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Materials education and research in Japan, and Japan-India cooperative science program

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National universities and national laboratories in Japan are changing quite rapidly and drastically. National universities are not directly under the Ministry of Education, Culture, Sports, Science and Technology (MEXT) after April 2004. Many national laboratories became Independent Administrative Institutions on October 1, 2003. Japan Society for the Promotion of Science (JSPS) supports Japan-India Cooperative Science Program with the Government of India, Department of Science and Technology.

1. Universities in Japan

In Japan, there are too many universities. In 1950 we had 201 universities and now in 2002 we have 686 universities. Among them, 99 are national, 75 are local (city or prefecture), and 512 universities are private. Therefore most universities are private. Number of newly born babies in Japan is decreasing. Now the average couples have only 1.29 babies in Japan. In 1950, 10% of the 18 years population entered higher educational institutions (8% to universities and 2% to colleges) but in 2002 49%, one half of the 18 year population entered higher educational institutions (41% entered to universities and 8% colleges). Therefore, anyone can enter a university, if one wants. 83.5% of the applicants can enter universities or colleges (Fig. 1). Fig. 2 shows the number of the students entering to universities to the number of applicants.

After April, 2007, all applicants can enter universities.

Systems of national universities are changing rapidly and drastically in Japan. After April 1, 2004, National Universities directly do not belong to MEXT (Ministry of Education, Sports, Culture and Science and Technology). All former national universities are under "Incorporation of National Universities". Budget and personnel of a university are deregulated. MEXT made a list of salary of teaching members of national universities but no list after April 1, 2004. The management of universities has more freedom and introduced management techniques based on "private-sector". The board of directors centered on the president is the top-management. People outside the university are participating in the management of the university. The selection process of the president of a university has been changed. The status of the personnel of a university is no more civil servants. Freedom carries responsibility with it. Universities have to disclose through the information and internal and external evaluation of the universities.

2. National Research Laboratories

Many National Laboratories have changed to Independent Administrative Institutions on October 1, 2003. For Example: National Institute for Materials Science (MIMS) which had been combined National Research Institute for Metals and National Research Institute for Ceramics recently and National Institute of Advanced Industrial Science and Technology (AIST) which was combined former 10 National Research Institutes under former Ministry of Industry and Foreign Trade have changed to Independent Administrative Institutions.

Some are still directly under Ministries but will be changed to Independent Administrative Institutions. MEXT is emphasizing Inter-University Research Institutes. For Example, Okazaki National Research Institutes, Kyushu University Institute for Materials Chemistry and Engineering, KEK B-Factory Project by High Energy Accelerator Research Organization.

Inter-University Research Institutions will eventually become corporations. For example, Human Culture Research Organization (tentative name), Natural Sciences Research Organization (tentative name), High Energy Accelerator Research Organization (tentative name), Information and Systems Research Organization (tentative name). Thirteen Organizations and sixteen Research Centers will be formed.

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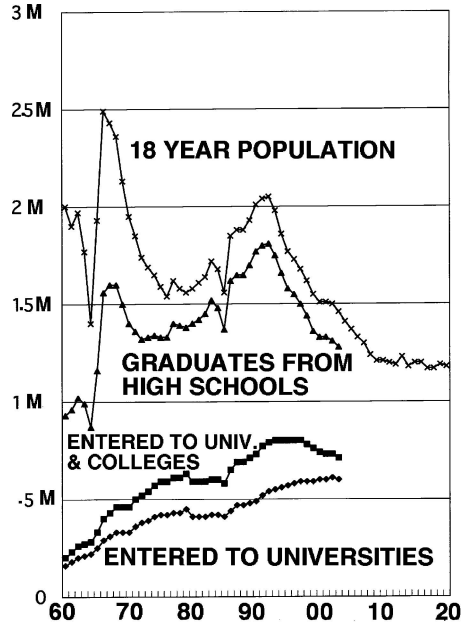

Figure 1 Number of students entered to universities and colleges and 18 year population in Japan.

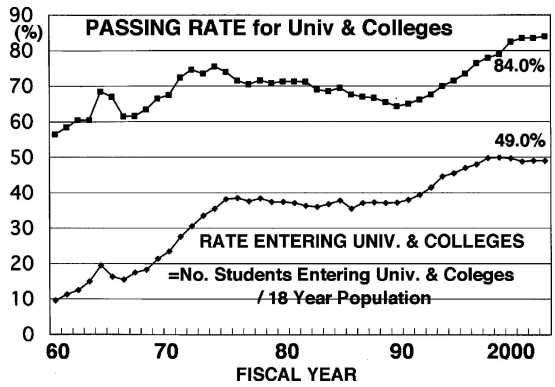

Figure 2 Passing rates for entering universities and colleges.

MEXT emphasizes following research fields:

(1) Promotion of Research and Development in Life Sciences, Promotion of Life Sciences and Measures for Bioethics and Biosafety are included.
(2) Promotion of Research and Development in the Information Technology Field.
(3) Promotion of Research and Development in Ocean Science, Earth Science and Environmental Science, Promotion of Research in Predicting Global Change and Promotion of Research in Observing Global Change are included.
(4) Promotion of Research and Development in Nanotechnology and Materials Science.
(5) Promotion of Research and Development in the Aerospace Field.
(6) Earthquakes and Disasters.

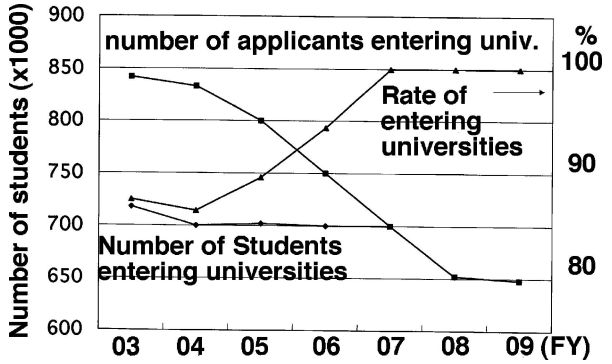

Figure 3 Number of applicants entering universities and number of students accepted by universities. After 2007, all applicants are accepted.

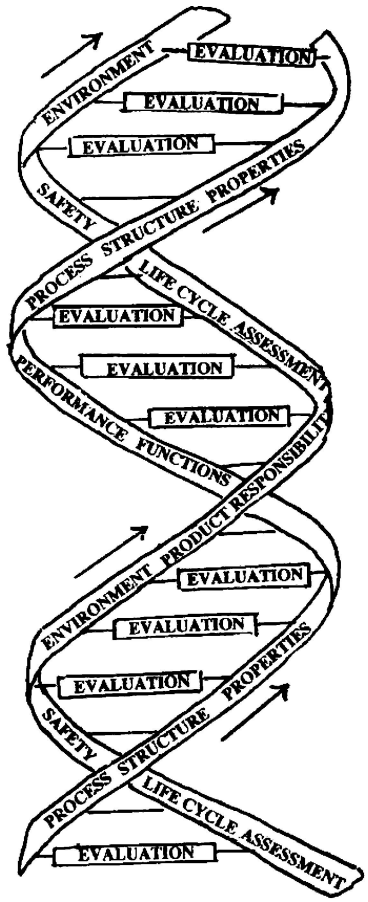

Figure 4 Double helix of materials science progress.

(7) Promotion of Research and Development in the Nuclear Energy Field.
(8) Promotion of Research in Humanities and Social Sciences.

Promotion of the Science and Technology for Society, National Universities and National Laboratories in Japan are in Great Confusion by drastic changes.

TABLE I Applications and selections in each category of the 21st century COE by university type (2002). (MEXT-JSPS)

Universities		Life science	Chemistry & materials sci.	Inf. sci. elec. Electr. eng.	Humanities	Inter displrinary comb. new des	Total
National	Applied	43/66	44/54	41/49	23 30	46/75	76/280
	Selected	16/21	12./18	12./15	10./13	15/17	31/54
Public	Applied	5./5	5./5	6./6	7./8	8./8	21/38
	Selected	1./1	0/0	0/0	1./1	2./2	4./4
Private	Applied	26/35	22/23	19/23	27/32	24/30	66/143
	Selected	6./6	3./3	5./5	5./6	5./5	15/25
Total	Applied	80/112	71/82	66/78	57/79	78/113	163/464
	Selected	23/28	15/21	17/20	16/20	22/24	50/115

TABLE II Applications and selections in each category of the 21st century COE by university type (2003). (MEXT-JSPS)

Categories Universities	Medical science	Math. phys. earth sci.	Mech. civil. architec, other	Social science	Interdiscipl comb. new	Total
National	41/86	33/56	42/62	19/38	59/95	81/337
Public	13/14	4./6	7./8	7./12	14/15	/2955
Private	31/38	18/24	29/36	36/55	54/66	115/219
Total	85/138	55/86	78/106	62/105	127/176	225/611

3. Science and Technology Policy in Japan

3.1. Science and Technology Basic Law

General Guideline for Science & Technology Policy was issued in March, 1986, and this emphasizes creativity. Science & Technology Basic Law Plan was passed on Nov. 29, 1995. The second five year plan has been started in 2001. Japanese government is spending 14 trillion yen (1.3×10^{11} US$) in 5 years. The Second Five Year Plan emphasizes

(1) Promotion of basic research,
(2) Life Science,
(3) Information and Communication Technology.
(4) Environmental Science & Technology, and
(5) Nano-Technology & Materials.

The Japanese government issues 40×10^{10} US$ of national bond per year for the deficit of national budget.

3.2. The 21st Century COE Program

MEXT started the 21st Century COE Program. The 21st Century COE Program seeks to establish within Japanese universities field-specific research and education bases at the apex of world excellence. The support is focused on elevating research standards at the participating universities and fostering creative young people capable of becoming future world leaders in their respective fields. Different from the Grant-in-Aid for scientific research, which is mainly awarded to individual researchers, this program concentrates its funding on the organizational level, namely, the creation of research and education centers of excellence. The application for the grant is filed by the president of the university.

(1) Improve the standard of research and education.
(2) Foster the development of creative people of caliber to become world leaders.
(3) MEXT has spent 33.2BJY 300M US$ in 2003FY.
(4) and MEXT will spend 36.7BJY (310M US$) in 2004FY.

MEXT started the 21st Century COE Program in the following Categories:

In 2002 FY (1) Life Science, (2) Chemistry, and Materials Science, (3) Information Science, Electrical and Electronic Engineering, (4) Humanities, and (5) Interdisciplinary, Combined Fields, New Disciplines. In 2003 FY (1) Medical Science, (2) Mathematics, Physics, and Earth Science, (3) Mechanical, Civil, Architectural and Other Field of Engineering, (4) Social Sciences, (5) Interdisciplinary, Combined Fields, and New Disciplines.

4. Materials education in Japan

The Japan Materials Department Council consists of the Department Heads of the Materials Departments in Japan; 21 former national universities (35 departments), 3 local government universities (prefecture or city universities) and 9 private universities (9 departments). The materials department group produces 2,877 bachelors, 900 masters and 237 doctors per year. They correspond to about 0.5% of total bachelors, 2.5% of masters and 3% of doctors in Japan. These are 4% of bachelor, 2.5% of masters and 3% of doctors in engineering schools.

The graduates from materials go to more diverse fields. Almost all companies in Japan have training period or training centers themselves. What we should teach in

TABLE III Number of Indian scientists Invited to Japan as JSPS program

Indian scientists invited to Japan	2000	2001	2002
Invitation fellowship for indian scientists			
Short-term	8	32	35
Long-term	13	15	29
Postdoctoral fellowship	115	147	205
Jap-ind bilateral program	12	64	101
Cooperative programs	37		
Multilateral program	6		
Total	185	264	370

TABLE IV Number of Japanese scientists invited to India as JSPS program

Japanese Scientists to India			
Fellowship for Research			
Bilateral Program	5	67	52
Cooperative Program	52		
Multilateral Programs		5	
Total	57	72	52

graduate courses, knowledge is of course important but challenge to unknown knowledge is more important. In Japan most graduate students are not supported by funds. They have to pay tuition fee and living expenses by themselves or parents. Government provides education loans but they have to return in the future. In this sense professors in Japan are easier to get graduate students. Even they do not have research funds they are able to keep graduate students.

I am afraid lectures in graduate schools in Japan are not very refined. Writing good textbooks is not highly evaluated. One reason is due to Japanese language. Publishers cannot sell many copies. Practically no publishers in Japan publish textbooks in English, they do not have world sales links.

Recently Departments of Materials Science and Engineering cannot attract students, again they start changing their names to new names and these are vague and unclear and classified as "others" in Engineering filed and it is difficult to take statistics as materials.

Many departments of materials emphasized materials science, but now materials science alone cannot attract many good students. Producing materials with good physical and chemical properties is not enough any more. The departments are changing to emphasize ecology, environment, life cycle assessment (LCA), product responsibility, safety, recycles, bio-materials, nano-structures, resources, and more applied electronic fields such as electronic devices. Process, structure, properties, performance and functions are quite important elements of development of materials but these have to be evaluated by "evaluation means" from the point of view of LCA, safety, environmental effects, product, and responsibility and feed back to process, structure, properties, performance and functions for improvement. They are evaluated and feed back for farther progress of materials as shown in Fig. 5. These are shown using a double helix model.

It was Frederick Seitz who systematized solid state physics field and published the book "Modern Theory of Solids" in 1940. Materials accepted the knowledge of solid state physics, and established materials science, particularly from the view of electronics, atoms and molecules in late 1950's. Electronic, atomic and molecular treatments of materials have been greatly developed. Many of individual properties and interactions of defects or mechanism of electronic applications have been cleared but the bulk properties are not the extension of micro-properties. There is a large gap between atomic and bulk treatments. We are facing a thick wall to connect these two. This point of view has been discussed for many years but the situation to connect micro and macro point of view is not easy.

Materials are not very popular in high schools. The teachers do not understand or know materials or have no interests. In Japan, we have enough food stock to live and this makes young people lazy. The salaries of part time workers are high, they can live on without hard working. We call them freeters who do not have permanent jobs. (They do not want to have permanent jobs.) They enjoy their freedom escaping from restrictions. Even they do not want to marry. Number of newly born babies is decreasing. On the contrary the portion of aged people is increasing. Japanese have the longest average life in the world; 84 years for ladies and 78 years for men.

5. Japan-India program by JSPS

5.1. Japan-India cooperative science program

Japan Society for the Promotion of Science (JSPS) started the Cooperation with Government of India, Department of Science and Technology (DST) in 1993. The areas of cooperation are:

(1) Molecular structure, dynamics, and molecular materials, including supramolecular science
(2) Advanced materials, including polymer and nanomaterials
(3) Modern biology and biotechnology
(4) Manufacturing sciences
(5) Astronomy and astrophysics, and
(6) Surface and interface science, including catalysis.
(7) There are three categories in the cooperation.

(1) Cooperative research
(2) Seminar, and
(3) Scientists Exchange

According to the agreement, air-fares are paid by the organization sending scientists, but the staying expenses are paid by the accepting organization.

Seminar expenses are paid by the country held. Ideally the three categories are split evenly.

Japan Society for Promotion of Science (JSPS) changed to an Independent Administrative Institution on Oct. 1, 2003. Procedure is more strict now.

For the Japanese System, all plans of individual area for the following fiscal year has to be submitted before the end of March by coordinator of the area. Each area has 5,500,000 JPY (50,000 US$). As a rule, total budget has to be allocated by the end of March, before a fiscal year starts. The coordinator of an area cannot allocate more than 5.5M JPY during the fiscal year. So increase some budgets during fiscal year is quite difficult, the coordinator has to ask someone in the area to reduce his budget. Only the highest applications recommended by the Indian Coordinator and the Japanese Coordinator are selected in the area.

5.2. Asian science seminar

JSPS holds about three seminars in Japan and other Asian countries every year. These seminars are designed to spur scientific achievement in the region by introducing the latest scientific advances to the attending young Asian researchers. Asian science seminar can be held within the Japan-India Corporative Science Program.

6. Receiving researchers from abroad

6.1. JSPS postdoctoral fellowships for foreign researchers

6.1.1. JSPS postdoctoral fellowships for foreign researchers

Duration is 12 to 24 months. In 2003 FY 1,711 fellows were invited. From India 115 in 2000, 147 in 2001, and 205 in 2002. Japan-India Corporative Science Program agrees to accept five postdoctoral fellowships and four pre-doctoral fellowships a year.

6.2. JSPS invitation fellowships for research in japan

6.2.1. Short term program

The first category is for a short term program from 14 to 60 days. There are two channels for applications:

(A) Prospective Japanese host researchers apply to JSPS
(B) Foreign postdoctoral researchers apply through the nominating authority in their home country (INSA, DST)

From India for the short-term, 8 in 2000, 32 in 2001, and 35 in 2003.

6.2.2. Long-term program

The period is 2 months to 10 months From India, 13 in 2000, 15 in 2001 and 29 in 2002.

6.3. JSPS award for eminent scientists

JSPS awards invitations to Nobel laureates and other leading scientists to come to Japan. The duration is 6 months to 12 months.

6.4. International scientific meetings in Japan

JSPS supports a portion of the costs for holding approximately ten of these meetings each year. Relatively small scale, less than 100 participants, more than 25 are from foreign countries. Applications are submitted by researchers in Japan.

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