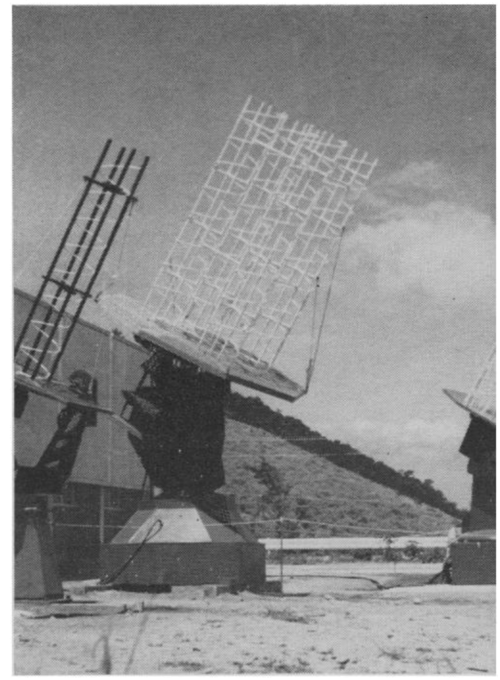
日本の科学



Receiving antennae adjoin telemeter center at new space research site.

Science in Japan

Brainpower, not lavish capital investment, is the basis of rapid advance in science and technology.

Seventeen Japanese scientists, chosen by their colleagues to represent fields of science in which Japanese achievement has been outstanding, reported on work in these fields at a symposium at the AAAS meeting in December 1963. The symposium was supported by the National Science Foundation.

Their reports and their conversations with American colleagues provided what is probably the most comprehensive account of recent scientific progress in Japan available to the West and also gave some impression of how scientific development has been shaped by aspects of Japanese culture that define a milieu at once familiar and oddly unfamiliar to American workers. Almost every report included evidence of the extent to which an island people have learned to substitute brainpower and craftsmanship for lavish use of capital and natural resources.

In nuclear physics, for example, a field in which Japan's eminence is well established, workers have not felt handicapped because they have not had their own high-energy accelerators as experimental instruments. While Japanese experimental physicists are now working with data from the 750-Mev electron synchrotron which began operation at the Institute for Nuclear Studies in Tokyo in 1961 and hope soon to begin construction of a 12-Bev proton synchrotron, they are not dissatisfied by the progress they have already made in interpreting nuclear interactions on the basis of cosmic ray observations, a much less expensive experimental approach.

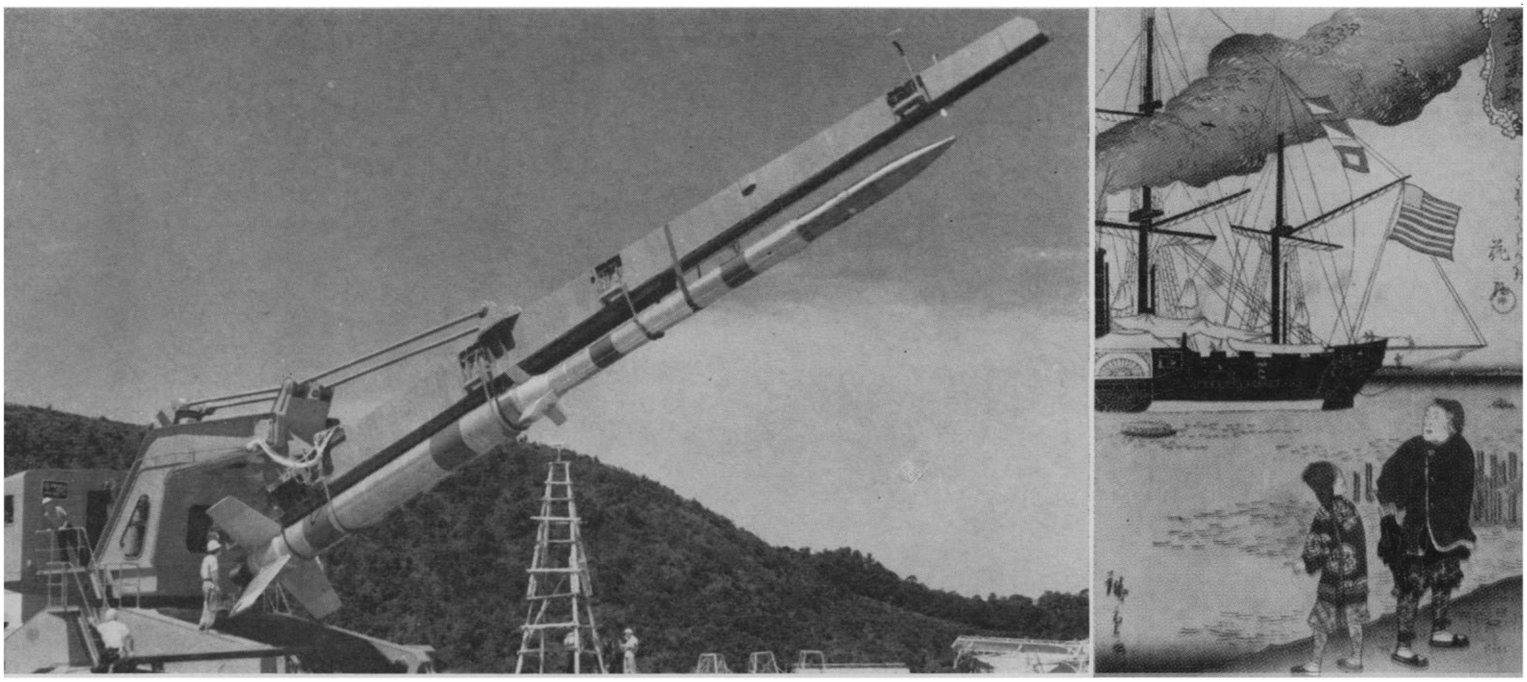
Gyo Takeda, who spoke on Japan's program in this field, said: "It is understood that we have to walk on a rather narrow, long, unpaved, cheaply constructed, and yet well-designed road to reach the fruitful goal of high-energy physics."

In structural chemistry, another field in which Japanese contributions have been outstanding, the hard years after the war made it impossible for university laboratories to buy the nuclear magnetic resonance spectrometers which were becoming commercially available throughout the world. But "Japanese chemists made an almost desperate attempt to construct the equipment by themselves," as Ken-iti Higasi, who spoke on structural chemistry, put it. They succeeded in building high-precision instruments with which they were able to make new approaches to the study of proton shifts and of interconvertible isomers in carbon ring compounds.

Japan's success in the international market with optical goods and electronic equipment and in railway and marine engineering design suggests that the craftsmanship evident in research has been translated to mass production methods with perhaps greater success in quality control than has been achieved by U.S. industry in these fields. Another example of the characteristic Japanese approach is the fermentation industry, based initially on study of the mold that accomplishes the first step in saké-making, saccharification of rice. "Because relatively valuable products can be obtained in fermentation industries with comparatively little capital," Japanese government support of this industry has been substantial, Koichi Yamada of the University of Tokyo said in a report on this field.

Yet it would be a mistake to associate the Japanese talent for craftsmanship and design too closely with technological gains. When one of the visiting scientists casually made artistic line drawings of mountain peaks, valleys, and volcanoes to sum up his view of the world's scientific landscape ("Now, let's say, this peak is Beadle . . ."), a strand of Japanese character with which the West is less familiar became evident.

The visitors disclaimed any Japanese split into "two cultures" such as C. P. Snow finds in the West. Scientific research has a broad and popular base, they said, in the love of nature so marked in the Japanese people, and in the high status traditionally given the scholar in Japanese society. Kizaemon Ariga of Keio University, who spoke on sociology, suggested that the introduction of modern science over the



Six-ton Lambda rocket was launched from Kagoshima Space Center, recently opened by University of Tokyo. Japan's scientific eminence is harvest of 101 years of rapid development after ports opened to world.

last century had been especially accelerated because Japanese culture values childhood curiosity and, unlike some other societies, does not attempt to repress it.

The alliance of science with other sorts of cultural endeavor is evident in the organization of the Science Council of Japan, a body that has no parallel in the United States and whose 210 members are elected every 2 years by vote of all the scientists of the country. Three of the Council's seven sections represent the humanities and the social sciences.

Sensitivity to the beauty and symmetry of the natural world, some of the visitors also felt, is the basis of Japanese interest in theoretical work in science, which has been especially fruitful in nuclear physics. Other members of the group criticized what they described as the "Japanese inclination toward theory rather than experiment." One of these said a "distinguished British scholar had told him that he was impressed by the distaste felt by Japanese academic researchers for work aimed at solving practical problems and that this might be a source of economic weakness."

One of the new trends in Japan, accelerated by the recent economic expansion, is establishment of basic research institutes by industry; hitherto almost all basic research has been conducted by the universities, especially by the seven universities known as Imperial Universities before the end of World War II. Large basic research laboratories have been established by the Tokyo Shibaura Electric Company, the Yawata Iron and Steel works (this is a laboratory for research in solid-state physics directed by one of the great men of Japanese structural chemistry, S. Mizushima, who has retired from the University of Tokyo), the Toyota Motorcars, and the Toyo Rayon Company, Ltd.

Those at the meeting who thought Japanese scientists should have more concern with "practical problems" are looking to the new institutes as a means of strengthening the relation between science and industry. Those more interested in theoretical work describe the new institutes as evidence of increased understanding by industrial management of the prime importance of basic research.

The most obvious difference in the scientific climate in the United States and in Japan is that our Pacific neighbor is not using scientific resources in the development of nuclear or other weapons or in an effort to orbit satellites and manned space vehicles. (Japanese rocketeers are pressing for a government appropriation to build a rocket capable of launching orbital satellites, but the expenditure is opposed by a bloc of scientists who say less expensive instruments are adequate for gathering basic knowledge of the ionosphere and remoter space.)

It follows from this that Japanese industry is paying most of its own bill for both basic and applied research. "On this point things are very different from the situation in the United Kingdom or the United States, where over 60 percent of government grants-in-aid for research are awarded to private enterprises," said Tomizo Yoshida, who is vice president of the Science Council of Japan, director of the Cancer Institute of the Japanese Foundation for Cancer Research, and one of the first men in the world to succeed in growing cancer cells in culture.

Yoshida said that the rapid recent development of science in Japan "is largely due to the democratic reformation of the organization of science" after World War II.

Japan is now spending about 2 percent of its national income for scientific and technological research, as compared with a U.S. expenditure for R&D of 3.3 percent of national income. In 1961 industry appropriations for research in the natural sciences amounted to the equivalent of $504 million, and national and local government appropriations, to about $177 million. Other indications of the weight of science in Japanese society are shown by the following figures, drawn from Yoshida's report:

► 143,412 researchers in all fields of

science, including the humanities and the social sciences [while the difficulties of comparing such figures are well known, the National Science Foundation estimated that in 1960 over 400,000 scientists and engineers were working in research and development in the U.S. (*1*)]

► 1 college or university student for every 142 members of the population [1/51 is the ratio in the U.S. (*2*)]

► 1 graduate science student for every 10,600 persons [1/1429 is the ratio in the U.S. (*3*)]

► 2240 scientific journals

► 340 scientific societies

In addition to the universities' departmental research, there are 64 well-equipped university-operated research institutes. Nine of these, Yoshida said, are available for "common use by qualified workers throughout the country."

The Research Institute for Fundamental Physics at Kyoto was the first of the "common use" resources to be established. Staff appointments to these institutes are made (at 2- to 3-year intervals) by a committee elected by general vote of researchers at the various universities. Another committee, similarly elected, plans the program.

The Science Council of Japan, which selected both speakers and subjects for the symposium on Japanese science at the request of AAAS, was established by Japanese scientists after World War II as a means of democratizing Japanese science. The Council makes recommendations for government support of scientific programs and appoints Japanese representatives to the international scientific unions. After the war, the Japanese Academy of Science, established in 1879, was incorporated into the Council, but regained its independent status in 1956 and, with a membership of 150, is now under the jurisdiction of the Ministry of Education.

Other government agencies concerned with science are the Council for Science and Technology, which advises the Prime Minister and on which the Prime Minister sits as chairman; the Science and Technology Agency, which formulates government science policy and acts on the recommendations of the Science Council of Japan; and the Atomic Energy Commission, whose chairman is also the director of the Science and Technology Agency.

High-Energy Physics

Like most physicists elsewhere in the world, Japanese workers believe that some of nature's most fundamental secrets will be revealed by the present intense study of particle interactions within the atomic nucleus and of the multiplicity of secondary particles produced when nucleons collide. In certain aspects of this invisible universe of very short distances, some of the conservation laws (parity is an example) that have enabled physicists to use quantum theory with such brilliant success in predicting the outcome of fundamental atomic experiments and in creating nuclear chain reactions seem to be inoperative.

The fact that "researches abroad have shown multi-bev high-energy accelerators to be indispensable for further studies" persuaded Japanese physicists to ask their government for the equivalent of about $55 million to build a 12-Bev proton synchrotron, Gyo Takeda of Tohoku University said. This fast-cycling alternating-gradient instrument will deliver from 30 to 60 pulses per second, as compared to the approximately one pulse every 2 seconds delivered by the Brookhaven 33-Bev alternating-gradient synchrotron, which cost $31 million in 1960.

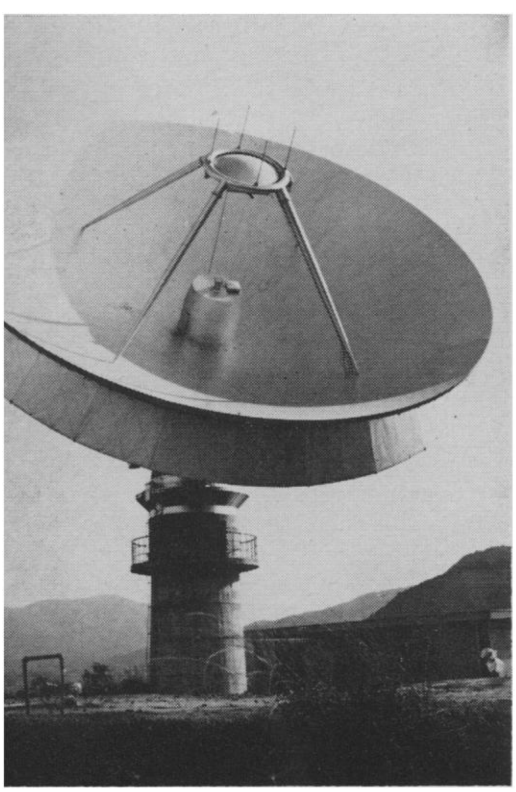
But in Japan the decision to divert funds and talent to high-energy-accelerator experiments is perhaps not so generally endorsed as such outlays are in the United States, where the top nuclear physicists are asking for instruments that will take them up to 200 Bev, or even to 600 to 1000 Bev. According to Takeda, who is well known in American circles as a former research associate at Brookhaven, Japanese physicists are anxious to maintain a well-balanced nuclear research program.

"Emphasis on theoretical physics, cosmic ray physics and low energy nuclear physics . . . has given us advantages in competition with nuclear research abroad, where tremendous emphasis on high energy physics by large accelerators . . . has been seen."

Furthermore, "in spite of our success and previous experience in constructing lower-voltage accelerators, it is not very obvious whether we can build a 12 Bev proton synchrotron within a reasonable time and with enough strong intensity."

Takeda said that construction of the proposed synchrotron would take at least 6 years, and that the usefulness at that time "may not be as great as that of comparable existing machines."

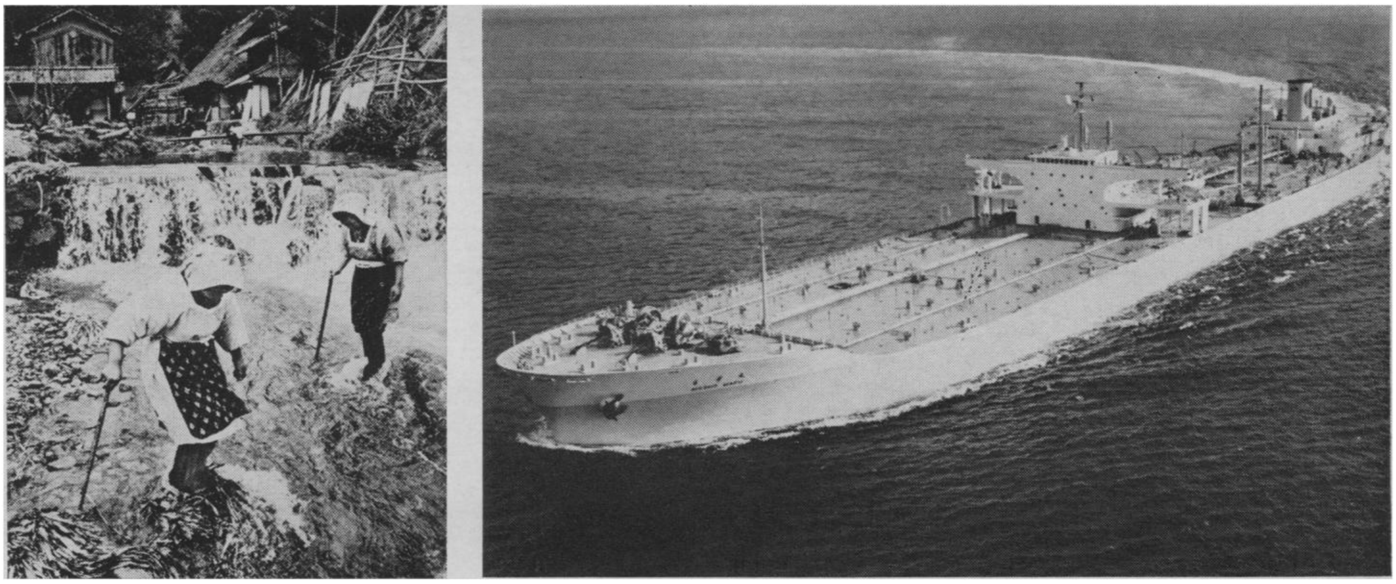
Japanese reserve about rushing for multi-million-dollar experimental instruments may be reinforced by a history of brilliant contributions to nuclear



Parabolic antenna at Kagoshima Space Center receives radio signals from satellites passing over Japan.

Ken-ichi Maeda, Kyoto University, who spoke on ionospheric research, said that Japan has so far made 10 rocket experiments, eight using solid fuel. Japanese researchers invented a resonance probe, which measures ionospheric electron density and temperature simultaneously. Tested against Langmuir probe in Nike-Cajun rockets launched by U.S., Japanese probe gave same accuracy, permitted faster results.

Radio frequency voltage is superimposed on direct current voltage in probe exposed in ionospheric plasma. When plasma electrons vibrate at the same frequency (resonance) as RF voltage in probe, there is a rise in probe's direct current. This permits determination of plasma electron density and temperature.



World's biggest tanker (132,000 tons) was built by Sasebo Heavy Industries. Japan's technology can draw on long craft tradition. Handmade paper is still produced by 2000-year-old skills. Here workers tread black mulberry bark.

theory. In 1937 Nobel laureate Hideki Yukawa greatly increased the power of quantum theory to predict nuclear events by proposing that the proton and neutron represent two states of one nucleon, interchanging with one another by virtual emission and reabsorption of field quanta (a prediction confirmed 10 years later by experimental discovery of the pi meson or pion). Yukawa and Shin'ichiro Tomonoga, who formulated a quantum mechanical theory of multiple production of secondary particles, are still the unquestioned leaders in theoretical physics in Japan, Takeda said.

Another landmark in Japanese theoretical work is what, in many parts of the world, is known as the Nishijima-Gell-Mann theory, proposed to account for the "strangeness" of the strange particles created when the nucleus is shattered. Independently of Gell-Mann's work to the same end, Kazuhiko Nishijima described a new quantum number called strangeness, the value of which distinguished the new strange particle from particles known earlier. Strangeness is conserved in strong and electromagnetic interactions but not in weak interactions. The Gell-Mann-Nishijima description based on assignment of a quantum number made it possible to explain the unexpectedly long lifetimes of strange particles and to predict discovery of several additional strange particles, and gave new insight into weak interactions.

At the Cosmic Ray Laboratory established in 1953 on Mount Norikura it has been possible to study particle collisions with energies up to 100,000 Bev, Takeda said; the highest energy obtainable with existing accelerators is about 33 Bev. These studies have led to such contributions as Nishimura's observation that the transverse momentum of secondary particles (mostly pions) produced by collision of nucleons at very high energies is extremely small and nearly constant, a conclusion very useful in analysis since it means that the transverse components of momenta can be neglected and the increase in primary energy measured by its concentration in the longitudinal momentum of the secondary particles.

Last year Japanese cosmic ray researchers began collaborating with Brazilian physicists in an observation station at Mount Chacaltaya, where nuclear emulsion chambers are being carried in automatically controlled balloon flights. In another such cooperative project, in Bolivia, Japanese workers are observing cosmic ray showers over a large ground area; Massachusetts Institute of Technology and University of Michigan researchers are associated in this study.

Takeda said there are about 700 nuclear researchers, including senior graduate students, in Japan; 100 of these are working with the 750-Mev accelerator. In addition to the projected $55-million accelerator, the 6-year program for expanding nuclear research approved by the Science Council of Japan, and for which appropriation requests are being considered by the Japanese government, includes installation of a large electronic computer at the Kyoto Research Institute for Fundamental Physics, at a cost of about $3 million.

Origin of Bread Wheat

What is known of the evolution of today's common bread wheats (*Triticum aestivum* spp. *vulgare*) was described by Kosuke Yamashita, one of the geneticists who have helped make Japan a world-renowned center of research in wheat genetics. One stimulus to Japanese research was the national need to develop a dwarf wheat hybrid that could be sown between rice rows in the heavily fertilized soil of rice paddies.

The evolution of bread wheat is based on the remarkable genetic mechanism of polyploidy. Polyploidy, or chromosome doubling, in wheat was first seen by Japan's Sakamura, who by 1918 had developed microscope technique to a level that permitted him to count the chromosomes in a dividing wheat cell taken from root tips. Schulz of Germany had earlier classified the many known species of *Triticum* into three broad groups according to the structure of the head or spike: Einkorn or one-kernel, Emmer (two or more kernels), and Dinkel (multikernel and with large spikes, today's bread wheat). Sakamura found that wheats of the Einkorn type had 14 somatic chromosomes (seven in the gamete), those of the Emmer type 28, and those of Dinkel 42. A few years later, by means of genome analysis, Kihara found that 42-chromosome wheat was the result of a crossing between two 14-chromosome or diploid wheats (AA and BB) to produce a 28-chromosome wheat (AABB, a polyploid) and a further mating of the latter with another 14-chromosome wheat (DD) to yield the 42-chromosome polyploid plant (AABBDD). Each genome donor had contributed a characteristic set of seven chromosomes.

Polyploidy, or doubling of chromosomes, seems to be a genetic mechanism that permits mating of rather unlike forms. When chromosomes are too unlike they will not combine; polyploidy apparently solves the problem of combining like with like by providing a double supply of somatic chromosomes from each gamete. Common in plants, particularly in cultivated plants, polyploidy is rare, but not unknown, in animals (in fact, some researchers have reported the observation of polyploid chromosomes in certain vertebrate tissues) (*4*).

Chromosome doubling seems to have some association with vigorous growth; polyploid plant species tend to be larger and hardier than diploids and are found particularly in regions of climatic extremes—in the Arctic and in very hot, dry, or salty areas (*4*).

Japanese workers found the A genome of today's polyploid bread wheats in two primitive species: *Triticum aegilopoides*, a wild grass that still grows widely in the Caucasus, and *T. monococcum*, a one-kernel-per-floret plant still cultivated in many parts of Turkey.

Although Kihara thought the ancestral donor of B genome had probably become extinct, he nevertheless organized botanical expeditions to look for it in Asia Minor and the Caucasus. Various species were collected and explored by experimental crossing, both by the Japanese group and by American workers, but the work did not produce chromosome pairing of the sort observed in the known AABB wheats. In the course of the search, however, Kihara found *Triticum timopheevi*, a wild wheat growing in Georgia, first described by Zhukovsky, and the most rust-resistant species known.

An American worker, J. A. Clark, used *Triticum timopheevi* in an attempt to produce a useful rust-resistant hybrid. His research encountered the well-known difficulties of hybrid production in wheat, which (until some remarkable recent discoveries) involved a tedious hand process of detaching the anther from each wheat floret and then dusting with pollen. A method which circumvents the limitations of hand pollination has just been disclosed by some American researchers whose work seems likely to launch the kind of world-wide revolution in wheat production that hybridization did in corn.

Sterility-Fertility Factors

While Yamashita did not discuss this aspect of current work, it is interesting to note that impetus for the recent American discoveries in hybridization came from Japan. Working with nuclear substitution techniques developed by Kihara, H. Fukasawa learned that a factor in the cellular cytoplasm of a 28-chromosome wheat strain determines inheritance of male sterility. He later found a chromosomal factor in a normal wheat which, on crossing with the male-sterile strain, showed some evidence of restoring fertility (*5*).

American workers J. A. Wilson and W. M. Ross later found a cytoplasmic sterility factor in a wheat strain derived from *Triticum timopheevi* and succeeded in transferring the factor to the bread wheat Bison. Recently scientists of the U.S. Department of Agriculture Research Service and the Nebraska Agricultural Experiment Station found a gene (or genes) that overcomes the block to normal pollen development in the male-sterile plants. Working with a Nebraska experimental strain derived from Clark's series of crosses, which began in 1936 with *T. timopheevi* × *T. aestivum* spp. *vulgare* and continued through Nebred, an important commercial variety, J. W. Schmidt, V. A. Johnson, and S. S. Maan found the restorer genes. This two-part genetic system is the key to the first practical method of producing hybrid wheat seed. The outlook for a world-wide increase in the productivity of wheat cultivation now depends on whether current vigorous experimental work will develop wheat hybrids with yields high enough to justify increased seed cost—an equation solved with spectacular success in the development of hybrid corn.

Search for the DD ancestor of common bread wheat met with success. Kihara and also McFadden and Sears in the United States established that a square-spiked plant, *Aegilops squarrosa*, now distributed over a region extending from the Caucasus to Pakistan, contributed the D genome to today's bread wheats.

The Japanese search for the BB ancestor continued, branching out from areas located by archeological discovery of the oldest known 28-chromosome wheat, *Triticum dicoccum*, found both at Jarma in the Tigris-Euphrates basin (7000 B.C.) and in the oldest materials found in Egyptian pyramids (5000 B.C.). "This amphiploid probably occurred spontaneously in connection with primitive cultivation of the diploid *T. monococcum*," Yamashita said. "Because of more favorable characteristics than its ancestral diploid, *T. dicoccum* was probably selected . . . for cultivation."

Before civilization spilled out of Asia Minor to spread through the river valleys of Europe, 42-chromosome wheat, a relative newcomer in the slow time scale of evolution, was on hand. Archeological work has traced it as far back as 3000 B.C., Yamashita said. The rapid rise of European civilization seems to be associated with the robust growth of the 42-chromosome polyploid.

The puzzle of the missing ancestor of today's common bread wheats, the donor of B genome, may be near solution. While the variety of *Aegilops speltoides* investigated in breeding analyses had not produced the chromosome pairing that would constitute evidence of its ancestral role, Yamashita thought this might be the result of mutation in the modern variety examined. A few years ago he organized an *Aegilops*-hunting expedition to the Eastern Mediterranean countries.

"Near Ankara Turkey we succeeded in collecting a new type of *Aegilops speltoides* with a compact head (one of the required characteristics of the ancestral form). Cross-breeding and other investigations of this wheat are now in progress."

If chromosome pairing identifies the Turkish *Aegilops* (found in the region near the Black Sea where the Hittite empire flourished about 2000 B.C.) as the missing ancestor, a half-century of genetic research will be complete, and the search for the primitive plants that

Anthers of wheat head are about to release pollen. Before recent discovery of male sterility factor, hybrids were produced by plucking each anther by hand and then brushing stigma with pollen. Temple of Ramses III is architectural triumph climaxing some 4000 years of development of Nile Valley civilization based on wheat and barley.

contributed to *T. aestivum* spp. *vulgare*'s sturdy inheritance will have traced the path of the wheat-based civilization of the West.

Theory of Numbers

Of all the elements of civilization, mathematics is the most easily transplanted across national boundaries. Shokichi Iyanaga of the University of Tokyo told how Japanese contributions to the algebraic theory of numbers have been closely interwoven with those of some of "the very best mathematicians" in many other countries, all "working with love in the theory of numbers."

Japan "can be justly proud of the creation of the class field theory by Takagi in 1920," Iyanaga said. He showed how Takagi's work had its source in two of the famous problems posed by David Hilbert at the 1900 congress of mathematicians in Paris, and how it generalized the theory worked out by the Austrian mathematician Furtwängler as a solution to one of the problems (to prove the reciprocity law for power residues in algebraic number fields—a needed parallel to the famous reciprocity law of quadratic residues proved by Gauss in the 19th century). In turn, number theorists in other countries, such as Artin (Germany), Hasse (Germany), Chevalley (France), and Weil (a Frenchman now at the Institute for Advanced Study, Princeton), extended Takagi's work. Outstanding recent work in algebraic number theory, Iyanaga said, has been done by Shimura, Iwasawa, Tamagawa, and Ono, Japanese mathematicians who are now working at U.S. universities.

"Although the algebraic theory of numbers is a special branch of mathematics, it is related to all other branches: algebra, geometry and analysis. Mathematics, in contrast to physics for example, is a remarkably unified science," Iyanaga said.

"Whereas in classical mathematics, algebra, the science of the rules devised for dealing with arithmetic properties of discrete quantities, and topology, which deals with continuity and the nearness of points, were two different fields, they are in a sense combined in the modern approach to mathematics. Algebraic methods are used in topology (there is a branch called algebraic topology) and also topological methods have been introduced in algebra (for example, homological algebra). Modern number theory, like other fields of modern mathematics (for example, functional analysis) utilizes both of these once widely separated fields."

Iyanaga's paper gave a glimpse of how the war impinged on the world of number theory. In 1940 workers everywhere were eager to read a paper in which Chevalley reformulated class field theory and succeeded in constructing it arithmetically—that is, without using zeta functions. When war broke out in the Pacific in December 1941, Japanese workers found it impossible to obtain the volume of *Annals of Mathematics* in which Chevalley's paper appeared. However, "our compatriot Nakayama, who was at the Institute for Advanced Study at Princeton in 1941, had access to Chevalley's manuscript, copied it by hand, and brought it back to Japan."

In the present period of expanding mathematical science there is a severe shortage of mathematicians in Japan, Iyanaga said. There are more than 200 universities in Japan, but only about a dozen of them, including the seven national (formerly Imperial) universities, have strong mathematics departments, and the number of active mathematicians is estimated to be about 100 to 200. Viewed against this total, the 20 Japanese mathematicians now working in the United States are a fairly large number.

Structural Chemistry

Higasi's summary of Japanese work in structural chemistry covered all the major methods of analysis: dipole moment measurement; ultraviolet, visible, infrared, and Raman spectroscopy; microwave spectroscopy; electron spin and nuclear magnetic resonance spectroscopy; x-ray and electron diffraction.

He said there are now more than 200 scientists working in structural chemistry in Japan, where this field was opened in 1923 by two young graduates of the University of Tokyo. One of them, San-ichiro Mizushima, produced the first experimental proof of Debye's theory of polar molecules and studied in Leipzig with Debye. The other, Isamu Nitta, specialized in x-ray crystallography and later provided the first explanation of the structure and behavior of molecules in plastic crystals (by his discovery that when pentaerythritol crystal is heated beyond 187.7°C it is transformed from a tetragonal to a cubic structure).

Recent work in Japan has included detailed determination of the heptagon-ringed tropolone structures (tropolonium$^+$ and tropolonate$^-$). Higasi said that, as of November 1963, "Nozoe and his group had prepared the amazing number of 2760 out of the 4110 new troponoid and azulenoid compounds thus far prepared throughout the world."

At the University of Tokyo, Yonezo Morino, a former co-worker of Mizushima's, is "probably entitled to be called the world's authority" on the effects of molecular vibration on the determination of internuclear distances by electron diffraction. Morino recently developed a general formula for calculating amplitude of thermal vibration.

Morino also showed how molecular vibration accounts for the so-called "shrinkage effect" first observed by Bastiansen of Oslo. Perpendicular displacement of end atoms as a result of normal vibration means that the distance between the two end atoms in (for example) CS_2 will be shorter than the distance of the sum of the two C=S bonds, and diffraction data will show the molecule as if it were slightly bent rather than linear. Morino and co-workers recently provided a means of calculating shrinkage effect (*6*).

Morino and the Tokyo group are also known for having constructed one of the world's best instruments for electron diffraction analysis, which involves a rotating sector mounted between the electron beam and the emulsion plate (designed to intercept the diffracted rays for a fraction of the rotation period proportional to the distance from the point of diffraction), and an optical densitometer which scans the electron densities recorded as diffraction rings. Since mounting the sector and securing proper rotation in the high vacuum surrounding the electron beam is a difficult engineering problem, not many laboratories in the world have such equipment. Higasi said this instrumentation had increased the accuracy with which atomic distances can be measured to 0.002 angstrom, in contrast to the accuracy of 0.02 angstrom obtainable with instruments not so equipped.

Now concentrating on study, by microwave spectroscopy, of molecular structures in the excited vibration states, Morino has been able to measure the change in moment of inertia that results from vibrational excitation. He has also made an approach to calculating the general intramolecular force field that governs any motion of the nuclei in the molecule, by using vibrational frequencies and a variety of other constants (*7*). "One has an impression that Morino is approaching his final goal," Higasi said.

In reviewing the development of structural analysis, Higasi said that "Pauling's classic work, *The Nature of the Chemical Bond*, had a great impact upon Japanese chemistry. It was immediately translated. Contrast may be made here with the response in the USSR to the same work."

Higasi also referred to Harry C. Kelly, now of North Carolina State College, who was the chief science representative of the U.S. military government during the American occupation of Japan (1945–52). Kelly presided at one of the symposium sessions and also spoke on current Japanese-American cooperation in science. Because of the "sympathetic understanding of Dr. Kelly" during the occupation years, Japanese chemists "continued their studies until they were able to make a fresh start with the rapid economic recovery which came later," Higasi said. In his opening remarks, Yoshida also gave a graceful tribute to Kelly and his office (which included Bowen Dees, now associate director, National Science Foundation) for great help given to Japanese science.

Symposium Volume To Be Published

Others who gave papers at the recent symposium were Denzaburo Miyadi (see pp. 783–786); Motinori Goto, on theory of computer circuit and logical design; Yoshikazu Sawaragi, on statistical studies of nonlinear control systems; Tatsuo Kariyone, on the chemistry of plant components; Kiyoshi Muto, on development of earthquake-resistant construction; Yoshiji Togari, on photosynthesis in the rice plant; Masao Onisi, on studies in experimental Vincent's disease; Tadao Yokoyama, on physiological and pathological studies of the silkworm; and Kin-ichi Yuki, on experimental psychology. Alan T. Waterman, AAAS president, presided at the first session; Yoshida at the final session. The reports presented at the symposium will be published in full in the AAAS symposium series.

—LOUISE CAMPBELL, *AAAS*

References and Notes

1. Dr. Yoshida said his figure included "developmental and other research" and was based on a 1962 survey of science and technology by the Statistics Bureau of the Prime Minister's Office. The U.S. estimate for 1960 is from "Profiles of Manpower in Science and Technology," *National Science Foundation Publ. 63-23* (1963). The NSF estimate includes research in the social sciences but not in the humanities.
2. Data for 1961; value for the U.S. is from "Comprehensive Survey of Enrollment in Institutions of Higher Education, First Term, 1961–62," *U.S. Office of Education Publ.* (1962).
3. Data for 1961; value for the U.S. is an estimate from data in "Enrollment for Advanced Degrees, Fall 1961," *U.S. Office of Education Publ.* (1962).
4. C. M. Bungenberg DeJong, "Polyploidy in Animals," *Bibliograph. Genet.* **17**, No. 2, 1957.
5. H. Fukasawa, "Fertility restoration of cytoplasmic male-sterile Emmer wheats," *Wheat Inform. Serv.* **1958**, No. 7, 21 (1958).
6. Y. Morino *et al.*, *J. Chem. Phys.* **36**, 1050 (1962).
7. Y. Morino and E. Hirota, *Bull. Chem. Soc. Japan* **31**, 423 (1958).

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Page 776, Japanese calligraphy by Ryuji Takeuchi, Japan's Ambassador to the United States. Page 777, University of Tokyo and Library of Congress. Page 778, University of Tokyo. Page 779, left, by Kotaro Tanaka from *Paper Making in Japan*, Bunsho Jugahu; right, Sasebo Heavy Industries. Page 781, left, Oriental Institute; right, Alan Linn, *The Farm Quarterly*.

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