may do so in certain unhealthy or stressed persons.

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10. "Deaths of 3 Patients Not Included in Report About AIDS Experiment," *New York Times*, April 14, 1991.

11. Outright pathogens; pathogens that cause disease in healthy persons.

12. See "Phenotypic Properties of Source Microorganisms and Their Genetically Modified Derivatives," pages 99-112 in National Research Council, *Field Testing Genetically Modified Organisms: Framework for Decisions*, National Academy Press, Washington, DC, 1989, for a discussion of the potential effects of genetic engineering on pathogenicity.

13. Components of the cell walls of gram-negative bacteria.

14. See discussion and references in "Inhaled Endotoxin and Decreased Spirometric Values" by R.M. Castellan, S.A. Olenchock, K.B. Kinsley, and J.L. Hankinson, *The New England Journal of Medicine* 317: 605-610, 1987.

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