Graduate Education in Science and Engineering in Japan

Arthur F. Findeis

Graduate education in the sciences and engineering in Japan differs considerably from that in the United States. A review of national science policy in Japan by the Organization for Economic Cooperation and Development has covered in detail graduate education in these areas (*1*). Tables with voluminous statistics on virtually every aspect of science policy were included in the report; most of the data are for science activities before 1965. Japan was noted in that report as being "arbitrary and uniform" in the distribution of funds for graduate research. A more recent examination of educational policy and planning in Japan (*2*) complements the earlier report in many respects, although it contains much less statistical data. The data presented in this article were collected in an attempt to gain further insight into the Japanese educational system in order to compare it with graduate education in the United States. Since my specific interest is chemistry, many references are made to that discipline, although statistics on funding extend to all areas of science and engineering. The final paragraphs of this article deal exclusively with chemistry, since that discipline extends throughout the entire science structure in Japan.

Because of the organizational patterns of the Japanese university, there is more diversity among the types of advanced degrees awarded in Japan than there are among American degrees. For example, a chemistry department may be associated with a faculty of science (*Rigakubu*), faculty of engineering (*Kogakubu*), or an institute such as the Institute of Industrial Science at the University of Tokyo. The Ph.D. degree is the most commonly awarded degree in American universities, whereas in Japan the Doctor of Science (*Rigaku Hakushi*) is awarded by a faculty of science upon fulfillment of its requirements, the Doctor of Engineering (*Kogaku Hakushi*) by a faculty of engineering, the Doctor of Pharmacy (*Yakugaku Hakushi*) by a faculty of pharmaceutical sciences, and the Doctor of Agriculture (*Nogaku Hakushi*) by a faculty of agriculture. A department in one faculty may be indistinguishable from a similar department in another faculty in terms of what each actually does. The line between pure and applied science, and therefore between science and engineering, is ill-defined. However, the Doctor of Science degree provides its holder with more flexibility than do other degrees, according to some Japanese scientists.

National universities dominate the graduate education scene. The teaching staff of the national universities has the status of civil servants. The organization of any given university depends upon the highest degree it offers. The chair, or *koza*, is the basic unit of university teaching and research. Research is concentrated in the national universities and in the associated research institutes. Funds for the national universities are controlled by the Ministry of Education. Only a few private universities participate in graduate education in science and engineering, and they emphasize engineering.

If a national university offers the doctoral degree, then it is organized around the koza system. Many universities that offer degrees only up to the master's level are organized along departmental lines more similar to those of American universities. According to 1971 Ministry of Education statistics, 61 universities have graduate schools. Of these, 34 offer the master's degree only, one offers the doctor's course only, and 26 offer both the master's and doctor's degrees.

In the natural science divisions, the koza is composed of one professor, one assistant professor, and two assistants. This group directs the work of graduate students and participates in research as well. The professor and the assistant professor generally hold the doctor's degree. The assistants may or may not possess the doctor's degree, depending on the emphasis of the koza. It is claimed that the advanced degree has little bearing on salary in any event. In some kozas in which the research is highly technologically oriented, research assistants other than those supported by koza funds often come from industry for several years of research, in order to acquire new knowledge or become expert in certain techniques that are closely related to their permanent employment. In special cases, an additional assistant may be provided if the koza is responsible for large items of equipment or instrumentation.

In the social sciences and humanities, where laboratory expertise has traditionally not been emphasized, the koza consists of one professor, one assistant professor, and only one assistant. In the clinical sciences, the koza consists of one professor, one assistant professor, and three assistants. Research funds allocated per koza vary accordingly. The koza in the natural sciences receives ¥407M ($13,213) per year (*3*). The koza in the social sciences and humanities receives ¥103M ($3,343) per year if no laboratory work is expected. A koza in the clinical sciences receives the largest amount, ¥442M ($14,351) per year, a figure that reflects the materials and supplies required for an additional assistant. It should be emphasized that this support is over and above that which is provided for salaries and associated overhead.

The designation of professor (*kyoju*) in the Japanese university has its counterpart in the United States. The professor is the titular head of the koza in Japan. This might superficially correspond to a chaired professorship in the United States. Funds from the Ministry of Education for the national universities are distributed by the koza. Graduate students are accepted by the professor, and their research is then done along the lines being pursued by the koza. There is no formal title of associate professor in Japan, although a few university catalogs in their English version give this title to the assistant professor (*jokyoju*) since his function most closely resembles that of the American associate professor. The assistant professor

The author is a staff associate, Science Liaison Staff, National Science Foundation, American Embassy, Tokyo, Japan. As of 4 September his address will be Chemistry Section, National Science Foundation, Washington, D.C. 20550.

Table 1. Hypothetical budget.

Costs	U.S. support ($)	Japanese equivalent	Japanese support ($)
Salaries and wages			
Senior personnel			
Principal investigator (2 months)	4,000	Professor	
Faculty associates (2 months)	3,000	Assistant professor	
Other personnel (24 months)	18,000	Assistants	
Graduate students (five per koza) at $3,500 per year	17,500	Graduate students	
Technicians (two per koza)	14,000		4,800
Secretarial	4,000		
Total	60,500		
Fringe benefits (15% of senior personnel)	1,050		
Total salaries, wages, and fringe benefits	61,550		
Permanent equipment			
Expendable equipment and supplies			
Travel	5,030		5,030
Publication costs			
Computer costs			
Other costs			
Total direct costs	66,580		
Indirect costs (50% of salaries and wages in the United States)	30,250		3,303
Total	96,830		13,213

in Japan may be a distinguished and, indeed, a senior scientist with an international reputation who, however, is progressing along the vertical structure of the university. The assistant (*joshu*) in Japan is often categorized as the equivalent of a combined instructor–assistant professor in the American system. Nevertheless, the assistant, in most cases, is ascending the vertical structure of the Japanese system if he remains in the university.

How does support in Japan compare with support in the United States for a research group of an equivalent size with five graduate students? Salaries and wages for the professor, assistant professor, and assistants are not part of the koza budget. Postdoctoral opportunities for foreign students are not readily available in Japan, since the Ministry of Education supports only about 15 postdoctoral students per year. Nonfaculty professionals are in the same category. Graduate students are not usually supported by the koza's funds. Secretarial help may be provided out of koza funds, and a koza usually has a full-time secretary. Technical, shop, and other categories of the budget may come from koza funds.

Fringe benefits, as they are thought of in the United States, have no obvious counterpart in Japan. Permanent equipment may come from koza funds, although large, expensive items of equipment would have to come from a separate grant program of the Ministry of Education. There exists a four-level grant system for support of general research, from which larger, more expensive items of instrumentation or equipment may be obtained by separate proposals. The more expensive items are the most difficult to obtain, thus younger staff members are discouraged from seeking the larger grants. Expendable equipment and supplies come from koza resources. Travel within Japan may be paid for with koza funds or with funds provided specifically by the Ministry of Education. International travel is very important, since many faculties avow that they are isolated and must see the scientific action where the action is. A very large percentage of Japanese professors and assistant professors in the sciences have traveled, lectured, and studied abroad. This is in marked contrast to science faculties in the United States.

The Japanese scientist knows far more about the United States than the U.S. scientist knows about Japan. In the period from 1968 to 1969, the number of Japanese faculty and scholars in all disciplines who were conducting research in the United States was 1262, while the number of U.S. faculty and scholars who were conducting research or teaching in Japan was only 144, a startling ratio of 9 to 1. In the physical sciences, there were 648 Japanese faculty and scholars in the United States, but only 34 American faculty and scholars in Japan. One often finds that younger Japanese scientists have children who are U.S. citizens.

Although foreign travel does not usually come from koza funds, support is available from many other sources. Publication costs are not provided from koza funds. Other costs, such as those of a machine shop or glassblower, may be paid by the koza. Indirect costs, or overhead, are taken out of koza funds at several levels within the university structure. For example, the central administration may delete a percentage, and the specific faculty may delete an additional amount for administrative costs. Such indirect costs have been estimated at about 25 to 30 percent of the support provided by the Ministry of Education for a koza at one of the national universities.

With the above in mind, one can construct a hypothetical budget similar to a National Science Foundation budget for the same level of effort in the United States. In this budget, I assign U.S. salaries, not their Japanese equivalents. A reasonable estimate of a professor's salary in the United States (from an institution that receives NSF support) would be $18,000 per academic year (9 months). Similarly, a salary of $12,500 per academic year is assigned to an assistant professor. The assistants are assigned a salary of $9,000 per year (about equivalent to a postdoctoral stipend) in the category of full-time research associates. No faculty professionals will be placed in the "other" category, which draws directly from koza funds.

Table 2. Funds for general research in chemistry other than koza support.

Type of grant	Level of grant (thousands)	Amount for chemistry (millions)	Total, all disciplines (millions)
A	¥10,000 to ¥25,000 ($32.5 to $81.2)	¥374 ($1.21)	¥1562.0 ($5.07)
B	¥3,000 to ¥10,000 ($9.74 to $32.5)	¥387 ($1.26)	¥1204.0 ($3.91)
C	¥1,000 to ¥3,000 ($3.25 to $9.74)	Unknown	¥853.0 ($2.77)
D	>¥1,000 (>$3.25)	Unknown	¥234.0 ($0.76)
Total		>¥761 ($2.47)	¥3853.0 ($12.51)

The actual salary of a university professor in Japan is complicated by an elaborate system of allowances and bonuses. The professor will receive basic pay, a bonus that amounts to 4.8 months' salary per year, an adjustment allowance, dependent allowance, city allowance, a housing allowance for those not living in government housing, commuting allowance, and a graduate school allowance for teaching in a master's or doctor's course. The allowances vary, but they may amount to as much as 60 to 65 percent of the basic salary of a professor who is about 45 years old. During the past 5 years, both basic salary and allowances have increased by about 50 percent.

In Japanese universities, graduate students do not usually receive support from koza funds, but they may receive financial aid from the Japan Scholarship Foundation. This foundation provides students in a doctoral course with ¥22,000 ($71.43) per month and those in a master's course with ¥17,000 ($55.19) per month. However, only 74 percent of students in a doctoral course and 49 percent of students in a master's course receive funds from this source. The Japan Scholarship Foundation extends aid to 12 percent (192,000) of the undergraduate students in Japanese colleges and universities as well. Of this 12 percent, 6 percent receive "regular" support—which is ¥3000 ($9.75) per month in national and public universities and ¥5000 ($16.23) per month in private universities. The other 6 percent receive "special" support—which amounts to ¥6000 ($19.48) per month for students who commute from home and ¥10,000 ($32.47) per month for those who live in student quarters at national or public universities. Students in the special category at private universities receive ¥9000 ($29.22) per month if they live at home and ¥15,000 ($48.70) per month if they live elsewhere. The placement of students in categories of regular or special depends on a number of factors such as family income and student performance, and these factors may be reevaluated on a yearly basis. Japan Scholarship Foundation support is given in the form of an interest-free loan that may be repaid over a 20-year period.

It should be emphasized that, in any case, the Japanese student pays tuition. The average tuition in private colleges in 1971 was ¥76,000 ($247) for liberal arts, ¥106,000 ($344) for science and technology, and ¥247,000 ($890) for medicine. In the national universities, tuition was a meager ¥12,000 ($39) for undergraduates and ¥18,000 ($58) for graduate students. In addition, examination fees and a matriculation fee are assessed. Thus, the total cost of a private college may range from ¥260,000 ($844) to ¥370,000 ($1201). The entire tuition and fees policy is undergoing review, and it was recently announced that there would be a threefold increase in undergraduate tuition at the national universities and a twofold increase in graduate tuition.

The koza support of $13,213 from the Ministry of Education is used for expendable equipment and supplies, computer expenses, secretarial help, and technical assistants. An equivalent U.S. budget for the same level of effort for 1 year, assuming U.S. salary equivalents for the professor, assistant professor, two assistants (for example, postdoctoral associates), and five graduate students, is estimated as $96,800. This hypothetical budget is given in Table 1. The usual 2-year grant from the NSF would be twice that amount. Many kozas have far more than five graduate students, however. The professor and head of the koza receives this support without a peer system of review throughout his entire career in the university. In the past, although support was not withheld from an unpro-

Table 3. Doctoral production in science and engineering in Japan, from 1957 to 1968.

University	Science doctorates (No.)					Engineering doctorates (No.)				
	1957–64	1965	1966	1967	1968	1957–64	1965	1966	1967	1968
				National						
Hiroshima	72	24	12	19	23					
Hokkaido	147	15	34	35	34	19	6	17	21	18
Kyoto	188	62	71	57	42	130	67	75	73	92
Kyushu	58	14	14	17	20	20	9	20	13	8
Nagoya	103	17	18	31	24	43	16	19	42	22
Osaka	182	39	52	54	57	113	63	58	87	80
Tohoku	158	71	60	67	81	84	26	35	55	79
Tokyo	447	89	86	93	109	333	113	152	161	155
Tokyo University of Education	180	33	58	25	47					
Tokyo Institute of Technology	73	16	33	24	26	145	55	59	79	82
				Public						
Osaka City	79	11	9	12	14	12	16	9	14	17
Osaka Prefecture						27	10	9	4	9
Tokyo Metropolitan	51	20	14	12	20	1	0	6	1	1
				Private						
Doshisha						3	0	1	0	2
Gakushuin	0	6	7	0	4					
Kansai						0	0	0	0	1
Keio						16	13	17	11	22
Meiji						2	0	2	3	4
Nihon	0	0	0	0	3	4	12	1	20	5
Rikkyo	6	1	1	1	2					
Science University of Tokyo	0	0	0	3	4					
Tokyo Electrical Engineering University						0	0	0	1	1
Waseda	0	0	0	0	9	53	15	11	22	20
Total	1,744	418	469	450	519	1,005	421	491	607	618
Former imperial universities* (% of total doctorate)	73.5	73.4	71.4	78.7	70.7	73.8	71.3	76.6	74.5	73.9

* Former imperial universities: Hokkaido, Tohoku, Tokyo, Nagoya, Kyoto, Osaka, and Kyushu.

Table 4. Doctoral production in national, public, and private universities by area of study, from 1957 to 1968.

Area of study	Doctorates (No.)				
	1957–64	1965	1966	1967	1968
		National universities			
Science	1,608	379	438	423	463
Medical	5,203	1,595	1,543	1,769	1,658
Dentistry	118	42	35	59	60
Pharmaceutics	291	93	102	100	103
Engineering	889	354	435	530	546
Agriculture	622	208	204	249	261
Veterinary medicine	28	5	4	5	1
Fishery	12	6	8	3	1
All others	261	104	116	127	85
Total	9,032	2,786	2,885	3,265	3,178
		Public universities			
Science	130	31	23	24	34
Medical	731	491	460	413	407
Pharmaceutics	0	0	1	3	5
Engineering	40	26	24	19	27
Agriculture	1	3	3	4	5
All others	3	0	5	4	2
Total	905	551	516	467	480
		Private universities			
Science	9	5	9	7	17
Medical	1,087	557	665	697	650
Dentistry	140	73	85	102	122
Pharmaceutics	0	0	1	1	4
Engineering	78	40	33	56	55
Agriculture	15	11	20	21	29
Veterinary medicine	14	3	4	15	10
All others	112	58	53	56	50
Total	1,455	747	870	955	937

ductive koza, a new koza was often formed in the same area.

I hasten to comment that the faculty of those institutions which are not organized in the koza style also receive support. In these cases, the support is provided to individuals. In the natural sciences where the departmental structure exists, the professor receives $3711, the associate professor $2208, the lecturer $1363, and the assistant $584 to support research endeavors. In such nonlaboratory areas as the social sciences and humanities, the stipend decreases accordingly, in a similar fashion to the koza support described previously. In these areas, the professor receives $2760, the assistant professor $1656, the lecturer $1006, and the assistant $455. The number of kozas or equivalent units in the national universities and colleges is published each year (*4*).

General research grants are provided in addition to koza funds for the support of research institutions of higher learning. Four kinds of grants (A, B, C, and D) are included in the general research category. These grants are available to individuals, from assistants through professors, or to single kozas or ensembles of kozas, in cases where very expensive, multipurpose items of instrumentation may be requested.

These grants are made for a 3-year period, and the amount available from the Japanese Ministry of Education during 1971 was $12.5 million for all disciplines. The amount in the general research category available for chemistry alone is greater than $2.47 million. Expenditures for chemistry in categories C and D have not been tabulated. Support for general research is listed in Table 2. The bulk of this support is for institutions that grant doctorates.

In addition to koza and general research support, several other possibilities exist for the support of graduate research. These include interdisciplinary, or special project research support, a category that was funded to the extent of $27.8 million during 1971. This category includes research in biophysics, water research, low temperature physics, disaster research, science education, environmental control, human existence and its relation to natural environment, molecular sciences, and the international biological program. Support in the above categories is for both individuals and groups. In addition, $1.73 million for applied research was allocated by the Ministry of Education in 1971.

Cooperative research for investigators from different institutions was supported in 1971 to the extent of $2.89 million, with chemistry receiving about $334,000 out of the total amount. Research encouragement grants are also supported in Japan, with $713,000 allocated for this purpose in 1971. Of this amount, over 90 percent went to universities, and the remainder went to high schools. A special fund for publication purposes is also available. This amounted to about $448,000 during 1971. Support for special studies overseas amounted to $472,000.

In Japan, doctoral degrees awarded in any given university are very likely to have been awarded to students who entered the university directly from high school. Traditionally, there has been negligible lateral transfer in the system, but this seems to be changing at the less "establishment"-oriented universities. Of 389 universities and

Table 5. Summary of doctoral production in Japan by area of study, from 1957 to 1968.

Area of study	Doctorates (No.)				
	Former imperial universities*	All national universities†	All public universities	All private universities	Total
Science	2,646	3,311	242	47	3,600
Medical	5,920	11,768	2,502	3,656	17,926
Dentistry	121	314	0	522	836
Pharmaceutics	689	689	9	6	704
Engineering	2,334	2,754	136	262	3,152
Agriculture	1,544	1,544	16	96	1,656
Veterinary medicine	43	43	0	46	89
Fishery	30	30	0	0	30
All others	494	693	14	329	1,034
Total	13,821	21,146	2,919	4,964	29,027

* Former imperial universities: Hokkaido, Tohoku, Tokyo, Nagoya, Kyoto, Osaka, and Kyushu.
† Includes the imperial universities' figures.

colleges (including 75 national universities), 33 public universities and colleges, and 281 private institutions, only 23 offered a doctoral program in science or engineering as of June 1971. The number of doctor's degrees awarded at these institutions in science and engineering through 1968 is shown in Table 3.

Statistics on doctoral production in the sciences for the national universities, public universities, and private universities are given in Table 4. The summary statistics in each area of graduate science education for the same universities are listed in Table 5. It is apparent that the liberalization of opportunities for graduate education had not had, as of 1968, a significant impact on the overwhelming productivity of the former imperial universities. These universities maintained an output of doctoral degrees in the sciences and engineering of about 75 percent of the total over the 12-year period covered in these statistics. During the period of increased production of doctoral candidates, the national universities increased their output sufficiently for the percentage to remain about the same from 1965 to 1968. It is obvious that ten of Japan's national universities dominate graduate education in the sciences and engineering. This domination is also evident in medicine, but the percentage of M.D. production, as opposed to doctorates in other sciences and engineering, is lower for the national universities because of the significant number of public and private medical schools of adequate quality. (There are 59 medical schools in Japan; thus the ratio of medical schools to doctorate-granting institutions is greater in Japan than it is in the United States.) Enrollments in the former imperial universities and the other national universities that offer the doctoral degree are given in Table 6.

Japan is showing an increasing awareness that it must become more self-reliant in the area of international exchanges. As part of this new image, several programs are being established by the government to pay for "leaders" from other countries to come to Japan, to bring foreign specialists to Japan, or to send Japanese students and scholars abroad. The Japan Society for the Promotion of Science, which is the Japanese agency for implementing the U.S.–Japan Cooperative Science Program, has sponsored since 1959 a foreign visiting professors program for senior scholars and, since 1967, a foreign researchers program for young, foreign, postdoctoral students in Japan. This program provides postdoctoral students with a round-trip, economy class ticket, miscellaneous allowances of about $150 per year, and a monthly stipend of $234.

Table 6. Enrollment in the national universities offering graduate education to the doctoral level.

University	Students (No.)		
	Undergraduate	Master's course	Doctoral course
Hiroshima	8,242	514	229
Hokkaido	8,815	812	525
Kyoto	11,435	1,917	1,067
Kyushu	7,698	760	524
Nagoya	6,942	951	521
Osaka	7,681	1,074	699
Tohoku	8,996	1,041	734
Tokyo	15,421	1,949	1,810
Tokyo University of Education	4,011	611	332
Tokyo Institute of Technology	3,642	707	334

A myth about lack of interaction between academic, industrial, and governmental research efforts has grown through the past 20 years. Indeed, this may have been true only a decade ago; however, in undergoing explosive growth in technology during this period, Japan could ill afford to maintain the status quo. The long winked-at, underground interaction between professor and industry, perhaps even between koza and industry, has finally been given respectability by a revised interpretation of the law in March 1971 (*5*). The new interpretation acknowledges their de facto cooperation and makes it legal for university professors to accept funds from industry, with the approval of the university president.

Table 7. Number of kozas or equivalent units in former imperial universities (in chemistry only).

University	Kozas (No.)
Hokkaido	56
Tohoku	39
Tokyo	61
Nagoya	45
Kyoto	56
Osaka	49
Kyushu	50
Total	356
Total of all national universities	912

Chemistry is pervasive in Japanese universities, and departments of chemistry are found in many different faculties and research institutes in the universities. The total number of kozas or equivalent units in chemistry in all of the national universities and colleges is 912. This figure was derived from an inspection of koza titles, and it includes all kozas that are listed in chemistry and biochemistry departments in a number of different faculties. Many national universities and colleges that do not have a koza system are included in the above total. In the seven former imperial universities there are 356 kozas listed for chemistry and biochemistry. These are given in Table 7.

Because of the multiplicity of chemistry and other science- or technology-oriented departments in the Japanese university system, the compilation of degrees awarded by field of study becomes an imposing task, unless one has access to statistics on degrees granted by department for each faculty in each university. To my knowledge, no governmental scientific organization has such a listing.

The classical divisions of chemistry [that is, analytical chemistry (*bunseki-kagaku*), biochemistry (*sei-kagaku*), inorganic chemistry (*muki-kagaku*), organic chemistry (*yuki-kagaku*), and physical chemistry (*butsuri-kagaku*)] are used for descriptions of kozas, yet Japanese university catalogs include a much wider range of subdisciplines.

Appointments to faculties at the various universities may be simultaneous with appointments to the various institutes that abound in Japan. Some kozas may not have a titular professor at any given time, although the positions of the assistant professor and assistants are filled. Lecturers are part of the university staff to a much lesser extent. The lecturer is in a position between the assistant and the assistant professor, and his position originated because of the need for additional teaching staff. Traditionally, assistants are not expected to teach; when additional positions of assistant professor could not be established because of budgetary limitations or a ceiling on kozas, the lecturer was originated. Occasionally an assistant was given an interim appointment as a lecturer, but that has become a rare practice in recent times. The Ministry of Education has been trying to eliminate this position in order to maintain a uniform organizational pattern in the koza. There is a general lack of uni-

formity in the listing of scientists in university catalogs, and such listings may bear little relation to the actual koza titles provided by the Ministry of Education. Assistants' names are not included in some university catalogs, and multiple appointments are difficult to assess.

Japan has effectively separated academic research from graduate education. Research opportunity for the professor is assured because financial support is automatic. The number of positions for graduate study in any area of science in the national universities is carefully controlled by the government. There is a limit of 14,394 entrants for the master's course and doctor's course in all areas of science, including medicine, in the national universities; this total rises to 24,654 entrants if one includes the local and private universities. The number of entrants into the doctoral course is limited to 4260 in the national universities, or 6793 if one includes the local and private universities. The actual enrollment in the doctoral course was only slightly over 50 percent of the maximum number allowed by the Ministry of Education, a fact that reveals the careful control of the productivity of the graduate schools.

In at least one major chemistry department at a national university, a graduate student's option to choose his major professor is based on his performance in the entrance examination. Those students who place highest on the examination may choose their area of study and research. Those further down the scale are assigned to kozas on the basis of their selection of priorities for area of study. The remainder are assigned to kozas in such a way that all professors have the same number of students. The rationale is that all professors are "equal." It is uncertain just how much recruiting for graduate students takes place. Usually, about twice as many candidates take the examination for entrance to graduate study as there are positions available. The automatic support in the Japanese system is not without its problems, since the professor may be subject to the whims of the Ministry of Education.

According to recent figures compiled by the Science Council of Japan, there are 37,136 research chemists in Japan, including 26,720 in industry, 3407 in research institutions, and 7000 in universities and colleges. The Japan Chemical Society, the oldest society for chemists in Japan, has 29,229 professional members, 6151 student members, and 1139 corporate members. Chemistry has the second largest group of researchers in Japan; it is surpassed only by the area of agriculture and forestry, which has 99,674.

The future directions of chemistry are not well defined. A change in Japan's economy is causing a tight job market, although supply and demand are carefully monitored by the government. There is now disagreement as to how academic research should be motivated. The Science Deliberation Council of the Ministry of Education recently stressed that academic research is a moving force for economic and industrial development. Emphasis on economy first contrasts with the viewpoint of the Science Council of Japan, which had released a report declaring that academic research should emphasize humanism and no longer be dominated by economic considerations. It is reasonable to assume that this controversy will not be resolved in the near future.

References and Notes

1. *Reviews of National Science Policy, Japan* (Organization for Economic Cooperation and Development, Paris, 1967).
2. *Reviews of National Policies for Education, Japan* (Organization for Economic Cooperation and Development, Paris, 1971).
3. All conversions reported in this paper are at the current rate of ¥308 = $1.00. It should be noted that, when the conversion rate was ¥360 = $1.00, the dollar equivalents were 16.88 percent lower. With the change in the value of the yen, a significant number of changes are taking place in Japan; these changes must be constantly reevaluated if one is to realistically convert to dollar equivalents.
4. *Official Gazette* (Printing Bureau of the Finance Ministry, Government of Japan, special issue No. 45, Tokyo, April 1971), pp. 1–63.
5. *Ministry of Education Notification No. 223* (Ministry of Education, Tokyo, 12 March 1971), pp. 1–5.

6. Opinions expressed herein are the author's and do not necessarily represent the views of the National Science Foundation. The author is indebted to the Ministry of Education of the Japanese Government for supplying the detailed statistics on doctoral production in Japan. Special thanks are due to Masanobu Miyahara of the National Science Foundation, Tokyo, who helped in collecting the material summarized in this article and in translating important items of information.

NEWS AND COMMENT

Delaney Anti-Cancer Clause: Scientists Debate on Article of Faith

When the carcinogenic beef additive diethylstilbestrol (DES) was banned earlier this month, there was little rejoicing in the halls of the Food and Drug Administration (FDA) that a threat to public health had been forestalled. On the contrary, FDA Commissioner Charles C. Edwards explained apologetically that he had "been left no choice" but to ban DES under what he implied were the unreasonable dictates of the law known as the Delaney anticancer clause. Edwards had good reason to be wary of invoking the Delaney amendment. The previous commissioner of the FDA lost his job when he used the Delaney clause to ban cyclamates in 1969. Almost from the moment it reached the statute books the clause has been the focus of vigorous debate, which is fanned into flames each time the clause is invoked. The DES ban is no exception. Representative William J. Scherle (D–Iowa) has introduced a bill to amend the Delaney clause, manufacturers have renewed their charge that the clause is unreasonable, and last month a senior government health official suggested in so many words that the clause should be scrapped. Why so much heat about a law which says only that cancer-causing substances shall not be allowed in people's food?

The distinctive feature of the Delaney clause is that, once operative, it cannot be bent. All other kinds of poison that manufacturers need to put in food, or find it inconvenient to exclude, are permitted in doses, known as tolerance levels, that the FDA deems small enough to be safe. Such would still be the case with carcinogens but for Representative James J. Delaney (D–N.Y.), who in 1958 devised a 50-word law that forbids any tolerance level being set for a carcinogen. The