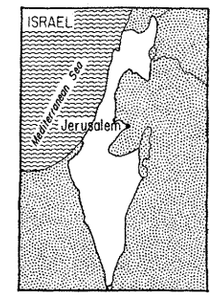

Israel Worries about Its Applied Research

Jerusalem (Israeli sector). Israel is the perfect example of a country which requires a strong effort in applied science. Israel is a beachhead in the desert, absorbing immigrants and still dependent on foreign gifts. Weather and terrain are harsh, and natural resources are limited. Hence, Israel depends greatly on foreign trade; surrounded by Arab countries which refuse either recognition or trade, it must trade with distant European markets (and maintain a military research effort disproportionate to its size). The distance of the markets, the inefficient use of shipping space (caused by discrepancies in the size of export and import cargoes), the fluctuations in world market prices of agricultural products—all push Israel in the direction of manufacturing products of low volume and shipping weight and high monetary value, such as fine chemicals, pharmaceuticals, and electronic instruments.

Actual and potential water shortages lie at the heart of Israel's development problems. Water, indeed, has been the prime focus of the country's effort in applied research, and there are those who think it has drawn attention away from emerging problems of almost equal importance. Nonetheless, Israel must have an assured water supply, and the country already uses about 70 percent of the maximum 1.8×10^9 cubic meters of water available annually (80 percent of the water used goes for agriculture). So Israel eagerly embraces the idea of developing jointly with a foreign power a $200-million desalinization project, in which a reactor of proved design would be linked with the boilers of a power plant and the distilling units of a plant to desalt sea water. At the moment it appears that an American reactor will be chosen, and an American firm is making the feasibility study this year.

The sun plays an important role in the economy—especially the water economy—of Israel. Sometimes this role is negative: every year the sun evaporates huge quantities of fresh water from the surface of the Sea of Galilee. But it is also positive. Sunny weather much like California's produces similar opportunities for irrigation agriculture. The sun provides the energy for extracting, through evaporation, potash from the waters of the Dead Sea in salt-extraction pans covering 130 square kilometers. And on thousands of rooftops householders have installed the storage tanks and collection panels of a system for direct heating of rain water by the sun.

In Israel, however, solar power does not have the significance that it has in remote areas of large and underdeveloped countries. Israel is compact, and so a national grid easily carries electricity to most of the settled regions. And Israel can afford to buy the petroleum to run the power stations. A newly expanded pipeline system distributes irrigation water to the sprinklers. Israel, through her own efforts and through gifts and reparations, has attained a standard of living about like northern Italy's. The major cause of disequilibrium in the economy is the continuing flow of immigrants, now chiefly from Asia and Africa, who lack money and skills.

In Israel today, paradoxically, basic science is strong and applied science is weak. Atypically for a new nation, Israel acquired a large and vital establishment for undirected research before industries had sprung up as insistent customers for research results. Given the migration of many researchers from Europe, a steady stream of grants and gifts from abroad, and a Jewish cultural bias in favor of fundamental research, the growth of laboratories for basic research is not surprising. But while science sprang full-grown from Europe and America, industry did not, local observers assert. The firms tend to be small, and concerned with the manufacture of nontechnical products. Their founders generally were without technical training. Government protection (now ending) and the demands of a goods-hungry population have kept down competition. All these factors have reduced industry's demand for applied research.

Spurred by insistent farmers of the Israeli cooperatives, researchers on university faculties and at government stations have contributed importantly to agriculture. But in areas of importance to industry, it is claimed, a climate favorable to applied research has been lacking at such institutions as the Hebrew University of Jerusalem and the Weizmann Institute at Rehovot, while at the Technion in Haifa, training ground for engineers and architects, little has been done until recently in the way of applied research.

Hence, the problem boils down to finding ways of mobilizing scientists for work that is relevant to the economy. In the absence of industrial customers, such a mobilization would mean a kind of revolution from the top—even the provision of means for scientists to create new industries. But what industries should be created? Answering this question requires a coherent picture of the technical future of Israeli industry, now in its infancy.

One of the paradoxes of Israel's economy is the fact that the agriculture which launched the country economically is not enough to make it self-supporting. A nation tied economically to the fluctuating prices of citrus fruits is hardly better off than a nation tied to cocoa or coffee or palm oil or peanuts. Especially is this true when those citrus fruits must make a long sea voyage to Europe (often arriving just as the fruits from Italy

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and Spain do), to be sold at prices elevated by the tariff of the Common Market.

In the Israeli view, Israel requires industries which go beyond the extraction of bulk products, like fertilizers and copper, or the cutting of diamonds on their way to world markets. It needs to produce fine chemicals, pharmaceuticals, and instruments. It needs to find new uses for the bromine and magnesium that could be extracted in large quantities from the Dead Sea.

How the chemical products and instruments would be marketed is an important problem. A number of Israeli observers recognize that selling arrangements must be made with established American, European, or Japanese manufacturers. The sales and service problems faced by European manufacturers of scientific instruments, and the success of some organizations which make few chemicals of their own but concentrate on marketing the products of other firms, make the Israelis doubt the wisdom of trying to market their products under independent firm names.

The imbalances in shipping space are another important problem. From the Red Sea port of Eilat, fertilizers move out to the east, but few goods except bulk petroleum make the return voyage. On the Mediterranean the situation is reversed: goods pour in from Europe but relatively little goes the other way. The situation could be aggravated greatly if Israel sought to expand her eastward exports of fertilizer. Hence, there is much talk of importing materials from Asia and east Africa for processing in Israel before shipment to Europe.

With these needs in mind, scientists and engineers all over Israel urge that applied, directed research be pushed forward. The idea is voiced as often at the Weizmann Institute or the Hebrew University as at centers of applied research such as the Negev Institute for Arid Zone Research in Beersheva, the research laboratories of Israel Mining Industries near Haifa, the Israel Institute for Biological Research at Nes Ziyyona, or the national agricultural experiment station at Beit Dagan.

In the past 5 years, concern about applied science has gone far beyond mere conversation. Industries have expanded their research groups. Through special research and development agencies and companies, the universities have started looking for ways of applying their scientists' work as part of a campaign (i) to get more grants and contracts, (ii) to make university scientists more available as consultants, and (iii) to make money through patent-licensing.

Council for Research and Development

One of the most important steps was the foundation in 1960 of the National Council for Research and Development. The council, which reports directly to the prime minister, was given the task of outlining a national policy for research and development for Israel, while coordinating research in industry, government, and the universities and advising the government on scientific aspects of the budget. The agency has made considerable progress under its three successive chairmen, Israel Dostrovsky of the Weizmann Institute, David Ginsburg of the Technion, and Alex Keynan of the Nes Ziyyona biological institute.

The council has assumed control of three government laboratories: the biological laboratory at Nes Ziyyona, the Negev Institute, and the National Physical Laboratory in Jerusalem; the last, directed by H. Z. Tabor, has won notice for its work with solar-powered devices. In its only report so far (published in November 1962), the council underlined the importance of the government laboratories and criticized them.

"Government laboratories are important for work in areas where there is no industry as yet, for basic resource development and where industry cannot yet undertake development because of the resources and skills needed. The vigor of these laboratories is greatly hampered by restrictions imposed by the hierarchical and salary requirements of the government service, and by the lack of mobility of manpower affected by the absence of interchangeability of pension and social security schemes. Research manpower will not be adequately used until these obstacles are overcome, either by instituting a scientific civil service or by removing these laboratories from direct administrative control of the ministries."

To encourage development of the pharmaceutical industry, the council sponsored the establishment of a pharmaceutical screening organization, with one group at the Beilinson Hospital in Petah Tikvah and a fermentation unit at the biological institute in Nes Ziyyona.

Through a special "fund for the encouragement and initiation of research," administered by Shalheveth Freier, the council has already begun pushing projects which could affect industrial development. The fund now spends $700,000 a year. Keynan says the fund is to foster research *in* and *for* industry. "It doesn't always support fantastically original work," Keynan notes, "but the idea was to establish research *inside* industry, to create people as effective receivers of technical information, to create a climate for innovation; at this moment, if a Weizmann Institute man discovered something industrial, he'd have a hard time finding someone in industry to talk to."

Until recently, Keynan asserts, "there was very little communication between industry and the scientists. This must be changed. Industry is acknowledged as the essential next step for the country. Logic requires competition on the world market. Israel can't compete on natural resources, energy prices or labor costs. So we must seek to add originality through a science-based industry open to new processes or better processes. We must not only use the scientific method but also use scientists at many of the stages from research idea to economic process."

Although the council is supporting applied research at the universities and at government and industry laboratories, it thinks something more is required: a large institute for applied research. Planning for the institute is being completed this winter, and its opening is scheduled for 1967. In its first 5 years the institute will operate on a budget of $4 million, of which $1 million—mostly for experts and equipment—will come from the U.N. Special Fund. The institute will be in Haifa and will start with units in industrial chemistry, plastics, and food technology. Nuclei of these research efforts exist at the Technion now. The institute will also be linked to the Israel Mining Industries laboratory nearby, and to a fibers research institute in Jerusalem.

The planning for the institute has been somewhat muddled. At first, it was hoped to place it near the Weizmann Institute in Rehovot, but this idea was rejected. A recent announcement indicated that the part of the institute concerned with textiles would be in Tel Aviv, not Haifa. Many observers feel that the council has not

made up its mind about just what it wants from the institute.

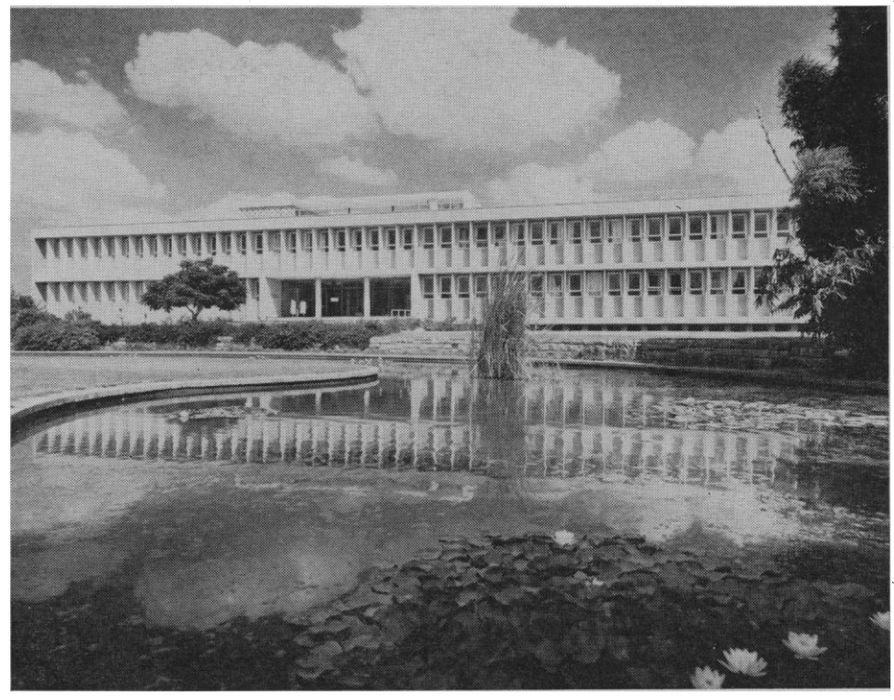
The research efforts at the Technion, the Hebrew University, and the Weizmann Institute have received strong backing. The Technion's research and development foundation, set up as long ago as 1954, directly administers more than a dozen research groups and employs over 300 people. Since 1960 the head of the foundation has been an associate professor of civil engineering, Joseph Karni. Another influential figure in the foundation is the Technion's vice president for research, Professor Rachel Shalon.

At the Hebrew University, Canadian-born Jack Gross, professor of cancer research in the medical school, heads the research and development authority established in 1960. His predecessors were Aryeh Dvoretzky, professor of mathematics, and William Low, professor of experimental physics and a specialist in solid-state physics.

The Weizmann Institute's efforts in applied research are typical of what the larger institutions are doing. The institute founded its development company Yeda in 1959, as a means of earning some money. Yeda has developed, and now helps sell, a protective coating for citrus fruits, developed in the plastics laboratory directed by David Vofsi; new varieties of seeds; a constant-velocity Mössbauer spectrometer, developed in the electronics department headed by Ephraim Frei; and an ultramicrotome, developed by David Danon, head of the department of biological ultrastructure. Yeda markets polyamino acids and amino acid derivatives. It also makes use of the Weizmann Institute's unique plant for manufacturing oxygen-17 and oxygen-18.

Yeda often turns over an idea to someone else for exploitation. One of Israel's outstanding instrument manufacturers is the Elron firm of Haifa, run by Uzia Galil. This firm has taken over the manufacture of a "fragiligraph," invented by Danon to measure the fragility of aging red blood cells in samples from a blood bank. The instrument records the bursting of older blood cells when the *p*H of a solution containing the blood sample is changed.

Developments like these make many scientists in Israel confident that "science-based industries" could spring up around the universities. One group leader of the Weizmann Institute, Joseph H. Jaffe, has set up an instrument-manufacturing company of his own, in a building rented from the institute, where he provides space for other scientists with similar projects. Jaffe and others, like Low of the Hebrew University, are convinced that the exploitation companies must move completely outside the academic structure to attain full commercial vigor. Yeda is not fully divorced from the Weizmann administration.



Institute of Nuclear Science, Weizmann Institute. [A. L. Goldman, New York City]

Such efforts to stimulate new industries do not mean that the National Council for Research and Development and other governmental agencies are neglecting the fundamental problems of agriculture and water supply. In 1960, the year the council was created, another potentially important step was taken: the national agricultural experiment station and the Hebrew University's faculty of agriculture were merged. This merger has not been fully successful, in part because the faculty of agriculture buildings are in Rehovot and the main site of the agricultural station is at Beit Dagan.

To extend the studies of plants in dry regions, the council agreed, 18 months ago, to add a plant physiology research group to the Negev Institute. Israeli-born Yoash Vaadia returned after a decade in California to head the group. He has been joined by Avinoam Livne, Daniel Rubinstein, and Hans Kende, who have Ph.D.'s from the University of Nebraska, the University of California, and the California Institute of Technology, respectively. Kende recently reported experiments indicating that hormones from the root of a plant regulate the metabolism in its leaves (*Science*, 4 Sept. 1964). Vaadia and his colleagues are continuing these studies, looking for the role hormones may play in regulating the response of plants to environmental stress in desert areas.

Studies of the use of reactors to provide the energy for desalinization are directed by Shimon Yiftah, head of the reactor engineering department of the Technion and scientific director of the atomic energy research center at Nahal Soreq. Eventually a power reactor and desalting plant are to be constructed on the Mediterranean coast. Meanwhile an electric power station is being built at Eilat; this year its oil-fired boilers will provide enough steam to distill about 4000 cubic meters of water a day. Another plant at Eilat is already desalting 1000 cubic meters of water daily by means of the Zarchin freezing process. Studies of an electrodialytic method of desalting brackish water are being made by a group at the Negev Institute, led by R. Matz.

A pilot plant producing 500 cubic meters of fresh water a day will begin operating at an agricultural cooperative in 1965. Matz's group, to-

gether with a group from Tabor's National Physical Laboratory, is also studying the use of a solar-heated pond, with artificially steep temperature and density gradients, as a salt-extraction "pan." After testing near the Dead Sea salt works at Sdom, such a pond has been built near salt works at Atlith on the Mediterranean coast. Tabor and Matz report that the pond produces rather pure salt at competitive prices.

Water is the main concern of Ernst David Bergmann, who is professor of organic chemistry at the Hebrew University, head of the Atomic Energy Commission, and head of Israel's defense research. For many years Bergmann was scientific director of the Weizmann Institute, but he resigned in protest against what he considered excessive concentration on research that had little relevance to Israel's development.

Bergmann maintains that Israel's transcendant development problems are water and defense; all else is secondary. He holds this view in the face of objections from colleagues, such as Gavriel Stein, who say that security and water are merely commodities: the real question is what you do with them.

Israel's water needs are only now being properly formulated, Bergmann asserts, even though many individual steps have been taken. Engineers have provided a water-supply network, and experiments with silver iodide seeding of rain clouds (a technique about which there is much debate in Israel as elsewhere) have continued for the past 8 years. Israel and Australia are the two countries which have been able to show statistically significant increases in rainfall through seeding from airplanes, Bergmann maintains.

Although Israel must maintain a "disproportionately large" military research effort, he says the secrecy curtain has not been allowed to harm the economy unduly. The defense establishment includes a reactor at Dimona, fueled with natural uranium, which is said to be capable of producing enough plutonium for a couple of nuclear bombs a year. The defense research effort must be large, Bergmann says, because Israel can never hope to match the potential size of Arab armies; instead it must compete technically. It must, in fact, compete technically with the Soviet Union, supplier of weapons to the Arabs.

Although Bergmann and many others are critical of the level of industrial research in Israel, they have to make an exception for the Israel Mining Industries Research and Development Institute near Haifa, headed by A. Baniel. Founded in 1951 when intense exploration of Israel's mineral resources was beginning, IMI began by processing phosphates, ceramics, and copper. In those days, the IMI laboratory mainly served its parent company, but sales of processes to foreign licensees increased gradually. Little by little the ministry of development, IMI's owner, diverted mineral and chemical production to other firms. In the spring of 1964 the Timna copper mines near Eilat were placed under separate management, and the IMI laboratory became available for general service.

According to Ruth Blumberg, a South African who studied for her Ph.D. at Columbia and who heads IMI's process development, many of the processes involving heavy inorganic chemicals, such as a number of salt-acid fertilizer techniques, are at or near the point of industrial application. Hence, interest in organic chemicals has been developing. This is L. M. Shorr's department. Shorr joined the laboratory in 1955, shortly after receiving his Ph.D. from the University of Pittsburgh. His group is interested in polymers generally, and interested specifically in finding whether any local chemical wastes might be economic sources of useful polymers. Also, Shorr and his group are surveying processes already developed, to see if they might be important in the projected manufacture of fine chemicals. His group also studies reagents for various processes, and it developed the process to prepare the alpha-bromo lauric acid that Blumberg and Pnina Melzer used for the recovery of metals from solution by solvent extraction. The process has the advantage of using bromine, available in great quantities from the Dead Sea.

In cooperation with Shorr, Abraham Mitzmager and his group worked with tetrabromoethene, a heavy liquid for use in float-and-sink processes of concentrating ores. They first worked to produce the heavy liquid cheaply, then tested it with hundreds of ore samples from many countries.

In the course of this work, which began in 1956, the laboratory has had to abandon its original reluctance to construct large machines, Blumberg said. Inquiries to potential suppliers of plant equipment in other countries always brought a request for consultation with someone from IMI. To Blumberg, such a request simply means, "You had better do it yourself." For a solvent-extraction process for obtaining pure phosphoric acid, the laboratory has tried three sizes of pilot plants; the latest will produce about 50 tons a day. This process has already been licensed in the United States, in Brazil, and in Japan.

IMI has developed five fertilizer processes to the point of industrial application. In two of these processes the hydrochloric acid so plentiful in Israel is used to produce pure phosphoric acid from phosphate rock. In another process solid potassium chloride is converted into solid potassium nitrate in one step, by the addition of nitric acid. Magnesium phosphate and monopotassium phosphate are produced by still other processes. Heading this work on new fertilizers is Y. Araten, born in Holland.

Behind these efforts to improve fertilizers are several main goals, according to A. Alon, Italian-trained assistant managing director of IMI. They are: (i) to increase the availability of fertilizer constituents to the plants; (ii) to reduce the nonnutrient "ballast" fraction, a matter of importance not only to shippers but also to the farmer who carries a sack on his back; (iii) to make more sophisticated use of the phosphates and potash so plentiful in Israel; and (iv) to cut the energy input.

In traditional and nontraditional industries alike, Israel is trying to build an establishment for more sophisticated applied research. In a difficult environment where there is a crying need for scientific applications, fundamental research flowered first. But laboratories like that of Israel Mining Industries show that a climate for directed research exists in at least one area of Israeli industry. This is a good sign for Israel's future.

—VICTOR K. MCELHENY