

Japan builds a science city

Henry Birnbaum

Japan is building a major science city, Tsukuba Newtown for Research and Education, a project so massive that it took the government ten years to commit itself to the undertaking. Although construction at the site north of Tokyo has been under way for three years, the debate on Tsukuba still continues.

The new experimental Tsukuba University, the largest organization of the new city, is already completed, with 180 faculty members teaching its first freshman class of 740. The new proton synchrotron is well on the way, with a 200-GeV storage-ring complex being designed. A new plasma research facility is also planned for Tsukuba.

Twice the size of Novosibirsk

What gave rise to the project? There has been a universal movement toward planned communities, and specialized cities for science and technology were definitely a facet of that trend, at least in Asia. Large technological-trade cities, such as Jurong in Singapore with its shipbuilding and machine production, and Kaohsiung on Taiwan where complex electronic and solid-state products are assembled, were being planned. Even more to the point, Novosibirsk, the USSR's Siberian science city (see the box on page 46), had been created and appeared to be thriving.

The Japanese did not specifically model their city on these other East Asian experiments, but they were surely

aware of them, and were not to be outdone. Tsukuba Newtown, as finally conceived, is to be twice the size of Novosibirsk. It is to be an academic city devoted to study and research without commercial and industrial taint.

Powerful requirements gave rise to the planning. Japan, in the early 1960's, had just come out of its post-World War II era of economic dependency, emerging as a surging industrial giant. With such economic dynamism came unbridled growth, metropolitan overconcentration and pollution. Nippon's citizenry came to feel the need for rational planning on a nationwide scale. The physical condition of the nation had to be assessed, and reasoned alteration of the islands undertaken. Scholars, politicians, and a well-read populace called for a redistribution of Japan's population and a balancing of its energies, both industrial and intellectual. Reforms in the exploitation of its resources and land were sought and, as is often the case, the Japanese mind focused on congested, under-served Tokyo. After ten years of sporadic planning and political byplay resulting from these forces, the government approved the master plan for Tsukuba Newtown—it was to be a government city of scientists, educators, and students.

Construction of Tsukuba Newtown started in 1972, and it is now half built. From the outset it was to be Japan's major center for government in-house research. The idea was to aggregate a critical mass of scientists and experimental facilities close but not contiguous to Tokyo. Tsukuba Newtown was to serve both as a model for new city planning and a scientific resource for

solving national problems. A photograph of the High-Energy Physics Research Institute under construction is shown in figure 1.

By the time the Japanese Diet finally gave their approval to the plan, almost one billion dollars had been spent on planning, and some ministries had already begun construction. Table 1 provides a schedule of the major facilities, and figure 2 shows the layout of the organizations to be transferred. The construction appears to be only slightly behind schedule, chiefly because of inflation.

Public sector on schedule

Tsukuba Newtown is being carved out of a rural setting of farms and villages. More than 10 000 acres in a diamond-shaped area running 11 by 5 miles along a principal north-south axis has been dedicated to the city, with about 7000 acres now under active construction. The remaining 3000 acres, as well as a large additional area surrounding the planned city, may be developed over the succeeding ten-year period. The original population of the area, largely village and pastoral, was about 80 000. Plans call for an expansion to 200 000, of which 6000 will be scientists, engineers and educators, accompanied by their families, or 30 000 people. About 10 000 will be students at Tsukuba University; the remaining population growth is accounted for by an expected influx of about 74 000 technicians, service personnel and small businessmen who will deal with the city's daily needs.

The total basic cost of the enterprise is expected to be about \$3.0 billion, of which the national government will pay

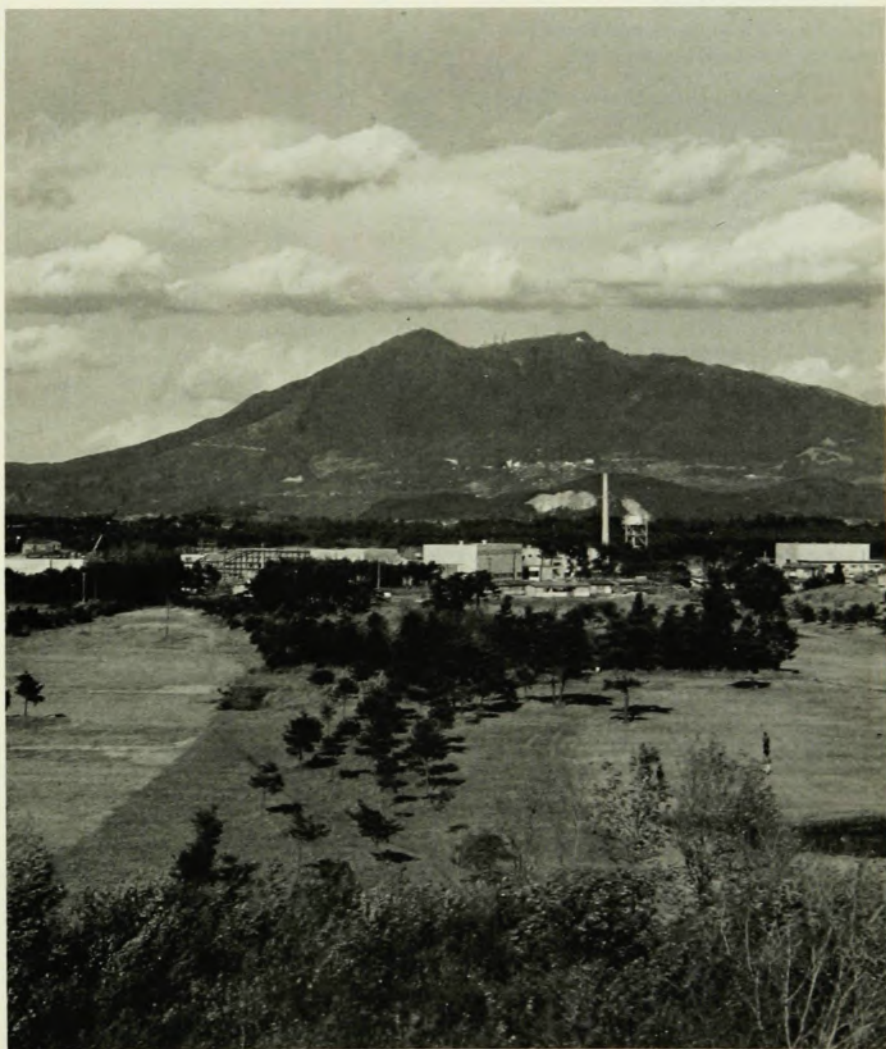
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With a new university already open
and a 12-GeV proton synchrotron under construction,
Tsukuba Newtown is to be completed in 1977.

half. The government's portion pays chiefly for the construction of laboratory and research facilities, Tsukuba University, roads, utilities and communications, while the private sector is expected to provide at least 70 percent of the required new housing and all of the local business and services. The government is now spending slightly over \$900 million a year in the hopes of keeping on schedule and completing the city by the end of 1976 or early 1977.

Although the government's program is moving along well, investment from the private sector is seriously lagging. Creation of a living community is still several years off. Although some of the installations are now just about complete, the city itself is a skeleton. Buildings, roads and related utilities and services are now in that state of seeming disarray that characterizes any major construction in midpassage. While laboratory and related scientific office buildings are going up in all quadrants of the new city, the center of the site, which is to provide the core of high-rise apartment dwellings, downtown shops and entertainment areas, has yet to get under way. About 50 000 people are expected to be housed in this high-density core. Some housing has been started at other points, but even in those cases construction is lagging and only a very small portion of the estimated requirement for 70 000 people is being met. At this halfway point, it can be said that technical facilities are moving along at a deliberate pace, but the accommodations for the new population are far behind.

The new proton synchrotron, along with Tsukuba University, promises to play a leading role in Japan's scientific



The National High Energy Physics Institute under construction. It is part of Tsukuba Newtown, the new Japanese science city being built on some 10 000 acres that were formerly villages and farmland. The twin peaks of Mt Tsukuba dominate the background. The institute will be operated as a national facility open to academic researchers throughout Japan. **Figure 1**

Table 1. Transfer plan for the organizations to be transferred

	Time of transfer	Start of construction	Completion of Construction: Main Building	All Facilities
	fiscal year	fiscal year	fiscal year	fiscal year
Science and Technology Agency				
National Research Institute for Metals (partially)	1975	1974	1975	1975
National Center for Disaster Prevention Science and Engineering	1975	1967	1974	1975
National Institute for Research in Inorganic Materials	1971	1968	1971	1975
Organization for Common Use	—	1973	1974	1974
Tsukuba Space Center of the National Space Development Agency	—	1970	1975	1975
Environment Agency				
National Research Institute for Public Pollution	—	1972	—	—
Ministry of Education				
University of Tsukuba	—	1971	1975	1975
College for Library Science	1976	1974	1975	1975
Research Institute for High Energy Physics	—	1970	1974	1974
National Education Center Annex	1973	1972	1974	1974
Ministry of Health and Welfare				
National Institute of Health (partially)	1976	1974	1975	1975
National Hygienic Research Laboratory (partially)	1976	1974	1975	1975
Ministry of Agriculture and Forestry				
National Research Institute of Agricultural Engineering	1975	1973	1975	1975
Central Agricultural Experiment Station	1976	1973	1975	1975
National Institute of Animal Health	1975	1973	1975	1975
Fermentation Research Institute	1975	1972	1975	1975
National Research Institute of Agricultural Engineering	1975	1973	1974	1975
Sericultural Experiment Station	1975	1972	1975	1975
National Institute of Animal Health	1975	1973	1975	1975
National Food Research Institute	1975	1973	1975	1975
Institute for Plant Virus Research	1974	1973	1974	1974
Tropical Agricultural Research Center	1973	1972	1973	1973
Forestry Experiment Station	1975	1972	1975	1975
Office of Agricultural, Forestry and Fisheries Engineering Conference (partially)	1975	1972	1975	1975
Agricultural Land, Raw Silk and Horticultural Bureaus of Ministry of Agriculture and Forestry	1975	1974	1975	1975
Ministry of International Trade and Industry				
Industrial Technology Institute (partially)	1976	1973	1976	1976
National Research Institute for Measuring	1976	1973	1976	1976
Mechanical Engineering Laboratory	1976	1974	1976	1976
Government Chemical Industry Institute, Tokyo	1976	1974	1976	1976
Fermentation Research Institute	1976	1974	1976	1976
Research Institute for Polymers and Textiles	1976	1974	1976	1976
Geological Survey Institute	1976	1974	1976	1976
Electrotechnical Laboratory	1977	1974	1976	1976
National Food Research Institute	1976	1974	1976	1976
National Research Institute for Pollution and Resources	1977	1974	1976	1976
Ministry of Transportation				
Meteorological Research Institute	1975	1973	1975	1975
High Altitude Observatory	1974	1973	1973	1973
Meteorological Surveying Instruments Workshop	1974	1973	1973	1973
Ministry of Postal Service				
Tsukuba Technological Center for Telegraph and Telephone Line Construction	1974	1971	1974	1975
Ministry of Construction				
Geographical Survey Institute	1975	1972	1975	1975
Public Works Research Institute	1975	1971	1975	1975
Building Research Institute	1975	1970	1975	1975

future. At the northwest corner of Tsukuba Newtown is the National Laboratory for High Energy Physics of the Ministry of Education. Its acronym, KEK, is based on the first sound of the Japanese version of the laboratory's name. As a National Laboratory, KEK will serve the high-energy experimental interests of Japan's academic scientists. It will be the nation's largest nuclear research facility.

The major interest of the laboratory at present is the construction of a 12-GeV proton synchrotron; figure 3 shows the schematics of this accelerator. Construction was started in April 1971, and completion is scheduled for late 1975. At this point, most of the construction has been completed. The 750-keV Cockcroft-Walton generator, a photo of which is shown in figure 4, was transferred from the University of Tokyo in November 1971. The LINAC construction was started in April 1971, and the first LINAC beam of 20 MeV was obtained on 1 August 1974. The booster, which is a fast-cycling alternating-gradient synchrotron, is now nearing completion, and it is expected that the LINAC beam will be injected into the booster, which should become operational by the end of 1974. The energy of the booster will be 500 MeV. The main synchrotron is one year away from being operational; the enclosure and the service building were completed in 1973, and all of the magnets have been installed. It is expected that the synchrotron will have a high-intensity 12-GeV accelerated proton beam by the end of 1975. There will be a shake-down phase during 1976. Experiments are planned to begin in 1977 with three beam channels: a fast extracted beam for bubble-chamber experiments, a slow beam and an internally converted secondary beam for counter experiments. The total expense of construction will be about \$13.0 million, excluding planning, design and staff salary costs. The parameters of the proton synchrotron are given in Table 2.

A three-ring complex

From the very beginning, it was expected that a major extension of the facility would be undertaken to produce a machine that would reach a much higher energy range. Plans now exist, and have been informally presented to the government and discussed at international high-energy conferences, for the addition of a circumferential 2-km complex of rings with superconducting magnets, capable of achieving about 200 GeV. The project has the acronym TRISTAN (Tri-Ring Intersecting Storage Accelerators in Nippon), and preliminary design for it has been completed by members of the National Laboratory. Construction of TRISTAN is tentatively scheduled for the period

between 1978 and 1985. The completed facility will occupy most of the 550-acre site dedicated to the National Laboratory. The preliminary parameters of TRISTAN's rings are given in Table 3, and figure 5 provides the schematics for the total facility.

The higher energies will be reached by injecting the 12-GeV beam of the proton synchrotron into another conventional ring to be built in the very large ring enclosure. This conventional ring will serve as a booster for accelerating protons to 50 GeV before insertion into the major superconducting rings of the enclosure where, by employing proton beam stacking and collision strategies, energies up to 200 GeV are predicted. It is expected that the large conventional ring will be completed in 1982 and the superconducting rings in 1985. The total budget for the 200-GeV facility, not yet approved by the Japanese government, would be \$340 million. These plans, it can be seen, extend ten years beyond the current planning for Tsukuba Newtown, indicating that expansion is bound to continue beyond the present construction phase of the science city.

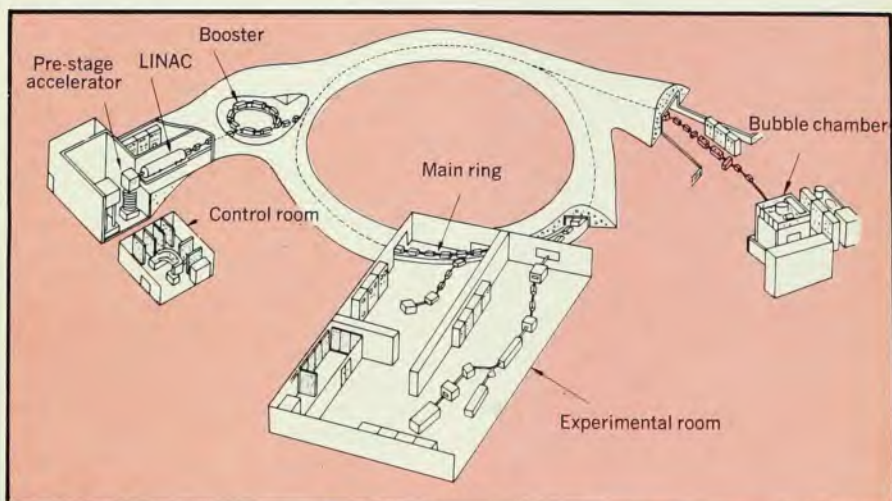
The National Laboratory staff has been spending most of its time on the design, construction and testing of the various elements of the facility. Shigeki Suwa of Tokyo University's Institute for Nuclear Study has served as the laboratory director from the outset. Tetsumi Nishikawa, director of the Accelerator Department, played a leading role in the machine's design and construction. There has been a fair amount of interaction with American high-energy machine scientists, especially those from Brookhaven and the National Accelerator Laboratory. Members of KEK's staff have presented several papers on the synchrotron's development. In November 1973, a US-Japan Seminar on High Energy Accelerator Science, held in Tokyo and Tsukuba under the auspices of the US National Science Foundation and the Japan Society for the Promotion of Science, provided considerable detail on the Japanese construction program. The present staff amounts to about 130 persons, equally divided among scientists, technicians and administrative personnel; by 1975 the staff will grow to 280. More than half of the members of the scientific staff have doctorates in physics. KEK is eager to interact with groups outside Japan and hopes to have 30-50 outside scientists involved in their programs in any one year. Future projects involving international cooperation are now being developed with BNL and NAL.

"Tsukubadai"

The largest single organization in Tsukuba Newtown is the new national university, Tsukuba University, or



Layout of the organizations to be transferred to Tsukuba Newtown. The largest area will be occupied by the organizations under the Ministry of Education. Figure 2



The 12-GeV proton synchrotron of the National Laboratory for High Energy Physics (KEK) of the Ministry of Education. Started in 1971, it is scheduled for completion late this year. Its design calls for an intensity of over 2×10^{12} protons per pulse; the other parameters are given in Table 2. The 20-MeV LINAC beam was obtained in August 1974, and the 500-MeV booster, a fast-cycling alternating-gradient synchrotron, is nearing completion. Figure 3

Akademgorodok, the science city at Novosibirsk

The Soviet science city of Akademgorodok, nearly two decades old, serves both as a prototype and as a standard of comparison for planned science communities such as Tsukuba Newtown. It is located 15 miles from the 1.3-million-population industrial city of Novosibirsk in Siberia. Together with its ancillary services, Akademgorodok comprises about 40 000 people, of whom 8000 are scientists. It was initiated by Mikhail Sergeevich Lavrentyev, who founded the Hydrodynamics Institute there in the late 1950's. Akademgorodok is the seat of the Siberian division of the USSR Academy of Sciences, and embraces 17 institutes including the Computer Center and covering such other fields as catalysis and chemistry, solid-state physics and electronics, applied mechanics and aerodynamics, genetics (particularly of furred animals), botany (with a botanical garden) and geology. Novosibirsk State University, a prestigious institution of some 4000 highly-selected students, was established about 1958. A branch of the Institute of Health specializes in heart surgery.

Akademgorodok has major facilities in high-energy physics and controlled nuclear fusion, as well as a thermophysics institute. The Nuclear Physics Institute, headed by G. I. (Andrei) Budker, was described in detail in the August 1969 issue of *PHYSICS TODAY*. The most significant high-energy machine the Institute operates today is the VEPP-2M. This colliding electron-positron beam storage-ring accelera-

tor has a total energy of about 1.5 GeV and the unusually high luminosity of several times $10^{29} \text{ cm}^{-2} \text{ sec}^{-1}$. The experimental equipment, including on-line computer displays and spark-chamber readouts, is "state of the art" by US standards.

A unique development at the Novosibirsk laboratory is the electron cooling of a stored proton beam. Synchrotron radiation reduces the phase space (spread in angle and energy) of an electron beam by damping its oscillations. A proton beam does not have this advantage because it does not radiate. In this new development, however, an electron beam with the same velocity skims the proton beam tangentially and conveys transverse momentum to it to reduce the proton beam's phase space—the beam diameter may be reduced from 1 cm to 1 mm approximately—and thereby increase its luminosity.

The somewhat older VEPP-2 is now used as a buffer between the sources and the VEPP-2M; VEPP-3 is being used for synchrotron-radiation experiments while undergoing modification, and VEPP-4 is still under construction. An unusual aspect of the Institute of Nuclear Physics is the fact that it manufactures high-intensity pulsed-electron accelerators for use elsewhere in the Soviet Union and for export abroad.

The fusion program involves 200–300 people, with Budker himself playing a very active role. Two of the major areas of concentration, multiple-mirror wall confine-

ment and rotating plasmas in magnetic mirrors, are judged the biggest such efforts in the world. The Akademgorodok fusion experimenters have just brought into operation a multiple-mirror experiment in which the plasma is to be heated by a beam of relativistic electrons. They are seeking to build a system in which the pressure of the plasma is taken up by the wall rather than by the magnetic field, which would then serve mainly to reduce drastically the thermal conductivity of the plasma. In this unique system β , the ratio of plasma to magnetic-field pressure, would be around 100 instead of the 1 or less required for purely magnetic confinement.

The reduction of losses from the ends of the magnetic mirror by rotating the plasma, a concept that was tried and dropped in the early days of the fusion program at Livermore, is being revived in modernized form at Akademgorodok.

The third major effort in controlled thermonuclear reactors is the development of ion sources and neutral-beam injectors. To heat the plasma, currents of hydrogen, deuterium and tritium ions as high as 50 A are injected into the plasma. Because of the intense magnetic fields, however, these ions must be neutralized before injection. The high energies used require that the ions be negative, as the stripping of electrons is not subject to the decrease in cross-section that occurs in the neutralization of positive ions. Novosibirsk is viewed as a major contributor to the world effort in this area. —HRL



The ion production source for the Tsukuba synchrotron will be this 750-kV Cockcroft-Walton preinjector, moved from the University of Tokyo in 1971. Figure 4

"Tsukubadai," as it is known colloquially. Most of the university has now been completed, with only some additional dormitory space and specialized laboratory equipment still to be added. In April 1974, the first class of 740 freshmen entered the University. The campus, which occupies the largest educational area in Japan (about 610 acres), compares favorably with most American university settings. The buildings are modern, functional and well designed. Figure 6 shows the layout of the campus, which is located just north of the proposed downtown high-density area. At the heart of the campus are the teaching and research facilities, which are divided into seven colleges or "clusters." Surrounding this core of colleges are agricultural experimental areas and, interfacing with the community, sports facilities and a medical complex. Within the central academic complex are facilities for faculty, graduate and undergraduate student research.

The most striking features of the new university cannot be deduced from its buildings—they come out of the planning studies for the university itself. University policies are established by a board autonomous both from the Ministry of Education and from the fac-

ulty. New, to Japanese universities at least, is the appointment to the board (along with the President), of five vice-presidents: one each for education, research, medical affairs, student affairs and administration. This may not seem radical to Western observers, but it marks the first time in Japanese education that a relatively independent executive-policy group will run a national university.

Still another feature of the university is the fact that 20 percent of the students will be enrolled on the basis of high-school achievement rather than on entrance examination scores. This is a departure from the present system in other universities, challenging the dreaded "examination hell" patterns that Japanese students and their parents now endure. If these students compete successfully with their examination peers, the technique may be tried at other universities.

The most radical feature is the concept of "clusters." These are described as areas of academic inquiry or training designed to produce students of "various types of individuality." The clusters are interdisciplinary but in relatively coherent fields of study. The seven clusters are: basic sciences and the humanities; culture and the life sci-

ences; engineering and management; international relations; physical education; fine arts, and medicine. To give these clusters educational texture, the study programs are given direction by emphasizing fields of interest such as philosophy and logic, history and anthropology, language and culture, social engineering and physical sciences. The actual course work can be tailored individually to meet student goals. These programs are oriented toward undergraduate students.

Tsukuba University will have a strong graduate program, but the goals of the masters' degree students will be distinguished from those of students seeking their doctorates. Students will be separately enrolled for each of these graduate areas; masters' students will be trained for professional activities in the private sectors of Japan, while PhD courses will be directed toward careers in research.

Faculty will be provided with high-quality research facilities. Research will also be encouraged at all student levels with, of course, a concentration of such activities in the doctorate programs. At present, research, both for students and faculty, is a prospect rather than a reality because there are no graduate students on campus, and research equipment is still on order.

Also still in the future are plans to invite foreign faculty to the campus. It has recently been reaffirmed that Tsukuba University will have an international look about it; considerable effort is expected to be devoted to language and intercultural studies.

Tsukuba University, which by Western educational standards may not seem radical, is a challenge to traditional methods in that it provides much greater freedoms to university administration, faculty and students. As such it is looked at with skepticism by the established schools, their faculties, and even some of the faculty being transferred to Tsukuba.

At present Tsukubadai has 180 faculty members including ten in physics. Ultimately there will be about 8000 undergraduate and 2000 graduate students and a faculty of 1500. Education in the physical sciences, especially physics, will receive special attention. Tsukuba University is considered a replacement for Tokyo University of Education (not to be confused with Tokyo University) which is said to be going out of existence because its campus in Tokyo is crowded and obsolescent. Tokyo University of Education has had an excellent reputation in the sciences, especially physics. Shinichiro Tomonaga, the Nobel Prize winner, taught there and is a former President of it. Its research in the fields of optics, low-temperature physics, solid state and theoretical nuclear physics has merited

world recognition. Now, with the transfer to Tsukuba Newtown, there is every expectation that this tradition will be reinvigorated with the establishment of new, more fully equipped laboratories.

Two prominent Japanese physicists and science administrators are involved in trying to make the transition a success. One, Nobuyuki Fukuda, a nuclear physicist who was associated with Tomonaga when they were both members of the famous atomic-physics laboratory of Yoshio Nishina at the Institute for Physical and Chemical Research back in the 1930's, is a leading figure in push-

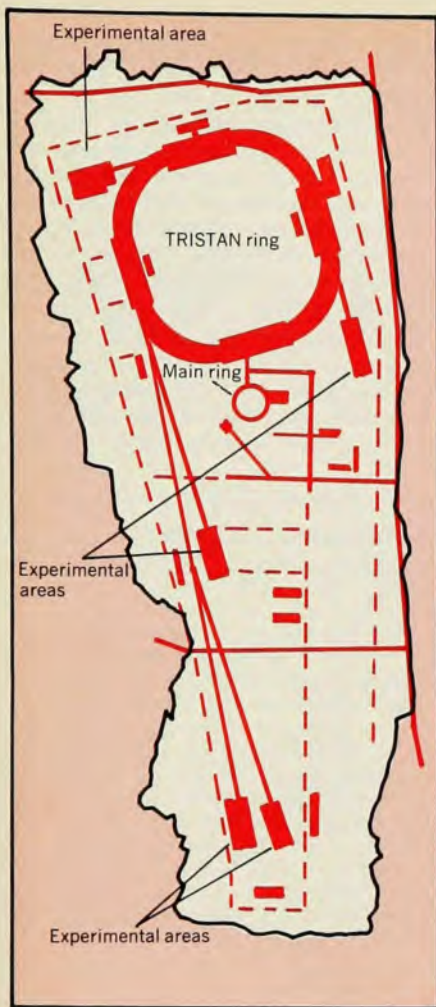
ing the new look of Tsukuba University. He was dean of science at Tokyo University of Education and has become vice-president for research at Tsukubadai. An experimenter and internationalist, Fukuda is providing the leadership for educational change and the infusion of foreign talent to the campus. The other is Fumihiko Takano, also a former member of the physics faculty of Tokyo University of Education, who is the physicist member of the three-man planning board of Tsukuba University that is charged with the responsibility of creating the actual scheme of transition from the Tokyo campus. In the

Table 2. Parameters of KEK proton synchrotron

Main ring	
Kinetic energy	12 GeV
Intensity (Space-charge limit)	$>2 \times 10^{12}$ (1×10^{13}) p/pulse
Type	Separated-function
Focusing order	FODO
Average radius	54 m
Number of superperiod	4
Number of betatron oscillations	7.25
Maximum bending field	17.5 kG
Injection energy	0.5 GeV
Repetition rate	0.5 Hz
Booster	
Kinetic energy	500 MeV
Space-charge limited intensity	3×10^{12} p/pulse
Type	Combined-function
Focusing order	FDFO
Average radius	6.0 m
Number of cells	8
Number of betatron oscillations	2.25
Maximum magnetic field	11 kG
Repetition rate	20 Hz
Linac	
Energy	20 MeV
Type	Single-tank D-T Linac
Cavity length	15.5 m
Number of cells	90
Peak current	~100 mA
Repetition rate	20 Hz
Preinjector	750-kV Cockcroft-Walton

Table 3. Parameters of TRISTAN pp rings

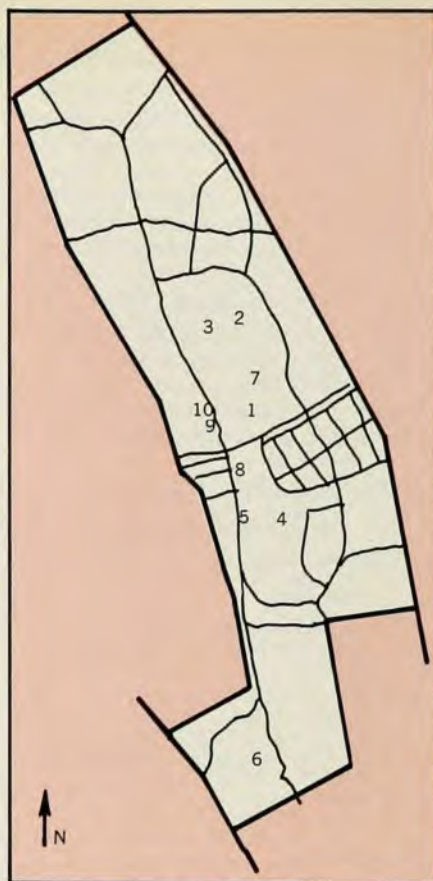
Injection energy	12-50 GeV
Maximum final energy (each ring)	180 GeV
Number of intersecting points	4
Average radius (curved section)	204 m
Length of long straight section	150 m
Length of short straight section	30 m
Total circumference (6X that of the 12-GeV ring)	2035 m
Maximum magnetic field	50 kG
Total stored energy	~70 MJ
Acceleration time	~100 sec
Number of betatron oscillations	22.25
Cell structure	Separated-function FODO
Number of cells (each ring)	80
Cell length	~16.4 m
Full-vacuum chamber aperture	6 cm
Crossing angle	40 mrad
Total charge (each ring)	6×10^{14}
Circulating current (each ring)	15 A
Luminosity (at 180 GeV)	$7.5 \times 10^{31} \text{ cm}^{-2} \text{ sec}^{-1}$
Maximum luminosity for collinear crossing	$10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$



Energies up to 200 GeV are predicted for TRISTAN, shown here, to be started in 1978 and completed in 1985. Figure 5

field of physics, Tsukuba University will inherit by transfer all the research programs of the old institution. It hopes in addition to develop strength in the areas of astrophysics, experimental nuclear physics and plasma research. Ultimately, it hopes to house a physics faculty of 80.

The proposed program in experimental nuclear physics is a natural outgrowth of the interests of men like vice-president Fukuda. It will not only supplement existing programs in theoretical research, but it will also provide the basis for interaction with the nearby National Laboratory for High Energy Physics. The university will have a medium-energy accelerator of its own. It is expected that staff members of the National Laboratory will teach at the university, while graduate students and faculty from the university will, in turn, have access to the large synchrotron. Interaction will be made easier because National Laboratory principal staff hold the rank of professor, and also because the laboratory and the university will both be under the jurisdiction of the Ministry of Education. At the mo-

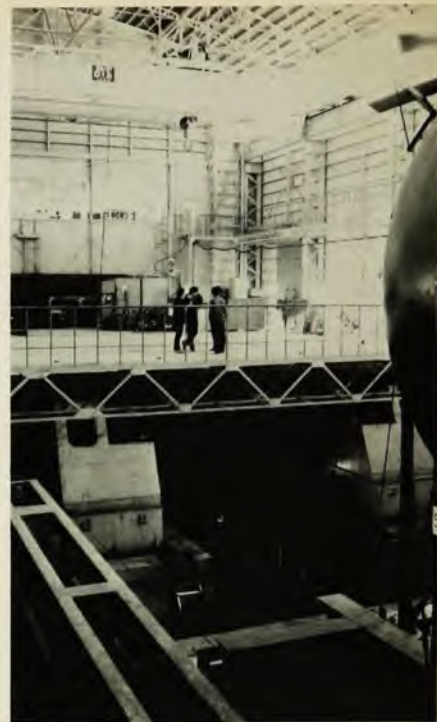


Tsukuba University's interdisciplinary clusters (1-6) are discussed in the text. Also of interest are the library (7), data processing center (8), low temperature center (9) and accelerator (10). Figure 6

ment, however, construction on the University's machine has not started, and discussions between the two organizations are still informal and tentative.

Plasma physics

The major planned new addition to Tsukuba University's physics program is plasma research. The largest plasma research facility now is the Institute for Plasma Physics Research at Nagoya University. This institute, which has been Japan's leading plasma and fusion research center for the past ten years, is nearing the limits of its capabilities. The plan now is to initiate a new broad program of plasma research at Tsukubadai, with the transfer of several of the key researchers from Nagoya. The Ministry of Education is considering plans for the creation of a new National Laboratory for Plasma and Fusion Research to be attached to the university. If this became a reality, the proposed university plasma research program would blend into the National Plasma and Fusion Laboratory, and would supplement or perhaps even supplant the present Nagoya effort. Details of the proposed new laboratory are not known, but it is said that the size and space requirements would be substantially larg-



Largest of its kind in the world, this 225-m² shaking table is capable of subjecting structures such as a model of an oil-storage facility to lateral and vertical motions severer than any earthquake. Figure 7

er than that existing in Nagoya, and that the research would be undertaken along new lines to achieve higher energies under conditions of increased control, along with some applied research leading toward electric power generation.

The National Laboratory for High Energy Research and the physics research and education activities of the new Tsukuba University are the major programs of interest to physicists. Of course, the discipline of physics is pervasive and enters almost all of the physical sciences, especially in their applied form as reflected in the various laboratories supported by the government ministries. One organization doing such applied research is the National Center for Research on Disaster Prevention, which will conduct large-scale experiments on weather simulation and modification in addition to operating the giant shaking table for earthquake simulation shown in figure 7. All of these institutions are in the process of building and organizing.

The science city is on its way. It is bound to have major effect on Japan and possibly on the world. It will be interesting to speculate on what the effect of those two large science cities—Novosibirsk and Tsukuba—will have on Asian research once the latter becomes active and interacts with the former. The two will make for a powerful center of attraction to the Far East. □