Science And Technology Education in Japan

— Prospects & Future Tasks —

By Keiichi Oshima

Technological innovation and education

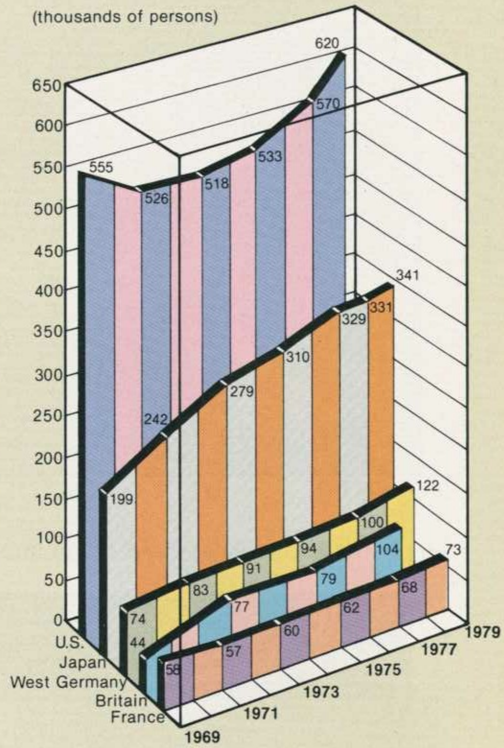
The remarkable technological advances achieved by Japan should be credited, first of all, to the extensive efforts made by industry. It is also necessary to note that such factors as economic and social conditions and government policies have made important contributions as well. Furthermore, an analysis of factors behind the country's technological development shows several important factors which can be identified as: 1) entrepreneurship, 2) introduction of technology from abroad, 3) active research and development, 4) strenuous efforts for market exploitation, 5) development of production technology, notably quality control, and 6) a climate of aggressive market competition.

In the background of these factors existed a socio-economic environment featuring the positive attitude of industry and government toward the promotion of investment and employment, and one of the most crucial elements to be singled out is Japan's high level of education in science and technology.

An international comparison of investment and manpower in R&D is shown in Figures 1-1 and 1-2. It indicates that, compared with American and European countries, Japan has seen a rapid increase in the number of researchers since World War II—particularly since the 1970s—at a rate of growth even faster than that for R&D expenditures. The role played by the nation's science and technology education efforts in this regard should be rated highly.

It takes time to train researchers and technical experts. On the other hand, such training is vital if a nation is to cope with the rapid advancements being made in technology. In this connection, education at school and in business should be complementary, like the two wheels of a cart.

Figure 1-1 Number of Researchers in Main Countries



Note: Figures are based on OECD data except for the U.S. Japan's data is based on a report on science and technology studies. All figures are the totals of natural and social scientists.

Sources: Report on Science and Technology Studies for 1970-80; Handbook on Science and Technology, 1982; White Paper on Science and Technology, 1981; White Paper on Health and Welfare, 1981

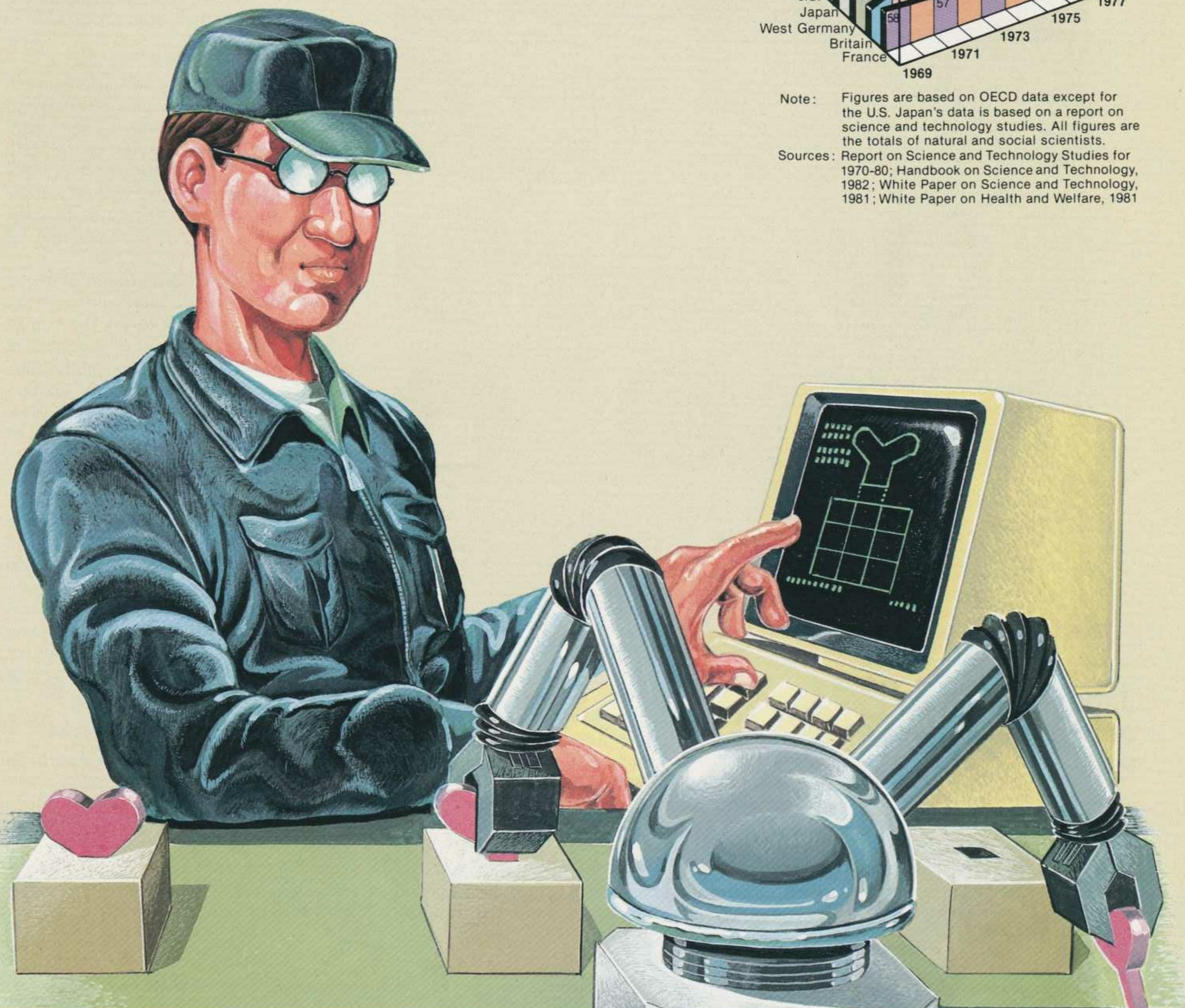


Figure 1-2 Research Spending in Main Countries

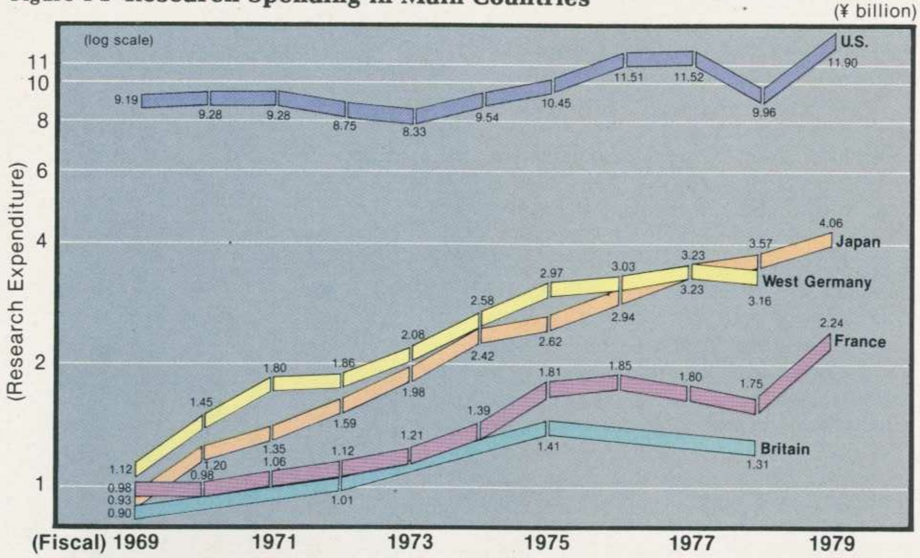
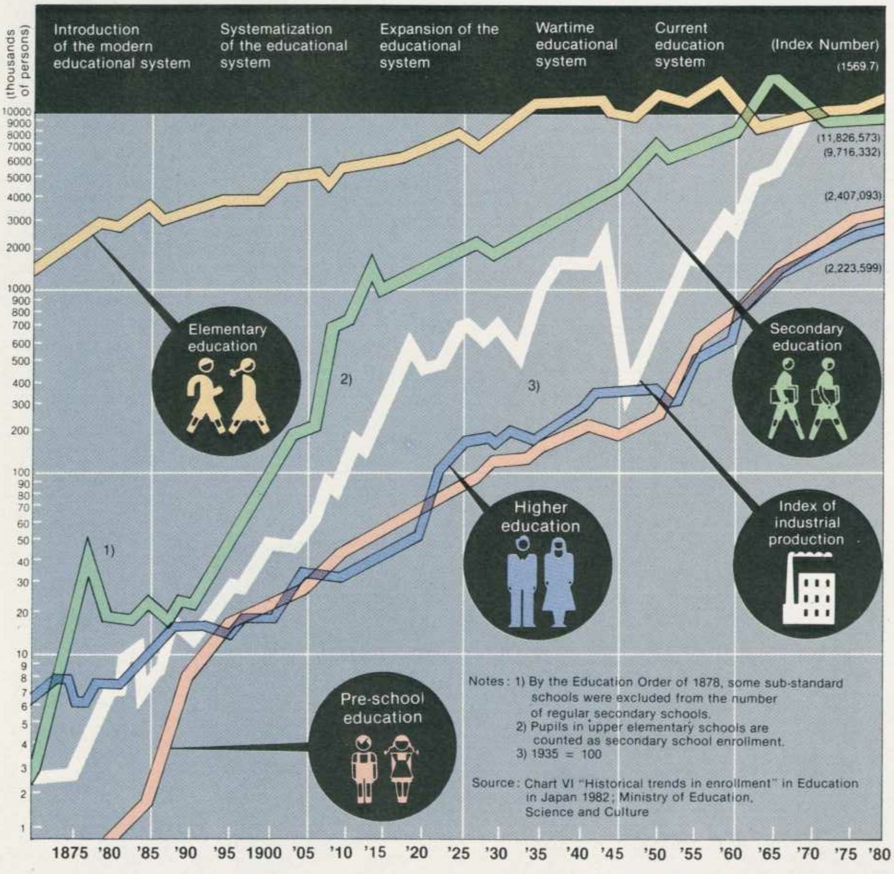


Figure 2 Historical Trends in Enrollment



Japanese school education—a historical view

The modern educational system in Japan was established as part of the modernization of social, economic, political and other systems which accompanied the Meiji Restoration in 1868. It was based on the policy of devoting maximum effort to bringing the traditional educational system in line with those in European countries. The present system was established by way of further major reform implemented after World War II. Figure 2 shows trends in school enrollment.

1. Zeal for education in Japan

Though the modernization of Japanese education has a history of only about 100 years, it must be noted that the tradition of public enthusiasm for education—and the subsequent high level of education—dates back much further in this country.

As clearly shown in Figure 2, the ratio of enrollment at elementary schools was very high (34% for boys and 10% for girls) when the modern educational system was set up at the start of the Meiji era (1868–1912). This was the highest enrollment rate in the world. The rapid progress in middle and higher school education as well as in intra-company education is a clear indication of the special enthusiasm of the Japanese public for learning.

2. Science/technology education in Japan

Japan's modern higher education in technology originates from the establishment of an engineering college in 1877 and its subsequent merger with the University of Tokyo, which was established in 1886. We can learn the characteristics of modern Japanese education in science and technology by following its history, starting with a review of the educational ideas that prevailed during the inaugural period.

i) Engineering given priority

As mentioned earlier, educational modernization was carried out as a part of much broader and general reforms of institutional systems at the start of the Meiji era. High-level scientific and technological education was given priority in the new government's modernization policies, particularly as part of its program of industrialization.

In contrast to Western systems of higher education—which originate in academicism's emphasis on improving the human intellect through conducting basic studies in science and technology, in philosophy and religion, independent of the government—Japanese modern education tended to give more priority to practical aspects, or, in the case of science and technology, to the promotion of industrialization. When Prof. Henry Dyer of Scotland's Glasgow University was invited to help set up the first engineering college in Japan, he had to adapt the traditional European model to Japan's requirement that the school be of a more practical orientation. The result moved Prof. Dyer to comment, "Britain's first modern engineering college has been created in Japan."

ii) Internationally high level targeted

Japan firmly established its educational system by inviting many outstanding scientists and engineers from abroad, such as the above-mentioned Scottish professor, despite the high costs involved. At the same time, it sent many young students abroad to study at foreign universities. With a rather low rate of "brain drain," these students returned to Japan and made important contributions to the advancement of the country's industrial technology.

Among such Japanese were Dr. K. Ikeda, a pioneer in the sodium glutamate industry, and Dr. T. Takamatsu, who established the gas utility industry. Such students back from abroad replaced the invited foreigners rather quickly. It is worth special mention that with such efforts, the quality of Japanese education in the engineering field reached the international level at a comparatively early stage.

iii) Exchange with industry

As mentioned, the establishment of scientific and technological colleges and universities was begun with industry in mind. For example, professorial chairs corresponded to industrial activities: at Tokyo Imperial University's Department of Applied Chemistry there were professorships in such fields of industrial chemistry as acids, alkalis and fertilizers. This corresponds to the practical role of university education in supplying highly qualified engineers to industry, one of the prominent features of Japanese higher education at that time. There was not, in fact, much active cooperation in research such as joint studies between industry and the universities. Rather, their relationship was so close at the human level as to offer numerous opportunities to exchange information and engage in personal collaboration.

Postwar development

In keeping up with the nation's industrial and economic development, Japan's system of higher education in science and technology has undergone continuous improvement and went through a major change after World War II along with all other institutional systems. However, the basic features of education in science and technology remained practically unchanged from those described above. The expansion of engineering education was accelerated in the 1960s in accordance with the government's policy of promoting the transformation of Japan's industrial structure to one more oriented toward high technology.

1. Higher education enrollment ratio; engineering students assume high proportions

The ratio of enrollment in higher education in Japan was about 37% in 1981, and has been dropping slightly since peaking in 1976. It is lower than the 45% in the United States but consideraly higher than the 20% range in European countries (see Figure 3). Shown in Figure 4 are the number of students enrolled in higher education and the holders of academic degrees in the United States and key European countries as well as Japan in recent years. Attention should be paid to the remarkable difference between Japan and the other countries in the ratio of figures for physical science vis-à-vis engineering.

2. The growing importance of company education

Rapid technological innovation and a subsequent change in the industrial structure have added to the importance of education given inside enterprises themselves. In other words, it has become an established practice to teach fundamental knowledge and give basic engineering training at university, leaving to the enterprises the responsibility for providing education in practical technology related to production and other corporate activities. It can be assumed that the reason for Japan's successful progress in company education is closely related to certain Japanese social phenomena, including: 1) lifetime employment, 2) job transfer and rotation, 3) the seniority system, and 4) improvement of the education system.

Future tasks and prospects

1. Taking up a new global challenge

Japan has made remarkable progress in using education to further the development of science and technology for the production of high-quality products.

Figure 3 Internationally Compared University Enrollment Ratios

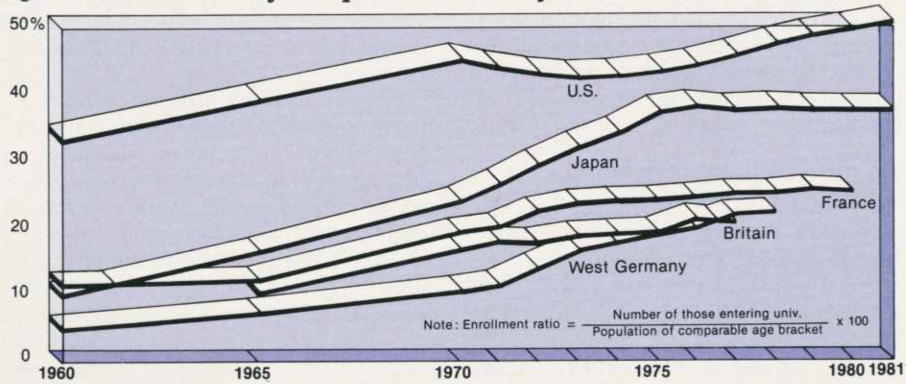


Figure 4-1 Number of Higher-Education Students by Subject

	FY	Total	Cultural and Social Sciences	Physical Science	Engineering	Agriculture	Medical Science	Others
Japan	1970	1,619,649	857,139	42,265	320,029	53,356	72,284	274,576
	1981	2,110,513	1,108,688	55,212	368,770	63,195	129,888	384,760
Britain	1970	185,872	81,167	45,775	30,261	3,640	20,616	4,413
	1979	245,093	113,157	55,590	35,817	5,124	27,629	7,726
France	1970	572,614	346,689		89,455		112,275	24,195
	1978	720,335	389,195		103,776		161,931	65,433
W. Germany	1970	407,107	164,514	69,917	39,580	7,065	44,748	85,283
	1979	970,284	455,433	141,653	176,494	24,014	83,238	89,422

Notes:

Japan—Total number of students at universities and junior colleges, and fourth and fifth graders at specialized junior colleges; "Others" includes students at merchant marine colleges.

Britain—Figures are for Great Britain, and represent total number of students at full-time university courses; students at polytechnic schools and other educational institutions are not included (students at full-time and sandwich courses numbered 194,034 in 1978). "Others" includes architecture, urban planning and hotel management.

France—Total number of students at first- and second-term courses of national universities, technical junior colleges and advanced courses of normal schools; those at grandes ecoles, etc. are not included. Students at technical junior colleges (24,195 in 1970 and 50,237 in 1978) are included in "Others" category.

W. Germany—1970 figures are students at academic universities and those for 1979 are students at academic and arts universities and specialized high-level schools (including foreign students). "Others" includes physical education and sports (20,107 in 1979).

Sources:

Japan—Report on Basic School Survey, 1970, and its Supplementary Report in 1981
Britain—Vols. 4 and 6 of each year's Statistics of Education
France—Statistiques des Enseignements, 5-2, 1972, and Tableaux des Enseignements et de la Formation, 1980
W. Germany—Statistisches Jahrbuch, 1972 and 1981 editions

Figure 4-2 Holders of Academic Degrees by Subject (Total for Masters Degrees and Doctorates)

	FY	Total	Cultural and Social Science	Physical Science	Engineering	Agriculture	Medical Science	Others
Japan	1970	13,879	2,847	1,794	4,633	1,026	3,219	360
	1981	21,665	4,124	2,532	8,161	1,695	4,234	919
U.S.	1970	262,616	102,056	26,520	21,797	3,543	6,215	102,485
	1978	333,809	141,349	22,692	21,292	4,944	16,203	127,329
Britain	1970	12,901	4,183	4,017	2,727	320	835	819
	1978	18,080	6,322	4,374	3,090	501	1,206	2,587
France	1970	7,526	1,702		3,049		2,775	—
	1977	17,273	2,421		5,178		9,674	—
W. Germany	1970	9,728	2,158	1,995	768	332	4,475	—
	1979	11,033	2,279	2,467	982	469	4,827	9

Notes:
Japan—Total of degree holders between April of previous year to March of relevant year.

Britain—Figures are for Great Britain, and represent number of degree holders at universities. They do not include holders authorized by a council for awarding academic titles (who numbered 170 in fiscal 1970 and 1,013 in fiscal 1978).

France—Number of holders of national doctorates, various doctorates obtained at third-term university courses (fifth grades or over) and other comparable doctorates.

W. Germany—Number of successful applicants in doctorate examinations in winter and summer semesters; social science includes education; foreign students (906 in 1979) not included.

Sources:
Japan—University Data
Other countries—ibidem as Figure 4-1

Now, however, with Japan accounting for about 10% of the world's economic output, it cannot overlook its responsibility to contribute to the revitalization of the stagnant world economy and the improvement of the well-being of humanity through its capability in technological innovation. To achieve this end, the country must take up the new challenge of technological innovation; no more can it afford to rely solely upon the conventional merits of Japanese education as in the past.

2. From discipline-oriented to creative education

In order to meet today's new challenges, Japanese science and technology must be directed from now on toward creative research and development which will lead to large-scale innovation. This has raised the necessity of emphasizing a new direction in education, one that will encourage more originality among researchers and engineers by promoting creative activities to a larger extent.

That is to say, Japan must switch from its traditional discipline-oriented science and technology education to one with a new orientation aiming at higher creativity. In this connection, it will be important to reconsider the present educational principle of placing priority on raising the average level of students as a whole, and to place more emphasis on the education of outstanding individuals and these blessed with creative talent.

3. Cultivating talent and originality through educational fluidity

Fluidity in education as a means of cultivating talent and originality is a subject that constitutes the core of the educational reforms instituted in Japan. There have been various arguments on the matter, although the government has made no definite decision yet. In view of the fact that Japanese science and technology are now expected to contribute to the international community as a whole, and that, by nature, science and technology should flow freely across national borders —in fact, these ideals are at the heart of the Japanese national policy on science and technology—the educational system should now be reformed along the following lines.

Fluidity is clearly mounting within different specialized organizations and different disciplines in Japan. This tendency first emerged in industry, where it is progressing rapidly, and is now gradually beginning to have an impact on universities and other higher educational institutions in terms of both teaching and research. One example is a proposal for the increased exchange of educational staff between universities; the proposal was advanced by the Ad Hoc Commission on Administrative Reform early this year.

Such promotion of fluidity stimulates the development of individuality and, furthermore, leads to increased expectations for the flowering of individuals with talent, originality and creativity. There are already examples of new efforts in this direction, ranging from attempts by companies to conduct freer education in their training programs to plans to set up new colleges of science and technology, such as the one in Nagaoka, and various international universities.

4. In quest of new expertise

Expectations for such a new educational system are growing and moves toward its promotion are active. It will be necessary to reexamine the basic thinking behind higher education in science and technology in search of a new orientation, taking account of recent trends in industry and other areas.

The eventual objective of science and technology is to promote the happiness and dignity of mankind. Science and technology in the 21st century will cause changes not only in industry but also in such public spheres as food and medical care, as well as in our living environment, behavior, culture, and civilization as a whole. The scientific and technological education that the world will look to for the expertise needed to handle the increasingly diversified and sophisticated aspects of these disciplines will not be of a simple technical nature; rather, it will be based on a new philosophy of mankind, aiming at cultivation of the human being itself. The development of innovative and progressive education in science and technology should do much to establish the educational expertise we now await. ●

Keiichi Oshima, Ph.D., is a professor emeritus at the University of Tokyo and vice chairman of the Industrial Research Institute, Japan. He is a member of the Royal Swedish Academy of Engineering Science and the United Nations Science and Technology Advisory Committee for Development. Oshima, 62, joined the faculty of chemistry of the University of Tokyo in 1944 after graduating from the university and served as a professor in the department of nuclear engineering 1961–1981. He also served as the director for science, technology and industry at the Organization of Economic Cooperation and Development in Paris 1974–1976 on leave from the university.