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THE ECONOMICS OF NEW INDUSTRIAL USES

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Executive Summary

I appreciate the opportunity to talk with you this afternoon about the Federal government's role in commercializing new nonfeed and nonfood uses of agricultural commodities.

In the remaining fifteen to twenty minutes I will:

1. provide a brief history of "new" nonfood and nonfeed uses of agricultural products. I will also show that many of these uses are not new at all, but the degree of action and the opportunities for success are new;

2. suggest that government support of commercial research and development must be based on the argument that private industry, acting in response to market incentives, will underinvest. There are basically four reasons why private industry may underinvest - problems with property rights, externalities, benefits localized in the public sector, and financial market/time preference considerations; and

3. outline the Federal government's response to new industrial uses.

A. **Brief History**

In the January 1927 edition of *Farm & Fireside* Journalist Wheeler McMillen wrote:

> "... Some of these days--not yet, but in time--you may run your own tractor and automobile with your own grain and potatoes, paint your buildings with your own soybeans, read magazines and newspapers printed on your own cornstalks and straw, and listen through radio horns and telephone receivers made out of your own corncobs and oat hulls."

McMillen argued that using raw materials from agriculture as a feedstock for industry would improve economic conditions in rural America. His diligence, along with some financial aid from Henry Ford, led to the formation of the Chemurgic Council in 1935. The Chemurgic Council had three primary aims:

- develop new nonfood uses for established farm crops;
- establish new crops for new or old uses; and
- discover profitable uses for agricultural wastes and residues.

The development of new uses for agricultural and forestry materials has also had a long history of Federal government support. In 1938, four USDA Regional Research Laboratories were created at Albany, California; New Orleans, Louisiana; Peoria, Illinois; and Wyndmoor, Pennsylvania. Their mission was and is to find new uses for farm products and to develop new products and materials. Over the years, this has included the development of water-based paints, plywood glues, animal fat detergents, lubricants and cutting oils, permanent press fabrics, and a low-cost method to produce penicillin.

More recently, during the Reagan administration, Secretary of Agriculture Block held a national "Challenge Forum" on new uses. Also, Secretary Madigan's "Vision For the Future" includes a strong commitment to research, develop, and commercialize new nonfeed and nonfood uses of agricultural commodities. He believes that U.S. agriculture must capitalize on recent market opportunities presented by the increased demand for environmentally friendly, safe-to-handle products. Madigan also believes the development of these markets will enhance the economic vitality of American agriculture.

Table 1 provides a brief listing of agricultural crops which have direct applications as industrial feedstocks. As you can see, McMillen's predictions

Table 1. Examples of Crops and New Uses.

SOURCE	PRIMARY PRODUCTS	CURRENT USES	POTENTIAL NEW &/OR HIGHER-VALUE USES
Animal Fats Vegetable oils	Fuels	Diesel fuel	Bus and equipment fuel for clean air attainment
Starch crops, primarily corn	Fuel and octane additive	Mixed 1:10 with gas	Increased use in gasohol, ETBE octane-enhancer
Forest products	Composite materials, chemicals	Tanning agents, adhesives, alcohol	Wide range of chemicals, plastics, synthetic rubber
Kenaf	Short and long fibers,	Poultry litter, specialty paper	Newsprint, paper products, composite materials
Livestock by-products	Hides, fat, bone and blood	Medicines, sutures, films	Plastics, medicines, photographic film, industrial chemicals
Starch and protein from crops	Biodegradable polymers	Limited use in degradable polymers	Extensive use in new high-performance polymers

are not too far from our current productive capabilities. Table 1 also shows that if these new uses are economically, politically, and socially viable, then agriculture can play an important role in the industrial evolution of the United States, and possibly the world.

B. Government Involvement in "New Use" Commercialization

Since the 1940's, private and public research in agricultural production has helped reduce labor requirements by 75 percent and increase productivity by 230 percent. Surveys on the profitability of agricultural research and development (R&D) indicate rates of return ranging from 10 to 100 percent. Federal, state, and local governments have played an integral role in funding agricultural research and in bringing new technologies to farmers. However, as shown in Table 2, the government share of agricultural R&D has decreased from roughly 50 percent in the 1960's and 1970's to less than 45 percent in the 1980's.

Table 2. Funding Sources for Agricultural R&D.

	Public Research	Industry Input Research	Industry Food Research	Total
	Million 1980 dollars category share in parentheses			
1960	657 (50%)	381 (29%)	279 (21%)	1,317
1965	856 (51%)	475 (29%)	324 (20%)	1,655
1970	930 (50%)	527 (29%)	379 (21%)	1,836
1975	1022 (50%)	618 (31%)	373 (19%)	2,013
1980	1186 (45%)	938 (36%)	508 (19%)	2,632
1985	1182 (41%)	973 (34%)	707 (25%)	2,862
1989	1373 (43%)	1068 (34%)	738 (23%)	3,179

As budgets get tighter at all levels of government, public agricultural research systems are being asked to do more with less. A related issue is whether traditional government models, which generally fund basic and applied research, often to the exclusion of commercialization, deliver the most "bang for the buck." This is especially important in new use applications to industry.

There are generally five stages in commercial R&D:

- BASIC RESEARCH - examines fundamental laws and properties of nature without regard to practical application or results;

- APPLIED RESEARCH - targets specific applications and may involve experiments designed to evaluate potential practical benefits;

- DEVELOPMENT - moves closer to practical application, and is usually conducted with larger equipment and facilities (e.g., a pilot plant for a new product);

- DEMONSTRATION - establishes the economic and technical feasibility of a product or process; and

- ADOPTION: when a private and/or public organization uses the new technology on a commercial scale.

As mentioned earlier, traditional U.S. policies have supported the first three stages of commercial R&D and generally ignored the last two. Daniel F. Burton, Jr., the executive vice president of the Council on Competitiveness (a private, nonprofit advocacy organization comprised of 150 CEO's from industry, academia, and labor) believes our bias for research and development and general neglect of demonstration and adoption may explain why U.S. firms lag behind some German and Japanese competitors in the rate of adoption and the intensity of utilization of new technologies. In comparison, Japan and Europe support demonstration and adoption by promoting partnerships between business, universities, and government "downstream" from basic and applied research.

Nevertheless, not all collective research efforts in Japan and Europe, particularly those subsidized by the central government, have been successful. For example, despite years of effort, Japan has failed to gain a major foothold in the U.S.-dominated pharmaceutical industry. And, similarly, Europe's heavily subsidized electronics industry has failed to close the gap with the United States. Therefore, "heavy-handed industrial policy," where the government picks technological winners and losers, is not the answer. The challenge is to develop programs that on the one hand, keep the government from picking technological winners and losers; but, on the other hand, promote financial support of economically efficient R&D.

Government support of commercial R&D must be based on the argument that private industry, acting in response to market incentives, will underinvest. Private investors rationally consider their own (private) benefits and costs when deciding on R&D investment. Thus, private sector underinvestment, from a national viewpoint, can occur when:

a. an individual cannot appropriate all of the benefits from his/her R&D investments because others can free-ride on the public goods produced as a result of the initial R&D (e.g., a firm building the first commercial-scale plant will go through a "learning by doing" period that, unless kept secret, will benefit competitors);

b. an individual's production or consumption activities impact another person's production or consumption and those impacts are not compensated through a market transaction (e.g., the effects of plastic waste on the environment);

c. the benefits of the R&D are localized in the public sector (e.g., biodegradable polymers from corn starch and the Federal corn commodity program); and

d. firms may value near-term payoffs more highly than society and society may value longer-term payoffs more highly than firms, thus leading to an underinvestment in activities that take a relatively long time to pay off.

B.1. Appropriability

It is when R&D involves the promise of useful new knowledge that is generic in nature, with wide applications across economic activities that appropriability is an issue. Generally, private goods can be sold commercially and the benefits from their sale are captured by those who own the associated property rights or patents. In agriculture, this would include hybrid seeds in which it is necessary to purchase new seed each time a crop is planted.

In comparison, collective goods do not lend themselves to profitable merchandising, even though there may be significant gains to society. An example, in a new uses context, may include the development of new wheat varieties for specific industrial applications - such as biodegradable polymers. Because wheat is a self-pollinated plant, once a new variety is released, growers can retain a portion of their harvest and use it as seed for planting in subsequent years. As a result, private firms cannot capture all of the benefits of producing new wheat varieties. This leads to suboptimal levels in both R&D and production.

B.2. Environmental Externalities

A second reason firms may underinvest in commercial R&D is due to an environmental externality. The crucial feature of an externality is that there are goods people care about which are not sold in markets. For instance, there is no market for pesticide leachate, nor is there a market for environmentally sound farming practices. It is this lack of a definable market which requires government action.

In a new uses context, consider the market for biodegradable polymers. Over the last 30 years, annual growth in plastic production has averaged 10 percent; far greater than the annual growth in the overall economy. Unfortunately, increased plastic use has resulted in increased plastic wastes. In a 1990 Environmental Protection Agency report, the Agency was primarily concerned with the impact of plastic waste on solid waste management and on the marine environment. Currently, plastics account for approximately 7 percent by weight and 14-21 percent by volume of the municipal solid waste stream.

Plastic waste in the marine environment pose risks to marine life, human life, and aesthetic appearance. The Marpol Treaty, signed in 1987 by 29 countries including the United States, prohibits the discharge of all plastic wastes at sea beginning in 1988 for commercial vessels and in 1994 for government ships. In an effort to adhere to the treaty, the U.S. Army--in conjunction with the USDA and private companies--has implemented a large-scale research effort designed to develop biodegradable polymers to replace petroleum-based plastics for all food uses. Many of these polymers are being made from corn, wheat, and potato starch. The advantage of these polymers is that they are fully degradable. However, starch-based polymers generally cost 4 to 10 times more than petroleum-based plastics.

In the case of a negative externality, the price system gives consumers too little information. Specifically, the price consumers pay for petroleum-based plastics does not incorporate the disposal, environmental, and other costs associated with plastic use. Consequently, from an economic and social perspective, we consume too much plastic.

In theory, government should increase the price of plastics to include or internalize the disposal, environmental, and other consumer costs associated with plastic use. In reality, the best the government can generally do is to achieve a politically determined level of environmental quality at the least cost. Often this objective can be achieved with taxes. In those instances when policymakers are reluctant to increase taxes, an environmental externality can act as a barrier to entry for more "environmentally friendly" products, like starch-based polymers.

B.3. Public Sector Benefits

The third reason government may intercede in the development of new-use products is that demand-creating innovations can reduce the social costs of farm-income-support policies. Economists have shown that a technological breakthrough in the production, for example, of starch-based polymers would increase market demand for corn or wheat and reduce program payments, without affecting total farm income. Because farm production would not change due to the technological breakthrough, total returns to producers are unchanged; thus, farmers have no incentive to fund demand-creating research. In comparison, the government has a significant incentive, because demand-creating R&D would reduce the costs of farm income support programs.

Similarly, innovations in the development and use of new crops that are economically viable alternatives to program crops could also reduce the costs of farm-income-support programs. The development of economically viable new crops which compete for program acres, excluding those acres in the conservation reserve program, would reduce the number of acres used to produce program crops. In turn, a reduction in program acres would decrease the output of program crops and reduce government support payments.

B.4. Financial Market Considerations

The final argument why firms underinvest in commercial R&D is that firms may value near-term payoffs more highly than society, and society may value longer-term payoffs more highly than firms; thus, leading to an underinvestment in activities that take a relatively long time to pay off. Also, banks and other financial institutions may be unwilling to finance commercialization because of the risks involved.

It is possible that, when financial markets match-up savers and investors thus setting interest rates, the resulting value is higher than the rate that would maximize social welfare. But, this has not been shown empirically and economists disagree on the veracity of this point. In addition, the industrial structure and corporate ownership patterns in the United States tend to support investments with high short-term payoffs relative to the economies of Japan and Germany. This is not the often-heard argument that U.S. financial markets are inefficient, rather its an argument that traditional business practices in Europe and Japan may favor longer-term investment relative to the United States.

There is some evidence the funding rate of pre-commercial R&D in Japan and the EC may be higher than in the United States. For example, through efforts like the MITI and Key Technologies programs, Japan has promoted partnerships between business, universities, and government "downstream" from basic research. Manufacturing extension services, capital subsidies, accelerated depreciation, as well as direct subsidies, have been used to promote technology development and the diffusion of new technologies into specific firms and industries. Similarly, the European Community has promoted collaborative R&D under the Framework Program. The Framework Program is scheduled to allocate $2.1 billion per year between 1990 and 1994.

In comparison, government-induced structural barriers -- differences in standard business practices -- may limit investment in pre-commercial R&D in the U.S. For example:

- capital gains of Japanese insurance companies must, by law, be reinvested in the company producing the gain;

- pension funds in Germany are customarily invested only in the stock of the employer company. This practice not only increases the amount of capital available to the company but also increases the financial stake of employees;

- accounting practices in Germany and Japan count investment R&D, employee training, and other similar expenses as capital, not as operating costs as is commonly practiced in the U.S. These practices reflect a longer-term orientation for German and Japanese government and business as compared to the United States; and

- laws in the U.S. keep ownership of banks and nonfinancial corporations separate, thus, requiring higher short-run payoffs to repay loans.

The U.S. must develop programs that on the one hand, keep the government from picking technological winners and losers; but, on the other hand, promote financial support for all R&D activities which are economically efficient.

An example in which financial markets may constrain the development of a "new use" agricultural product is kenaf. Kenaf is a non-wood, fiber crop which is especially attractive for manufacturing newsprint and other fiber-based products. For example, commercial-scale tests have shown that paper derived from kenaf is stronger, whiter, capable of sharper photo reproduction, and more user-friendly due to better ink adherence, than wood-pulp derived newsprint. Furthermore, the energy consumption to pulp kenaf is 15 to 25 percent lower than that required to pulp southern pine, and with fewer wastewater problems.

Because kenaf is bulky (low bulk density), transportation costs can make it non-competitive with wood for pulp and paper making. Consequently, intermediate or final value-added processing should occur near kenaf production fields. As a result, the economics of developing products, like kenaf, for industrial uses is a Catch-22. Farmers aren't likely to produce a new crop without an assured market, and industry isn't likely to retool, or in this case relocate, to process an alternative crop without an assured supply.

Given the start-up costs associated with the development of a new product and the availability of imported newsprint, banks have been unwilling to devote resources to kenaf production or kenaf processing. For that reason, in 1986 USDA's Cooperative State Research Service/Office of Agricultural Materials initiated a three phase program to commercialize kenaf. Phase I and II examine the agronomic issues of kenaf production and pulping, and Phase III involves commercial scale production of kenaf-based newsprint. Phase III is to be funded and carried out solely in the private sector. Over the last six years, the government has spent over $500,000 to commercialize kenaf and industry has spent over $700,000. Therefore, kenaf is a good example of the extended period of time and type of private-public partnerships often necessary to commercialize "new use" products.

C. The Federal Government Response

As Dr. Kugler expressed in an earlier speech, we are talking about doing things which create a demand driven need for a product and a derived demand for the agricultural sector to produce the crop. The Federal government is using several approaches to create this demand. There are currently six programs and two initiatives in various stages of development.

C.1. Programs in Progress

The first program involves the Technology Transfer Act of 1986 (Public Law 99-502). Under this Act, Federal laboratory researchers are encouraged to interact more extensively with industry. This includes cooperative research and development agreements or CRADA's and the TECH TRAN database which is available to industry and lists all government lab research.

Since 1986, scientists at the USDA have established over 250 CRADA's with various companies to commercialize technology arising from their research. This is the most among all sectors of the government. Furthermore, USDA efforts under the Technology Transfer Act have included many market successes like "Super Slurper," a highly absorbent starch polymer used in fuel filters, starch-encapsulated pesticides to increase herbicide efficacy and decrease runoff, and enzymes to dispose of leather tanning wastes.

Another program, mentioned earlier by Mr. Andreas, is the Alternative Agricultural Research and Commercialization (AARC) Center. Under Title XVI, Subtitle G, of the 1990 Farm Bill, Congress provided support for pre-commercial development of nonfood and nonfeed uses of agricultural commodities. The stated purpose of Subtitle G is:

- to develop and produce marketable products other than food, feed, or traditional forest or fiber products;
- to commercialize new non-food, non-feed uses ... to create jobs, enhance the economic development of the rural economy, and diversify markets; and
- to direct ... research and commercialization efforts toward ... agricultural commodities that can be raised by family-sized agricultural producers.

Fulfillment of Subtitle G is to be directed by the AARC Center.

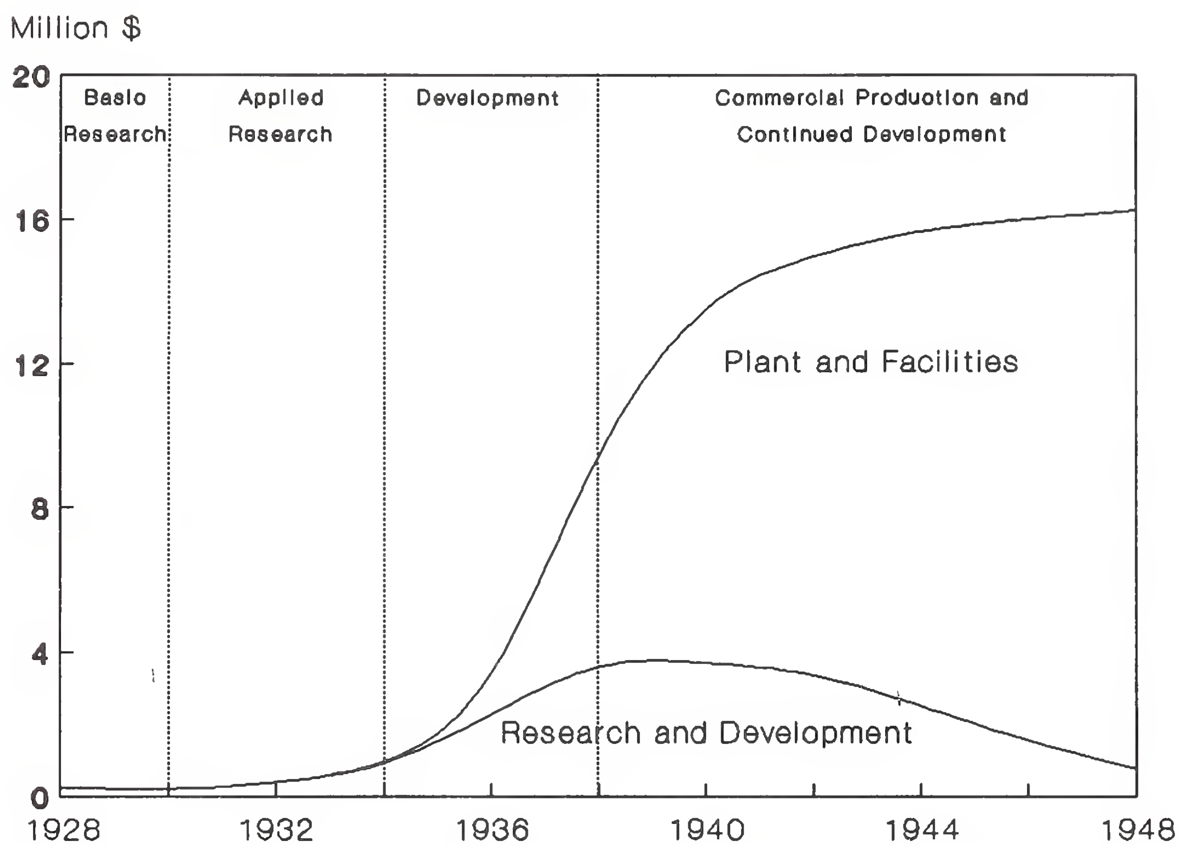
Dr. Davis Clements, former chairman of the Department of Chemical Engineering at the University of Nebraska-Lincoln and Director of the Office of Agricultural Materials/CSRS, points out that during precommercial R&D, risk tends to decrease from basic research through demonstration, but costs tend to increase. Clements' assertion is supported in Figure 1.

In Figure 1, DuPont's annual expenditures to develop nylon increased dramatically from the basic and applied research stages through the development and commercial production stages. Clements and others assert that often there is a funding gap at the point where technologies are brought out of the laboratory but are not ready for commercial prototyping. It is at this point - when the technology has not been demonstrated in commercial practice and must be moved from one organization to another - that technology transfer often fails. The AARC Center is especially situated to help private industry bridge the funding gap between development and commercialization, and to bring "new use" commercial technologies to the marketplace.

The third program is a joint effort between the USDA and the Department of Energy to develop a Situation and Outlook (S&O) Report for industrial uses of agricultural materials, highlighting new uses. The goal of the report is to supply relevant economic intelligence to people involved in the research, development, production, processing, marketing, and policy aspects of taking agricultural materials from the farmgate through the industrial marketplace. Current trends and new projects will be covered, but the goal is to use more rigorous analysis, evaluation, and forecasting techniques to provide researchers and decisionmakers with the economic intelligence needed to develop industrial uses for agricultural materials.

The S&O report will focus on industrial uses of agricultural materials, as well as their major substitutes and complements, in seven categories: starches & carbohydrates, fats & oils, fibers, animal by-products, forest products, natural

Figure 1. Dupont's Annual Expenditure to Develop Nylon



plant products, and natural rubber & resins. Industrial uses of both new and traditional agricultural outputs will be covered under each category. Special articles will provide in-depth analyses of particular uses and related markets.

The fourth program is being implemented by the CSRS Office of Agricultural Materials. The office emphasizes work to expand uses of industrial products and new crops beyond the "farm gate." Current programs include lubricants, polymers, coatings and specialty chemicals from vegetable oils, development of fatty acid resources; biodegradable polymers from starch and proteins; natural rubber and other polymers from guayule; newsprint, bond paper and other fiber crops from kenaf; and thermally insulating textiles from milkweed.

Projects are operated through cooperative agreements and grants to meet specific national needs and to use domestic resources more effectively. Work is conducted through both private and public institutions, generally with a multi-disciplinary team of experts and almost always with financial contributions by partners.

The fifth program is a study being conducted by the National Research Council of the National Academy of Sciences. The objective of this program is to address key aspects of research and commercialization of biobased products derived from agricultural and forestry resources. A committee of twelve experts will address future opportunities for biobased products as a result of recent advances in biotechnology and in the chemical and materials sciences. The committee will generate a final report intended to provide an authoritative perspective on biobased products as well as providing much-needed guidance for future action. The report is expected in 1994 and is funded by the Department of Energy, USDA, Department of Defense, and National Science Foundation.

The final program, which has already been completed, is a report by the Office of Science and Technology Policy; Federal Coordinating Council for Science, Engineering and Technology; Committee on Industry and Technology; Department of Commerce. The report addresses technologies in 10 categories for which materials R&D can contribute to resolving problems and improving applications cost-effectively. The opportunities are discussed in the context of the sector or applications category that would be the principal beneficiary of any advancement. Included are applications that would benefit the Departments of Energy, Transportation, Health and Human Services, Agriculture, and the Interior. Also included are applications that would benefit the Environmental Protection Agency, National Aeronautics and Space Administration, and National Science Foundation.

C.2. Initiatives Under Consideration

In addition to these six programs, there are currently two draft initiatives being considered at the USDA: the "New Uses Initiative" and the "Biofuels Initiative." An Initiative reflects the Secretary's vision for agriculture and determines how the Department will support that vision.

As it is currently written, the goals of the "New Uses Initiative" include:

- developing new economically competitive technologies and products from agricultural and forestry materials;
- developing new crops to generate renewable industrial feedstocks that are not produced domestically;
- developing new technologies and products that maximize the environmental advantages of renewable feedstocks; and
- maximizing the benefits of new markets to rural businesses and communities.

The specific objectives of the "Biofuels Initiative" include:

- increasing the efficiency of converting biomass to liquid fuels;
- improving and expanding the feedstocks available for conversion to liquid fuels; and

- expanding market opportunities for biofuels through the development of engine technology and fuel formulations that maximize the environmental and technical benefits of biofuels.

D. Conclusion

I would like to reiterate the three major points of my presentation:

1. "new" nonfood and nonfeed uses of agricultural products are not new, but the degree of action and the opportunities for success are new;

2. government support of commercial research and development must be based on the argument that private industry, acting in response to market incentives, will underinvest; and

3. federal government response to new uses includes research, CRADA's, and TECH TRAN activities at the Agricultural Research Service; development and commercialization projects at the Alternative Agricultural Research and Commercialization Center; a Situation and Outlook Report at the USDA with funding and cooperation from the Department of Energy; various industry-university-government partnerships sponsored by the Office of Agricultural Materials/Cooperative State Research Service; predictions on the future of biobased products from the National Research Council/National Academy of Sciences; a report, by the Office of Science and Technology Policy/Department of Commerce, addressing technologies in 10 categories for which materials R&D can contribute to resolving problems and improving applications for new industrial uses; and two draft USDA initiatives.