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**Chapter 20**

**Targeting” Policies  
in Biotechnology**

# Contents

	<i>Page</i>
Introduction .....	475
Timing and Coordination of Policies .....	475
Japan .....	475
Federal Republic of Germany .....	476
United Kingdom .....	477
France .....	477
Industrialists' Role in Policy Formation .....	478
Japan .....	478
Federal Republic of Germany .....	478
United Kingdom .....	478
France .....	478
Policy Goals .....	479
Japan .....	479
Federal Republic of Germany .....	479
United Kingdom .....	479
France .....	479
Policy Implementation .....	480
Japan .....	<b>480</b>
Federal Republic of Germany .....	481
United Kingdom .....	482
France .....	482
Findings .....	482
Issue .....	483
Chapter 20 References .....	484

## Figure

<i>Figure No.</i>	<i>Page</i>
32. Activities of STA's Office for Life Science Promotion .....	480

# Targeting Policies in Biotechnology

## Introduction

During the past few years, some governments in countries other than the United States have designated the commercial development of biotechnology as essential to their nations' continued economic well-being. Unlike the U.S. Government, which has relied on a policy of funding basic research in the life sciences and encouraging research and development (R&D) in all industries with tax credits, \* these governments have instituted targeting policies in biotechnology designed to promote the commercial development of biotechnology. In the context of this report, a targeting policy for biotechnology is defined as any policy that singles out the indigenous development of biotechnology for special attention from the central government. Foreign targeting policies in biotechnology may have the potential

both to enhance the international competitiveness of foreign firms and to weaken that of U.S. firms.

This chapter examines the targeting policies in biotechnology of Japan, the Federal Republic of Germany, the United Kingdom, and France. \* The targeting policies of most foreign governments are directed toward both "old" and "new" biotechnology. This chapter focuses on the aspects of these policies applicable to new biotechnology, as defined at the outset of this report. Although it does not address the issue of whether the U.S. Government should adopt a targeting policy for biotechnology, it does identify which targeting mechanisms could most readily be adopted in the United States if the U.S. Government chose to target biotechnology.

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\*See Chapter 12: *Financing and Tax Incentives for Firms* and Chapter 13: *Government Funding of Basic and Applied Research*.

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\*Switzerland is not considered in this chapter, because the Swiss Federal Government has no central policy for the industrial development of biotechnology.

## Timing and coordination of policies

The biotechnology targeting policies of Japan and the Federal Republic of Germany have evolved out of at least a decade of interest in the commercialization of life-science-related technologies; these policies have more recently emphasized the incorporation of the new recombinant DNA (rDNA) and hybridoma/monoclonal antibody (MAb) technologies, as well as advances in bioprocess engineering. The biotechnology targeting policies of the United Kingdom and France, in contrast, have developed since about 1980, largely in response to the recent developments that have occurred in the field of molecular biology. The

extent and degree of coordination of targeting policies differ among countries.

### Japan

As early as April 1971, the Council for Science and Technology, Japan's highest science and technology policymaking body, including government, business, and academic leaders, stressed the importance of promoting life science on a nationwide basis because of its commercial potential (16). Since then, three governmental departments in Japan—the Science and Technology Agency

(STA), the Ministry of International Trade and Industry (MITI), and the Ministry of Agriculture, Forestry, and Fisheries (MAFF)-have specifically targeted the development of biotechnology.

STA responded in 1973 by establishing the Office for Life Science Promotion to plan and coordinate STA'S R&D programs in life sciences. Until MITI's entry into major biotechnology programming in 1980, STA'S R&D programs in fields related to biotechnology were the largest and the best funded in Japan. Even today, STA'S programs are comparable in scale to those of MITI (25).

STA, in addition to being responsible for carrying out its own R&D program in the fields related to biotechnology, is responsible for interministerial coordination. It should be pointed out, however, that STA'S influence on the formulation and implementation of Japanese biotechnology policy is not as pervasive as it might appear on paper. Interministerial rivalries and competition are common in Japan, and as described below, MAFF and MITI, each with substantially larger in-house staffs and laboratories than STA, have independently formulated their own biotechnology targeting policies. Nevertheless, STA'S foresight with respect to the development of biotechnology has accorded the agency a more authoritative position for biotechnology than for other high-technology fields. \*

MITI did not enter the biotechnology area until 1981. In that year, MITI reorganized itself to deal comprehensively with the challenges of new developments in technology and established its "System for Promotion of Research on Next-Generation Industrial Technologies," an overall plan to promote "next-generation" industrial technologies (25). Three "next-generation" projects in biotechnology were established within MITI's Basic Industries Division, and an Office of Biotechnology Promotion was established within this division to provide policy oversight for MITI's biotechnology effort and to serve as liaison between MITI's Biotechnology Long-Term Vision Advisory Group and possible MITI efforts to obtain from the Jap-

anese Diet special legislation governing the promotion of biotechnology in Japan (25). \*

MAFF has more recently established the Committee on Biological Resources Development and Utilization, which compiled a report recommending actions MAFF could take to promote biotechnology's development (21).

In addition to STA, MITI, and MAFF, three other Japanese Government agencies are funding R&D in biotechnology: the Ministry of Health and Welfare, the Ministry of Education, and the Environment Agency (26).

### ***Federal Republic of Germany***

The West German Government's interest in the development of old biotechnology, like that of the Japanese Government, is more than 10 years old. In 1968, the old Federal Ministry for Scientific Research explicitly recognized the potential commercial importance of old biotechnology by including it in a program to promote new technologies (15). In 1972, the newly reorganized Ministry for Research and Technology (BMFT, Bundesministerium für Forschung und Technologies), along with the Ministry of Education, commissioned a report on old biotechnology from the German Society for Chemical Engineering (DECHEMA, Deutsche Gesellschaft für Chemisches Apparatewesen) (7). The DECHEMA study, completed in 1974, laid the groundwork for a comprehensive Federal policy for the development of old biotechnology (15). In 1980, in light of increasing evidence suggesting potential commercial applications of advances in both scientific and engineering aspects of biotechnology, BMFT presented its ***Leistungsplan: Biotechnologie***, a performance plan for biotechnology (5). This plan identified and targeted for support specific areas in which West German industry could commercially exploit both old and new biotechnology (15).

BMFT makes policy and coordinates German governmental activity for all biotechnology. BMFT funds basic and generic applied research in biotechnology through a number of public and non-

\*STA was involved from the beginning with its own program and had the central role in the setting of rDNA regulations. The agency has a policy of reviewing on a case-by-case basis scaled-up production of genetically manipulated micro-organisms beyond 20 liters and has been reluctant to relinquish this authority (4).

"Several factors, including visible American concern with Japanese Government aid to high-technology industries, have made the passage of such programs unlikely (25).

profit research centers (15). Its most important function, however, is to oversee the development efforts of various industries in biotechnology, and it aids such efforts with a strong funding program (15).

### **United Kingdom**

The formulation of official Government interest in the commercialization of biotechnology in the United Kingdom dates from March 1980, with the publication of the Spinks' report (1). This report identified major weaknesses in the country's biotechnology commercialization efforts and suggested ways of correcting them. The document elicited almost immediate Government action on its recommendations and sparked a spirited dialog among the various sectors with an interest in developing and incorporating the latest advances in this set of technologies into British industries. \*

The Department of Industry is the United Kingdom's lead department for biotechnology. Other Government departments involved in health, energy, the environment, agriculture, and food, however, contribute to the advancement of biotechnology within their respective sectors, primarily by funding basic research (8). In April 1982, the Department of Industry established the Interdepartmental Committee on Biotechnology to strengthen the existing coordinating arrangements by focusing the Government's effort on the commercial development of biotechnology. This committee coordinates the activities of other related bodies, such as the Research Councils, the British Technology Group (BTG), and the Public Health Laboratory Service, and serves as a point of contact for those outside Government.

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\**Biotechnology and Education: Report of a Working Group*, The Royal Society, 1981; *Biotechnology*, Cmnd 8177 (London: H. M. Stationery Office, March 1981); *The Strategy for Biotechnology in Britain*, BCCB Seminar, London, October 1981, series of unpublished papers, widely circulated at the time; *Biotechnology: Interim Report on the Protection of the Research Base in Biotechnology*, Sixth Report from the Education, Science and Arts Committee, Session 1981-82, House of Commons Paper 289 (London: H. M. Stationery Office, July 29, 1982).

### **France**

Official interest in the commercialization of biotechnology in France was marked by the appearance of the Pelissolo report (23) in December 1980. Since the election of the socialists in 1980, the French Government has resolved to push the development of several new technologies in French industries and has accorded a privileged position to biotechnology within this scheme.

In July 1982, the old Ministry of Research and Technology in France was reorganized into a new, more powerful Ministry of Research and Industry (Ministere de la Recherche et de l'Industrie) based on the model of Japan's MITI (29). Furthermore, a wide-ranging research law adopted by the French National Assembly in July 1982 stipulated a real increase in the civilian R&D budget of 17.8 percent per year for 5 years, economic conditions permitting, and set up seven technological "programmed," on which the majority of all civilian research funds are now to be focused (30).

Biotechnology was one of the seven "programmed" and a Biotechnology Mission (Mission des Biotechnologies), established in August 1981, produced a planning document for biotechnology in France in July 1982. This document, the "Programmed Mobilisateur: l'Essor des Biotechnologies," called for the restructuring of biotechnology policymaking into three separate coordinating bodies: 1) a national committee, presided over by the Minister of Research and Industry; 2) an interministerial coordinating committee; and 3) a program team to work in daily liaison with other Government organizations most closely involved in distributing research funds (18).

Since the publication of the "Programme Mobilisateur," the Ministry of Research and Industry has undergone a further restructuring. The new name of this ministry, Ministry of Industry and Research (Ministere de l'Industrie et de la Recherche), further reflects the efforts of French policymakers to focus on the commercialization of research results, including those in biotechnology (9).

## Industrialists' role in policy formulation

Formulating a policy with the assistance of the parties whose activities it is intended to affect usually makes its implementation far more effective. Foreign nations competing with the United States in the commercialization of biotechnology have various mechanisms which incorporate industrialists into the formulation of a government targeting policy.

### *Japan*

In Japan, technological strategy is usually formed by a "bottom-up" process, and the formulation of the strategy for biotechnology was no exception. After the announcement of the Cohen-Boyer patent for the basic rDNA process in 1980, five major Japanese chemical companies organized a joint study group called the Biotechnology Forum. The Biotechnology Forum was instrumental in lobbying for the establishment of MITI's three major "next-generation" biotechnology R&D projects: rDNA technology, bioreactors, and mass cell culture (25). \* Furthermore, discussions with industrialists helped narrow MITI's focus. A planned "next-generation" R&D project in cell fusion was dropped, because the chemical companies working with the Basic Industries Division of MITI were already rather advanced in this area and because MAFF and the Ministry of Health and Welfare were developing their own programs in the field (25).

### *Federal Republic of Germany*

The biotechnology policy of the Federal Republic of Germany was formulated with industry consultation. As noted above, a report on old biotechnology from DECHEMA, the private sector research association of the German chemical

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● In fact, following the award of the Cohen-Boyer patent, the Committee on Life Sciences of the Japan Federation of Economic Organizations met in alarm to discuss a Japanese response. Included at this meeting were representatives of 30 major Japanese companies with an interest in biotechnology. The Cohen-Boyer patent was seen as a matter of concern because, acceding to their company sources, the patent would affect almost any product application of rDNA technology. Ironically, it was suggested that the United States was designating biotechnology as a strategic national industry and was weaving about it a network of protective patents (27).

industry (7), laid the groundwork for a comprehensive Federal policy. Much of BMFT's funding goes to nonprofit research centers such as the Society for Biotechnology Research (GBF, Gesellschaft für Biotechnologische Forschung) that conduct generic applied research useful to industry (13). The research institutes of these organizations have boards of directors with strong industrial representation, so their research strategy is thus usually formed by a "bottom-up" process. \*

### *United Kingdom*

The Department of Industry launched in November 1982 a new 3-year, \$30 million program of support for biotechnology in industry (2). To promote and monitor its funding initiatives, the Laboratory of the Government Chemist, part of the Department of Industry, setup a Biotechnology Unit. The unit is headed by one official from the Laboratory of the Government Chemist and three full-time biotechnologists on loan from industry. The purpose of this group is to provide industrial biotechnology expertise previously unavailable in the Department of Industry (12). The establishment of the Biotechnology Unit in 1982 marks the first time the British Government has incorporated the industrial sector on a regular basis into the policymaking process for biotechnology. Previously, the direction of the United Kingdom's informal involvement in biotechnology was determined largely by Government officials and scientists acting through already existing committees, with only occasional input from the private sector.

### *France*

The presentation of the '(Programmed Mobilisateur' in July 1982 followed an intensive period of analysis and discussion between French Government officials, research scientists, and industrialists. A product of the plan was a National Biotechnology Committee, presided over by the

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● OTA's report *US. Industrial Competitiveness: A Comparison of Steel, Electronics, and Automobiles* (28) presents a general description of structural integration of business into West Germany's policymaking apparatus, pp. 196-200.

Minister of Research and Industry, with 30 to 40 members from the Government, academia, and industry responsible for providing general guidance in implementing the Government policy. In the past, the industrial policy of France has been more autocratic than that of West Germany or Japan (31). For biotechnology, enthusiastic

French Government officials advocated generalized support of R&D projects regardless of the prospects for successful exploitation, to the dismay of industrialists who doubted the viability of some of the projects designated to receive Government support (29).

## Policy goals

An examination of the goals of foreign biotechnology policies indicates that the domestic development of biotechnology, rather than the advancement of knowledge per se, is their foremost objective.

### **Japan**

Japanese Government programs for biotechnology R&D are concerned specifically with the development of Japanese industry.

MITI's interest in biotechnology has been almost exclusively related to a more general program of structural adjustment for Japan's extremely depressed basic chemicals industry (24,25). MITI's three "next-generation" biotechnology R&D projects are part of a 10-year program that is specifically designed to develop and diffuse biotechnology among Japanese companies. According to a recent MITI policy statement, it is not feasible to rely on the private sector for biotechnology-related research that involves huge economic risks, so "the Government itself must take the initiative in such R&D, while at the same time offering assistance to private corporations in various forms to expedite this R&D" (19).

STA also is directly concerned with providing the technological underpinning for industrial advancement in Japan. The essential distinction between the STA and the MITI biotechnology projects is that the former concentrate on medical applications and longer term development of advanced bioreactors, whereas the latter are mainly concerned with fine chemicals, biological routes to production, fertilizers, and enzyme technology (25).

### **Federal Republic of Germany**

According to a September 1979 BMFT statement, a primary goal of Germany's Federal biotechnology policy is "to establish the preconditions for industrial innovation in this key area of technology" (15). Another goal is "to strengthen the performance and competitive capacity of the German economy in long-range growth-oriented areas, in the process, correcting weaknesses revealed through international comparison and preventing distortions in Germany's competitive position" (15).

### **United Kingdom**

While the British Government recognizes the potential of biotechnology, it is fairly guarded about the objectives of its biotechnology policy. The Minister of Industry has stated that "many developments are only now beginning to emerge from the research phase, and the direction of development for commercial exploitation remains uncertain. In addition, new biotechnological techniques and processes may well emerge over the next 20 years with benefits as yet unforeseen" (8). Clearly, however, the British Government intends to assist the country's industries in realizing the commercial potential of biotechnological developments as such developments appear (8).

### **France**

The French Government "Programme Mobilisateur" plans to remedy the present deficiencies in qualified personnel and spending levels for

R&D in biotechnology in French industry and the lack of public sector applied research in 5 years. According to the document, French companies

should account for 10 percent of the world market in the “bioindustries” (not defined) in 1990, compared with an estimated 7.5 percent now (18).

## Policy implementation

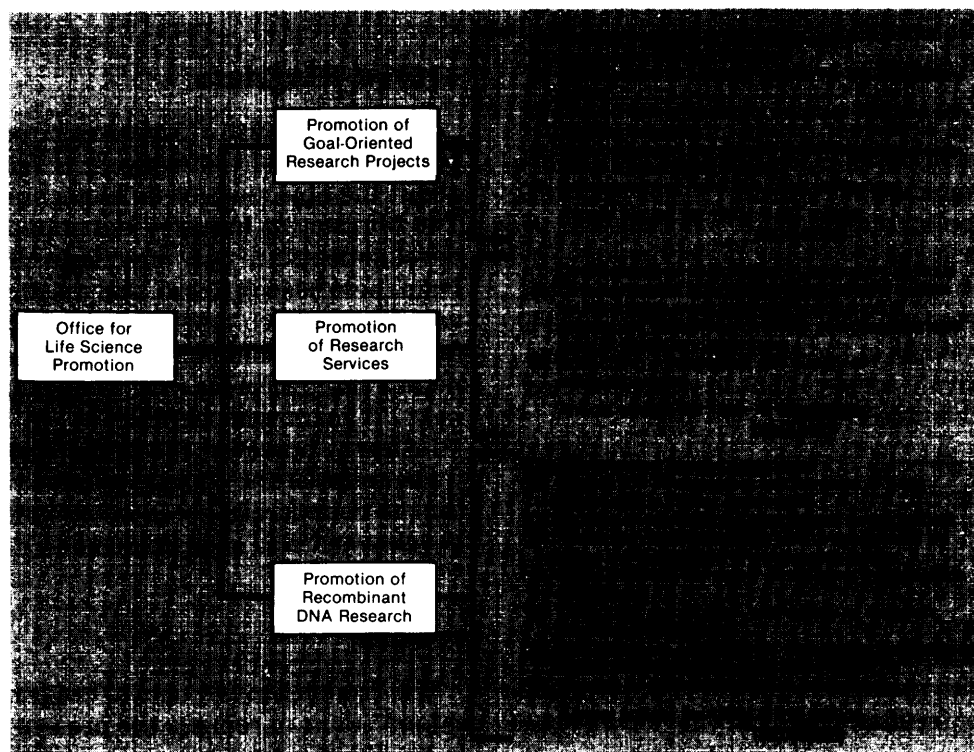
Examples of the mechanisms used to implement biotechnology targeting policies in Japan and other countries illustrate the variety of forms which biotechnology targeting policies can take. Several examples are cited below. For more information on government funding, see Chapter 12: *Financing and Tax Incentives for Firms* and Chapter 13: *Government Funding of Basic and Applied Research*.

### Japan

The activities of STA'S Office for Life Science Promotion are shown in figure 32. As shown in the figure, the Office is funding two goal-oriented

research projects in biotechnology. These projects are to be carried out in 10 years by research groups whose members are affiliated with Japanese universities and research institutes (26). One of the projects, the project on the development of bioreactors, aims to develop what the Japanese call “second generation” bioreactors and includes computer control, biochemistry, and systems design. STA has encouraged an interdisciplinary approach to the project by inviting a variety of Japanese companies skilled in various aspects of biotechnology to participate. This approach has been very productive (24). As shown in figure 32, the Office for Life Science Promotion is providing sup-

Figure 32.—Activities of STA'S Office for Life Science Promotion



\* = Biotechnology activities.  
SOURCE: Office of Technology Assessment, adapted from *Science and Technology in Japan*, April/June 1983.



port for rDNA research. This support includes funding for the construction of facilities. In 1982, construction was begun on a P-4 (highest physical containment level) facility in which experiments in genetic manipulation can be performed in Tsukuba Science City (26). In 1980, as one of the Office for Life Science Promotion's projects for the promotion of research services, the Japan Collection of Micro-Organisms was constructed to collect, preserve, and supply micro-organisms (26).

STA is implementing its policy in part through the general New Technology Development Fund. This fund has already commenced funding a number of biotechnology-related projects. A \$4 million grant to the pharmaceutical company Green Cross in March 1980, for example, launched Green Cross into the international arena of competition in pharmaceuticals by enabling it to conduct research on rDNA methods for the production of alpha interferon (25).

MITI's three next-generation biotechnology projects, which are targeted to establish and diffuse scale-up techniques among companies, are even more illustrative of Japanese Government cooperation with industry. MITI has invited 14 companies to participate in the projects on a long-term (10-year) basis\* and will provide allocations over 10 years of \$43 million each to both the rDNA and bioreactor projects and \$17 million to \$22 million for the mass cell culture project (10). Although some 10 percent of the R&D work (by expenditure) for MITI's biotechnology projects is being conducted in the national laboratories\*\* of the Agency for Industrial Science and Technology, the bulk of the work (90 percent) is conducted in industry laboratories. To facilitate coordination by the Office of Biotechnology Promotion and the Next-Generation Research Coordination Bureau of MITI's Agency for Industrial Science and Technology, the 14 companies receiving grants under the next-generation biotechnology

projects have been organized into the Biotechnology Development Research Association. This association has its own central office through which the various companies communicate with MITI, but otherwise there are no intercompany institutions (e.g., there are no common laboratories being maintained by the companies). MITI subsidies to these companies cover 100 percent of all direct expenses (salaries and laboratory expenses) for biotechnology R&D, but no overhead is allowed and any capital equipment purchased is nominally the property of the Japanese Government. Furthermore, all patents resulting from the work belong to the Japanese Government, which, MITI has assured other companies, both domestic and foreign, will be freely available (14).

MAFF also is actively promoting cooperative research with private industry at its laboratories and is currently funding work with both Nippon Shokuhin Kako and Oriental Yeast at the National Food Research Institute and with Kao Soap at the National Institutes of Agricultural Sciences. Further joint research is planned in the areas of plant breeding and species improvement with private seed companies. Achievements from the research are used jointly by Government and industry, but those companies that participate in the research projects receive exclusive licensing rights to the patents resulting from these projects for 3 years (22).

### ***Federal Republic of Germany***

BMFT implements its biotechnology targeting policy in the Federal Republic of Germany through three categories of support. One category is funding for already existing schemes for industrial development. Another category is funding for third-party organizations to which BMFT contributes as part of more generalized funding programs for all areas of public research. GBF is the foremost example of such an organization. Originally founded to conduct generic bioprocessing research to meet the needs of industries (17), GBF employs 365 people and has a budget (1982) of \$13 million (DM31 million), of which 89 percent came from BMFT (13). GBF's current activities include general development of bioprocess technology, scale-up of laboratory processes, screening

\*The bioreactor project has been divided into two subprojects with Mitsubishi Chemicals as the overall leader. Sumitomo Chemicals is the leader of the rDNA project, and Kyowa Hakko is the leader of the mass cell culture project (25).

● These include the Fermentation Research Institute, National Chemical Laboratory for Industry, Research Institute for Polymers and Textiles, Government Industrial Research Institute, and Institute of Physical and Chemical Research (25).

of micro-organisms and plant and animal cell cultures, support of other research groups in biotechnology, participation in joint biotechnology projects with industry, and advanced interdisciplinary training for scientists, engineers, and technicians.

A third category of support is funding for biotechnology programs specifically designated by BMFT. For these programs, BMFT has funded a wide spectrum of projects with about \$35 million (DM55 million) in 1982 (15): food requirements, biological pesticides, plant and animal cell culture techniques, biomass, metal refining, bioprocesses for commodity chemicals, bioreactors, and principles of biotechnological procedures (5).

The list of BMFT's grant recipients for these biotechnology programs includes every major German chemical and pharmaceutical company (5). BMFT's support for research on the development of interferon is particularly noteworthy. Between 1975 and 1977, BMFT gave Merck, Ltd., \$300,000 (DM0.6 million) for the study of interferon induction. Rentschler, Inc., has been supported since 1976 with about \$9 million (DM18.54 million) for its R&D effort on fibroblast interferon (6).

### ***United Kingdom***

In the United Kingdom, the Department of Industry has launched a new, 3-year \$30 million "Biotechnology in Industry" program. The British Government also funds BTG, which encourages cooperative projects between industry and public sector laboratories. Government laboratories, such as the Centre for Applied Microbiology Research, carry out both applied research of potential interest to industry and specific industrial contracts.

In 1981, the British Government, through BTG and in association with four private investors,

established Celltech, Ltd., to develop and market products made by some of the new technologies. In an arrangement similar to that of Immunotech in France, Celltech has a total initial capital of \$20 million and the right of first refusal\* on all work done in the Medical Research Council (20). In 1983, BTG, Advent Eurofund (a venture capital group), and Ultramar (a petroleum and financial group) established the firm Agricultural Genetics with a total initial capitalization of \$28 million. This firm has the right of first refusal on all work done in the Agricultural Research Council (3).

### ***France***

The French Government is supporting R&D in various governmental agencies, including the National Institute of Health and Medical Research (INSERM, Institut National de la Santé et de la Recherche Medicale), the National Center for Scientific Research (Centre National de la Recherche Scientifique), and the Institut Pasteur. Government funding in applied areas is intended to benefit the pharmaceutical, food, and agricultural industries.

In 1982, the French Government supplemented its applied research program by creating a company, Immunotech, to facilitate the commercialization of biotechnology and transfer the results of immunology research, a traditional French strength, to French industry. Immunotech does applied research on bioprocessing and hybridoma technology for the production of immunoassay and immunopurification systems. The Ministry of Research and Industry contributed \$3.2 million to its formation. Immunotech has the right of first refusal on all work financed by INSERM.

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\*This is the right to choose whether or not to produce and market any good or service without having to bid competitively with other firms.

## **Findings**

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The governments of four leading industrialized competitors of the United States—Japan, the Federal Republic of Germany, the United Kingdom,

and France—have instituted programs to target the development of certain areas of biotechnology. The targeting policies are intended to reduce

economic risk and lessen corporate duplication in biotechnology R&D.

The governments of these four countries took an interest in biotechnology at different times. The governments of both the Federal Republic of Germany and Japan identified the life sciences in the early 1970's as an area worthy of special government and private sector assistance. Those of France and the United Kingdom, on the other hand, realized the industrial importance of biotechnology only recently, primarily as a result of the recent advances in molecular biology.

The centralization of government activities varies among countries. In France and the Federal Republic of Germany, the direction of all activities, from basic research to industrial development, is centralized in a single ministry: the Ministry of Industry and Research in France and BMFT in Germany. In the United Kingdom, the Department of Industry is responsible for articulating and executing the Government's policy to commercialize biotechnology, but it must work with other departments that are concerned with the development of science in specific fields. In Japan, at least three Government departments have major biotechnology policies of their own.

These four foreign countries have various processes by which industrialists are brought into the formulation of their commercial biotechnology policies. Japan, France, and West Germany have a long history of involving industrialists. The United Kingdom, on the other hand, has only been officially involving industrialists in the formulation of its biotechnology policy for a short period.

The mix of policy measures to encourage industrial innovation in biotechnology assumes a variety of forms within each country. In Japan and the Federal Republic of Germany, the governments carry out their policies partly in the form of joint R&D projects with industry. These projects concentrate the resources of the government and private companies to meet specific objectives set by the government. In some cases, the companies have exclusive rights to the resulting patents; in other cases, the patents are made available to all interested parties. The British and French Governments, in addition to providing support for specific projects, have adopted a different sort of approach: the organization and support of small firms, such as Celltech in the United Kingdom and Immunotech in France, to commercialize the results of government-funded basic and generic applied research.

At this early stage, any evaluation of the foreign targeting programs' probability for success is preliminary. History has shown that even the best thought-out targeting policies do not guarantee competitive success. Whether the targeting policies of Japan, the Federal Republic of Germany, the United Kingdom, or France are superior to the U.S. Government policy of funding basic research in the life sciences and encouraging R&D in all industries with tax credits remains to be seen. The United States currently leads the world in the commercialization of biotechnology. Although targeting policies may not be of great importance when compared with other competitive factors, they could tip the balance of equivalent competitive situations in the future.

## Issue

### **ISSUE: How could the U.S. Government target biotechnology?**

It is beyond the scope of this report to evaluate whether the commercialization of biotechnology is of sufficient importance to the U.S. economy as a whole to warrant targeting efforts by the U.S. Federal Government. If such efforts are under-

taken, however, several targeting mechanisms might be considered.

The mechanisms for targeting biotechnology *in* France, the United Kingdom, the Federal Republic of Germany, and Japan range from highly coordinated to loosely organized, but all reflect some combination of the following:

- Firm-specific assistance. Firm-specific assistance involves choosing a single company or group of companies for assistance from the government in jointly agreed upon areas of high-risk R&D. The companies chosen sometimes perform the subsidized research in consortia.
- Industrywide assistance. Industrywide assistance involves providing government assistance to all companies that perform R&D in a particular area (or funding R&D in a national laboratory open to all interested industry participants). Low-interest loans or tax credits for R&D and procurement of new products are methods commonly used.
- **An interagency coordinating committee.** An interagency oversight committee without the authority to set goals or grant subsidies facilitates coordination of the policies and actions of government agencies and periodically recommends action through the appropriate agencies to address problems hindering the development of biotechnology.

The U.S. Government would probably have to avoid actions in the category of firm-specific assistance. If the U.S. Government were to select a few companies for subsidies, demands for equal assistance would probably arise from the companies that did not receive subsidies.

For U.S. Government policies in the category of industrywide assistance, there are historical

precedents. The types of U.S. Government support that were provided for the U.S. semiconductor industry in its early years are described in **Appendix C: A Comparison of the U.S. Semiconductor Industry and Biotechnology**. As it did in the case of the U.S. semiconductor industry, the U.S. Government could provide or guarantee low-interest loans for high-risk R&D in biotechnology. It could also guarantee Government procurement of certain products to eliminate some market size uncertainties. A commitment by the Federal Government to purchase certain drugs developed by biotechnology could spur R&D that otherwise might not be undertaken.

The third mechanism, an interagency coordinating committee, would probably raise the fewest objections in the United States but would also be the least substantial. The defunct Interagency Working Group on Biotechnology of the White House Office of Science and Technology Policy temporarily served this function and presented its recommendations to the Office of Science and Technology Policy in June 1983 (11).

Earlier chapters of this report have outlined options that could improve U.S. competitiveness in biotechnology. The adoption of the most acceptable of these options in a coordinated fashion would be one way in which the U.S. Government could target biotechnology.

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