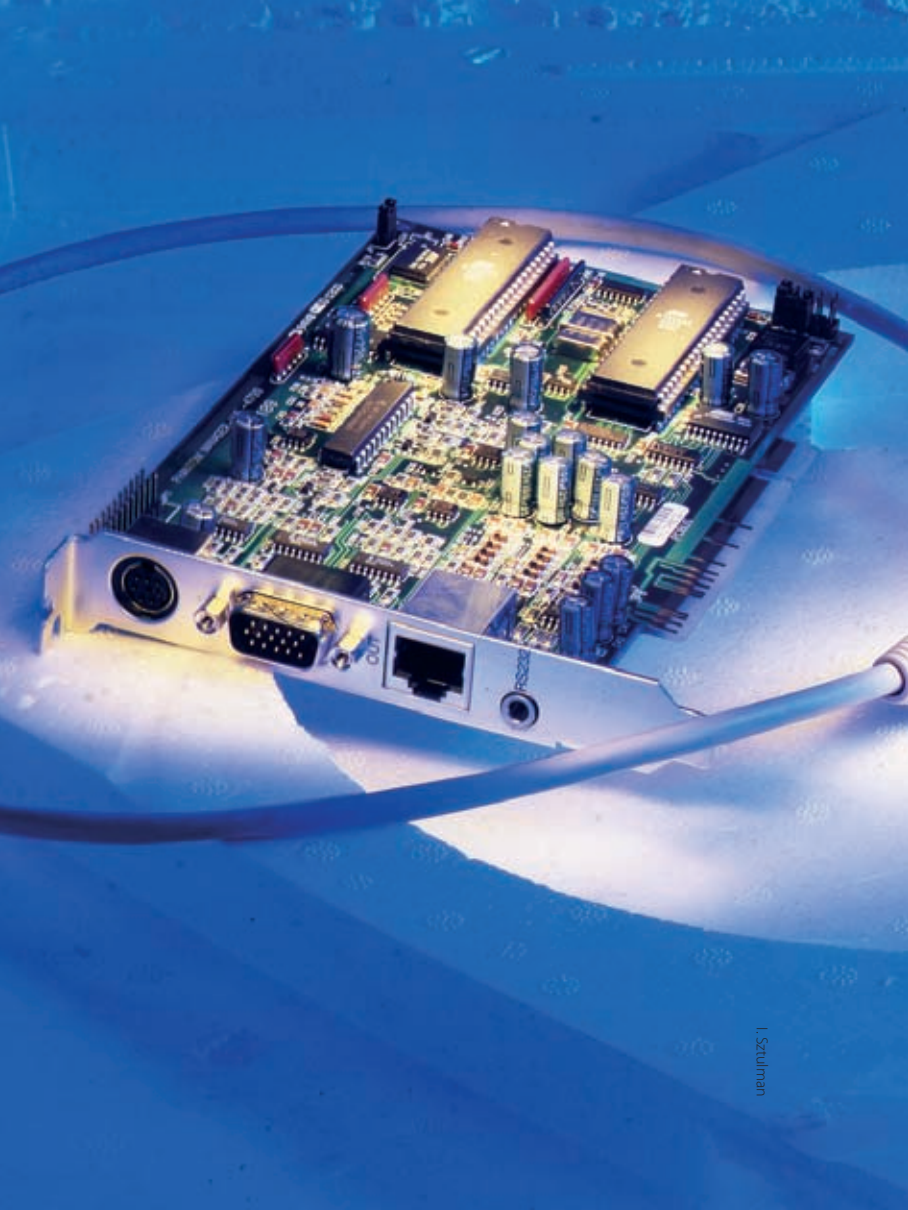


# SCIENCE AND TECHNOLOGY

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## SCIENCE AND TECHNOLOGY

Like many other small countries, Israel has sharply defined scientific and technological policies aimed at enhancing its competitive position. In science, it encourages the establishment of centers of excellence around outstanding scientists, while maintaining a level of quality across the broad spectrum of scientific fields. In technology, Israel strives for high performance through concentration on a limited number of areas.

The percentage of Israelis engaged in scientific and technological inquiry, and the amount spent on research and development (R&D), in relation to its Gross Domestic Product (GDP), are among the highest in the world.

המחקר המדעי והישגיו אינם עוד עניין אינטלקטואלי מופשט  
בלבד... אלא גורם מרכזי... בחיי עם תרבותי... (דוד בן גוריון, תשכ"ב)  
Scientific research and its achievements are no longer merely  
an abstract intellectual pursuit... but a central factor... in the  
life of every civilized people... (David Ben-Gurion, 1962)

## BEGINNINGS

The history of scientific research in Israel is an integral part of the story of the return of the Jewish people to its homeland. Theodor Herzl (1860-1904), the founder of political Zionism who actively promoted the idea of a modern Jewish state in the Land of Israel, envisaged it not only as the physical home of the Jewish people, but also as a major spiritual, cultural, and scientific center.



Laboratory of  
**FRUTAROM**, 1946

G.P.O. / H. Pinn

The desire to transform the Land, then a barren and disease-ridden region, into a modern state was a key factor in subsequent scientific inquiry and technological development. Agricultural research dates back to the end of the 19th century with the establishment of the Mikveh Yisrael School (1870). The Agricultural Station, set up in Tel Aviv (1921), eventually became the Agricultural Research Organization (ARO), today Israel's major institution of agricultural research and development. Medical and public health research was initiated prior to World War I with the founding of the Hebrew Health Station. It received a major boost when the Institute of Microbiology and departments of biochemistry, bacteriology, and hygiene were instituted in the mid-1920s at the Hebrew University of Jerusalem. These provided the basis for the Hadassah Medical

Center, today Israel's most prominent medical research facility. Industrial research was pioneered at the Dead Sea Laboratories in the 1930s, and advances in basic science and technology were begun at the Hebrew University (est. 1925), the Technion-Israel Institute of Technology (est. 1924 in Haifa), and the Daniel Sieff Research Center (est. 1934 in Rehovot), which later became the Weizmann Institute of Science (1949).

The country's scientific and technological infrastructure was already in place when the State of Israel was established in 1948. At first, research focused on projects of national importance, and on this foundation commercially oriented industries gradually developed.

## PROFESSIONAL PERSONNEL

Israel's large reservoir of qualified personnel is primarily responsible for its scientific and technological attainments. As the many highly trained scientists, engineers, and technicians among the hundreds of thousands of immigrants from the former Soviet Union gradually entered the labor force, the percentage of qualified personnel rose dramatically and they will significantly affect Israel's scientific and technological achievements for decades to come.

I. Sztulman



## RESEARCH AND DEVELOPMENT (R&D)

R&D in Israel is carried out primarily at seven universities, dozens of government and public research institutes, and hundreds of civilian and military enterprises. Significant research is also performed at medical centers and by a number of public service firms, in fields such as telecommunications, power production, and water resources management.

Government and public bodies are primary sources of R&D funding, providing financial support for well over half of Israel's R&D activities. The major share of these funds for civilian R&D purposes is allocated for economic development, mainly in the industrial and agricultural sectors, which, in comparison with other countries, constitutes a very large part of the total. Over 40 percent is used to advance knowledge through national, binational, and government research funds and through individual university allocations from the General University Fund administered by the Council of Higher Education. The remainder is dedicated to various health and social welfare fields.



I. Szulman



I. Szulman

Over 80 percent of all publishable Israeli research – and almost all basic research and basic research training – is conducted within the universities. The Israel Science Foundation (ISF), a legally independent body, is the predominant source of competitive basic research funding. Some 1,000 individual researchers receive grants from ISF, matched with university funding. ISF also funds special programs, such as Israel's participation in building the ATLAS detector for the Large Hadron Collider at CERN, and improving the quality of clinical research via an innovative series of 'physician-researcher' grants.

To fund and coordinate research initiatives too large for any one agency to handle, there is TELEM, a voluntary forum composed of the chief scientists of the Ministry of Industry, Trade, and Labor and the Ministry of Science, the president of the Israel Academy, and representatives of the Council for Higher Education, the Treasury, and others. TELEM engineered, and where necessary funded, Israel's entry into the European Union's Framework Program, membership in the European Synchrotron Radiation Facility and Israel's Internet II initiative.

The large number of patents taken out by Israel's universities is one measure of the effectiveness of the relationship between the universities and industry.

## R&D at Universities

As at universities all over the world, advancement in scientific knowledge is the chief objective of researchers at Israel's universities. Books and journal articles by Israelis, encompassing all scientific fields, are a primary expression of the university sector's output. Israel publishes a disproportionate percentage (about 1 percent) of the world's scientific publications, and in many fields, such as chemistry and computer sciences, they have a particularly high impact on the world scientific community.

Relative to the size of its labor force, Israel has a significantly larger number of publishing authors in the natural sciences, engineering, agriculture, and medicine than other countries, and an exceptionally high share of the country's publications are co-authored by Israeli scientists and those of other countries.

To integrate Israeli science into the international scientific community, post-doctoral research positions and sabbaticals abroad as well as attendance at foreign scientific conferences are encouraged, and a wide range of exchange programs and joint projects are maintained



at institute, university, and government levels with counterpart organizations overseas. Israel is also an important center for international scientific conferences, hosting many such gatherings annually.

Concomitant with their scientific research activities, the universities continue to play an important and innovative role in Israel's technological advancement. The Weizmann Institute of Science was among the first in the world to set up an organization for the commercial utilization of its research (1958); today, similar organizations exist at all Israeli universities. The establishment of science-based industrial parks adjacent to university campuses has been pioneered with great commercial success. Universities have also set up spin-off industrial firms for the commercialization of specific products based on their research, often in partnership with local and foreign concerns.

Interdisciplinary research and testing institutes are functioning at universities in diverse scientific and technological fields vital to the country's industry, serving areas such as construction, transportation, and education as national focal points for applied R&D. In addition, a high proportion of faculty serve industry in an advisory capacity on technical, administrative, financial, and managerial matters.

## Medical R&D

Israel has made significant theoretical and practical contributions to the biotechnology revolution and has developed an advanced infrastructure of medical and paramedical research as well as bioengineering capabilities. Biotechnology, biomedical, and clinical research account for over half of all scientific publications. The country's industrial sector has increased its activities in the medical field to capitalize on its extensive knowledge base.

Local scientists have developed methods for producing a human growth hormone and interferon, a group of proteins effective against viral infections. Copaxone, a medicine effective in the treatment of multiple sclerosis, was developed in Israel – from basic research to industrial production. Genetic engineering, has resulted in a wide range of diagnostic kits based on monoclonal antibodies, along with other microbiological products. Sophisticated medical equipment for both diagnostic and treatment purposes has been developed and marketed worldwide, such as computer tomography (CT) scanners, magnetic resonance imaging (MRI) systems, ultrasound scanners, nuclear medical cameras, and surgical lasers. Other innovations include a controlled-release liquid polymer to prevent accumulation of tooth plaque, a device to



**CT Scan**

Courtesy of Shaare  
Zedek Hospital

reduce both benign and malignant swellings of the prostate gland, the use of botulin to correct eye squint, and a miniature camera encased in a swallowable capsule used to diagnose gastro-intestinal disease.

### **Industrial R&D**

In the industrial sector, civilian expenditure on R&D and the number of scientists and engineers engaged in industrial R&D have grown abundantly over the past two decades.

Israel's industrial R&D, with a high concentration on electronics, is mainly carried out in a small number of large firms. These R&D-intensive companies have been a major source of industrial employment and exports over the years.

Fostering the growth of such enterprises, both large and small, is the focus of Israel's industrial strategy. The government promotes R&D in industry within the framework of the Law for the Encouragement of Research and Development, implemented by the Chief Scientist's Office of the Ministry of Industry, Trade, and Labor which in 2000 funded some 1,200 projects. R&D-related products comprise more than half of total industrial exports (excluding diamonds).

**Electronics**, limited until the late 1960s mainly to

consumer goods, has branched out into more sophisticated technological developments, both military and civilian. In communications, R&D-based applications include the digitalizing, processing, transmitting, and enhancing of images, speech, and data. Products range from advanced telephone exchanges to voice messaging systems, telephone line doublers, and a vast array of Internet applications.

**Optics, electro-optics, and lasers** have been growing rapidly as industrial fields. Israel is a world leader in fiber-optics, electro-optic inspection systems for printed circuit boards, thermal imaging night-vision systems, and electro-optics-based robotic manufacturing systems.

**Computer-based equipment**, mostly in software and peripheral fields, has been developed and produced. In printing and publishing, Israeli-made computer graphics and computer-based imaging systems are widely used locally and abroad. Activities in schools are enhanced by a variety of computer-aided instructional systems, many of which have been developed for export. While some of Israel's software products are designed for use on mainframe computers, most have been developed for small or medium-sized systems such as computer workstations. A computer mouse with three touch-pads, allowing the visually impaired to "read" text and graphics on screen, was developed in Israel.

**Robotics**, first researched in the late 1970s, is now producing robots designed to perform a wide variety of tasks, including diamond polishing, welding, packing, building, and more. Research is now under way in the application of artificial intelligence to robots.

**Aeronautics** related to defense needs has generated technological development with consequent civilian



**Col. Ilan Ramon**  
(far right),  
first Israeli  
astronaut, lost  
together with  
six American  
colleagues  
on board  
space shuttle  
Columbia

NASA Photo  
MSFC-0300309

spin-offs. The Arava, the first civilian aircraft to be produced in Israel, was followed by the Westwind executive jet. Locally designed and manufactured satellites have been produced and launched by Israel Aerospace Industries in cooperation with the Israel Space Agency. Israel also develops, manufactures, and exports a large number of related items, including

display systems, aeronautical computers, instrumentation systems, and flight simulators, and is a world leader in technology and production of drones.

### **Agricultural R&D**

The agricultural sector is based almost entirely on R&D, implemented by cooperation between farmers and researchers. Research results are quickly transmitted through an extension service to the field for trial, and problems are brought directly to the scientists for solutions. Agricultural R&D is carried out primarily by the Ministry

of Agriculture's Agricultural Research Organization. Most agricultural research institutes in Israel maintain close relations with the Food and Agriculture Organization of the United Nations, ensuring a continuous exchange of information with other countries.

Israel's dairy cows are, on average, the world champions in milk production, having increased the average yield per cow from 6,300 liters in 1970 to over 10,000 liters today through scientific breeding and genetic testing carried out by the Volcani Institute. By harvesting sperm and ova from cattle of superior bloodlines, Israel is able to upgrade its own herd as well as share its advances in this field with other countries.



Scientist at the  
**Volcani Center  
for Agricultural  
Research**

G.P.O. / A. Ohayon

Israeli agriculturists have pioneered trickle-drip irrigation, agricultural biotechnology, soil solarization, and the sustained use of industrial waste water for agriculture. These advances have been applied to marketable products, ranging from genetically engineered seeds and bio-pesticides to light-degradable plastics and computerized irrigation/fertilization systems.

Making optimal use of scarce water, harsh land, and a limited labor force has led to revolutions in agricultural methods. The search for water-saving techniques spurred

development of computer-controlled irrigation systems, including the drip method which directs water flow straight to the root zone of plants, helping farmers worldwide. Research relating to the electro-magnetic treatment of water to improve animal health and crop yields has also produced promising results.

Israeli-designed and manufactured computers are widely used to coordinate daily farming activities, such as guiding fertilizer injection while monitoring relevant environmental factors, supplying feed for livestock mixed according to tested least-cost/best-yield proportions, and providing a temperature- and humidity-controlled environment for poultry. In addition, a variety of innovative equipment for tilling, sowing, planting, harvesting, collecting, sorting, and packing has been developed, manufactured, and implemented.

Agriculture has also benefited from general scientific research and R&D, including automated plant tissue culture, biological insecticides, disease-resistant seeds, and biological fertilization.

### **Energy R&D**

Extensive development of alternative energy sources such as solar, thermal, and wind energy has been a positive outcome of the country's lack of conventional energy sources. As a result, Israel is a leader in the solar energy

field at every level and the world's largest per capita user of solar water heaters in the home. A new, high-efficiency receiver to collect concentrated sunlight has been developed, which will enhance the use of solar energy in industry as well.

An advance in harnessing wind energy has been the production of a wind turbine with a flexible, inflatable rotor. Technology utilizing pond water with a certain degree of salinity and mineral composition to absorb and store solar energy has also been developed. Geothermal power stations, capable of extracting heat from the ground and converting it to steam for powering turbines, are now being tested. A project developed by a team of scientists at the Technion, uses dry air and water (even sea or brackish water) to produce energy through 1,000-meter high chimneys.



Field of Mirrors  
at the Weizmann  
Institute of Science  
•  
Courtesy of  
the Weizmann  
Institute of Science