Science and Technology Policy for Bangladesh

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In a 2-part series the author — a noted scientist of the country — cites the lack of political will in the past to apply science for development and suggests effective implementation of the national science policy to better the quality of life of our people.

BANGLADESH is now at the crossroads of history in its transition to democracy. While everyone is eagerly awaiting a stable democratic government which can take policy decisions on issues that will determine the fate and way of life of the people, it has to be remembered that the stakes are high and responsibility, enormous. A small mistake or lack of effective measures can lead to far-reaching effects towards the establishment of a happy and prosperous country.

Bangladesh is one of the poorest countries of the world with more than 50% of the population living below the poverty line. Most people do not have enough to eat a balanced food a covered place to live and get any medical attention, not to speak of decent clothes and education. To them, democracy means not only freedom to speak but freedom from poverty. With what I would call the explosion of population, the production of food and other essential commodities are not catching up with the requirements and we are getting more and more dependent on foreign assistance. We thus need, on one hand, austerity and on the other, increased production and services. This needs formulation of a national policy and execution of a development plan which will lead to an accelerated increase of Gross Domestic Product (GDP) and improvement of the quality of life of our people. Failure to achieve this will result in countrywide anarchy and indiscipline and we shall just get poorer.

I am assuming that we are a free and sovereign country and thus shall not make any development plan which will permanently depend on foreign aid. No doubt, we shall need foreign assistance in the beginning, especially for finance and technology, but we shall have to build the infrastructure to achieve self-reliance, starting with some imported technology and developing appropriate technology ourselves.

This is where science comes into the scenario of development. The difference between the rich and poor nations is the fact that the former is developing science (means of understanding the natural environment) and technology (controlling and managing it) in order to discover natural resources and invent means to utilise them and improve their value by applying technology. Unfortunately science and technology developed faster for destructive purposes, especially in the twentieth century, but we, the late-comers in the use of science and technology, have the advantage of choosing the beneficial uses of the technologies already developed and engage in such scientific researches that help us to adopt the correct technology for our needs. Applied and goal-oriented research will automatically give rise to basic research.

I shall give one or two examples. Recently a new technique has been developed which could control pests in some crops. This nuclear method, using radiation, is called 'sterile made technique'. To apply such a method, prior to field research, one has to know the life-cycle and mating habits of the insects concerned, needing basic research. Development and invention of new materials to produce solar cells of higher efficiency that will enable us to make economic and wide application of solar PV-technology need fundamental research on properties of semi-conductors. And so on. It is however, very important to select areas of research so that it is in consonance with the principle of achieving technological self-reliance. Here, each country will follow its won policy, depending on requirements and optimum benefit.

In a recent study group meeting held in India between top scientists, industrialists and adminstrators (in which I was fortunate to be invited), the S&T policies of India and Korea were discussed. It was interesting to note that India was taking a longer time to develop some vital technologies for production because the country wanted to be self-reliant upto the level of the raw materials that are obtained naturally in the country so that they do not have to import any of them. Economic production needs larger output which is only possible for a country with a large internal market. Korea developed the same product, and faster, because they were willing to import some of the raw materials as well as the technology. They made up the larger import bill by exporting some of the products. It is, therefore, very important to draw the level of self-reliance to be achieved in technology. This depends on the need and circumstances of a particular country including the availability of the natural resources.

The concept of increased employment and low capital investment for production could be followed in our country in the beginning, especially for local consumption, but this policy should be replaced by methods for higher efficiency and quality of production and, in the meantime, the necessary technology has to be developed. Higher efficiency and quality does not necessarily mean lower employment, because increased and improved production leads to enhancement of the value of the product and a wider technological infrastructure which will create new job opportunities with higher skill.

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In the case of Bangladesh, it has to be remembered that we are a large country with a population of over 100 million, and we must have a long-term plan for technological self-reliance. Such a technology plan should be designed to meet the immediate requirements but gradually the level of technology and skill should be improved to match with the socio-economic plan and achieve ultimate freedom from foreign financial and technical assistance. The technology plan will be automatically tailored and expanded and the level of self-reliance will be determined by the ultimate capability of the country, at least upto a reasonable period of time (say one generation/20 years). In this connection, preference should be given to import-substitution than export-promotion (except in exceptional cases like garment industry), because such a policy would keep the products at home, thus meeting the needs of the people.

The determining factor in carving out a development programme for the country is the natural resources available. Bangladesh is rich in manpower and not so devoid of natural resources as is popularly believed. Production from renewable resources can be multiplied many times over with marginally improved technology and better production practices. As for the non-renewable ones, we must make optimum use of them and add their values with the input of technology and skill. I would like to give an example. The beach-sand at Cox's Bazar and adjoining coastal areas contain many heavy minerals including, amongst others, good quantity of "garnet". The garnet can be used as abrasives in the manufacturing of emery papers. If this is mixed with strong cement or stone, the resulting grinding wheel can be used for sharpening tools and other purposes. The value of garnet will then be increased.

Next, if the particles of garnet can be melted under heat and pressure to make stones or jewels, the price will be enhanced many times. Further addition of its value is possible with its use in making microchips and laser-like devises.

I would now like to give an answer to the adverse comments on the performance of our scientists and the large number of scientific research institutions that exist in the country. It is certainly not the fault of science, which has so been successfully applied to produce technology in other countries. The reason is not difficult to find. In spite of the fact that there is an excellent National Science and Technology Policy, last prepared in 1986, and the existence of a National Council for Science and Technology, there is lack of political will on the part of the Government to apply science for development. This is borne by the fact that the scientific institutions have been given no specific tasks to perform, except giving proper answers to audit queries in respect of non-scientific expenditure and other administrative issues. What is needed is to link their programmes with technology plans which, in turn, is related to national socio-economic development objectives. Funds to be allocated for such a purpose should be sufficient to conduct research and not just to cover the salary bills and transport cost.

According to the existing allocation, there is little left for research expenditure and thus it is an good as zero allocation with the added disadvantage of affecting the morale of the working scientists. Control of their expenditure has to be made with a different approach, but with accountability. Moreover, there is a big gap between research results and production which has to be filled up by necessary funds and linkages.

It is due to lack of moral support and incentive by the policy-makers that scientists of the country are frustrated. There is a large number of professional scientific bodies too, whose recommendations are only gathering dust in the administrative departments. The saying that "position makes a man perfect" is applicable to scientists also. If they are given a responsibility to help solve the problems of the country and are given assurance that their research results and recommendations will be properly followed up and a mechanism is set up to exchange experiences of scientists, entrepreneurs and administration, then the credibility gap between them will gradually disappear.

It is also important to involve scientists in policy issues, including export and import, and in the feasibility studies of nationally important projects. If scientists were involved in deciding whether to start the Jaipurhat Limestone Project or adopt a correct strategy for the exploration and use of natural gas, then the Government would have taken a different strategy. My own honest advice is that we should not wait for foreign aid to implement nationally important projects (to be identified jointly by professional persons, economists and administrators).

Just as 'Rome was not built in a day', it has to be remembered that science is not magic and a larger gestation period is required between scientific discovery and the development of technology or absorption of a new technology which has to be made appropriate for the country. This national scientists are given specific responsibilities and time, the investment is bound to bear fruit. This is the lesson of history, where nations following different political philosophies (e.g. Korea and China) progressed fast, mainly due to their long-term investments in science and technology. Bangladesh will be no exception.

In our struggle for democracy, let us not forget that the task of building a nation cannot be achieved by sentiment alone. The enormous gap in the standard of living of the rich and poor nations cannot be closed or narrowed without the input of technology in our production process and the required time can only be reduced by a massive use of high technology (e.g. bio-technology, electronics and computer science), which is by no means expensive, but whose fall-out effect in the field of local science and technology will be far-reaching.

Part II of this article on The Structural Framework for Implementation will appear on this page next week.

A Watched Atom Never Decays

THE GREEK philosopher Zeno of Elea is famous for demonstrating that motion is logically impossible. He argued that a runner who wishes to reach a goal must first run from the starting point to the midpoint of the journey, then run from this point to the midpoint of the remaining distance, and so on, for ever. The runner will never reach the goal, said Zeno, because it is impossible to traverse an infinite number of intervals.

Of course, Zeno refuted his own logical deduction each time he went for a walk. Nevertheless, the paradox stimulated considerable philosophical discussion, and led eventually to a mathematical understanding of the process of infinite subdivision of a finite but continuous entity.

In quantum mechanics, the theory of the microscopic world, there is a paradox which is similar in spirit to Zeno's paradox. In 1977, B. Misra and George Sudarshan of the University of Texas showed theoretically that the decay of an unstable particle — for example, a radioactive nucleus — is suppressed by the act of observation. The more times it is observed, the greater is the suppression. When it is observed continuously, the decay simply does not happen.

This has a quite staggering implication : a radioactive nucleus that is watched constantly remains intact for ever, despite the fact that it is intrinsically unstable. It is this phenomenon of "a watched pot never boiling" that Misra and Sudershan call the quantum Zeno effect.

For the effect to occur, one technical condition must be satisfied. For a short internal of time after an unstable particle has been created, the probability of it decaying should increase with the square of its age. In practice, the condition is usually satisfied.

The interval of time is known as the Zeno time. If measurements of the particle are made within one Zeno time of each other, a phenomenon known as "the collapse of the wave function" ensures that the decay is suppressed.

The wave function in quantum theory is a mathematical entity that contains information about the dynamic behaviour of a particle. The Schrodinger equation determines how the wave function evolves in time. While the wave function is evolving, it contains within it all the possibilities of the particle's future; but the moment the particle is observed, it falls into one particular state. Physicists say that the wave function "collapses".

The quantum Zeno effect occurs in the following way. Initially, the wave function of an unstable particle is concentrated around the undecayed state. As time passes, however, the wave function spreads out into the decayed state. But each time a measurement is made, the wave function snaps back, or "collapses", into the undecayed state.

The quantum Zeno effect would seem to imply that an unstable particle in a bubble chamber will never decay, because the track it leaves behind signifies that it is being observed continuously. But physicists see unstable particles routinely when they inspect tracks made in bubble chambers.

In fact, there is no paradox. When physicists look more closely — on the atomic scale — they find that the track is not continuous, but broken up. This means that the observation of the unstable particle is not continuous at all, but intermittent. Although the gap between consecutive observations is small, it is longer than the Zeno time, which is exceedingly small.

The quantum Zeno effect remains wonderfully counterintuitive and defies belief. Recently, however, David Wineland and his colleagues at the National Institute of Standards and Technology, Boulder, Colorado, have performed an experiment that leaves no room for doubt. The experiment carried out by Wineland is a slight variant of an experiment proposed originally by Richard Cook of the US Air Force Academy, Colorado Springs.

The researchers studied the behaviour of ions of beryllium. They confined about 5000 ions in an apparatus known as an ion trap and applied a radio frequency, or RF, field. They chose the frequency and strength of the RF field carefully so that it would stimulate the ions to make a transition from their lowest energy state to a state at higher energy. In the field, the ions jumped back and forth between the two energy states once every 256 milliseconds.

Next, the physicists illuminated the beryllium ions with short pulses of light, each lasting 2.4 milliseconds. These were the "measurement" pulses. If a particular ion happened to be in the low energy state, a photon in the pulse would rapidly excite it to the high energy state. The beryllium ion would then immediately remit the photon in a random direction, a process known as scattering.

The light was scattered only by the ions which were in the low energy state, not by those that had been stimulated by the RF field to make transition to the high energy state. This meant that the intensity of scattered light indicated how many ions were still in the low energy state, having failed to make the transition.

Wineland and his colleagues applied trains of pulses, with each train lasting 256 milliseconds. Within each train, the pulses were equally spaced. The most pulses they used was 64. At the end of each internal of 256 milliseconds, they measured the scattered light intensity and hence the probability of finding the ions in the high energy state.

Wineland and his colleagues found that the probability of finding ions in the high energy state was 1 when they applied no measurement pulse during the interval. But the probability decreased rapidly as they increased the number of measurement pulses. This agreed well with theory. When the researchers applied 64 measurement pulses, they found that almost no ions went from the low energy to the high energy state. The transition was almost completely suppressed.

In view of these results, there is an obvious question : will it be possible to make our radioactive waste safe by monitoring each and every atom? The answer, unfortunately, seems to be, no. It will be a long time before someone invents an instrument which can monitor radioactive decays on timescales shorter than the exceedingly short Zeno time.

Wineland and his colleagues will be publishing the results of their experiment in the journal Physical Review A.

— Piyush Ojha.

A Bumper Crop of Biotech

Genetic engineering promises to transform agirculture

Imagine a cow that produces skim milk, a cabola seed rich in spermwhat oil or a naturally decaffeinated coffee bean. Such curios may sound like sciecne fiction, but they are real possibilities in the brave new world being created by the marriage of biotechnology and agriculture. In scores of experiments, scientists are changing the genetic endowments of plants and animals, and the results could spawn a revolution in farm fields, feedlots and dairy barns.

So far this year, the U.S. Department of Agriculture has approved nearly 100 test planting of crops that have been genetically altered to give them traits such as pest resistance and tolerance to weed killers. More ambitious projects are envisioned, among them adding protein to staples like corn and changing the type of oil produced by soybeans. Pigs that grow faster and leaner and cows that manufacture medicine in their mild are other goals. Observes Arnold Foudin, a biotechnology specialist at the USDA: "Ideas that a short while ago might have been dismissed as harebrained Buck Rogers are now being taken quite seriously."

It was only in 1983 that scientists inserted the first foreign genes into tobacco and petunias, the "white mice" of the plan world. In the years since, similar work has been done on about 50 species of fruits, vegetables and grains. Calgene, a biotech firm in Davis, Calif. has developed a tomato that does not rot as fast as normal varieties, and hopes to market the new product by 1993. Early this year Bio Technica International of Cambridge, Mass. announced the first genetic alternation of corn, the No. 1 crop in the U.S.

In the past, desirable properties were introduced into plants and animals though simple crossbreeding, but for the most part scientists merely reshuffled genes within a particular species. Corn could not be crossed with soybeans, nor cows with pigs. Now plants as diverse as tomatoes and cotton have been equipped with genes that scientists have borrowed from bactera. Shrimp may soon be given disease fighting genes taken from sea urchins. Evertually, crops and farm animals may be raised to produce not just food and clothing but also a wide array of chemical compounds and human proteins like issulin. While research on plants has taken the lead, work with farm animals does not lag far behind. Last year the Baylor College of Midicine and Houstan-based Granada Bio Sciences susseeded in transplanting growth-promoter genes into cattle embryos. Granada now boasts four health calves, at least one of which appears to be slightly larger than others the same age.

Industry enthusiasts say bioengineered animals and plants could become commercially available within the next five years. First however, they must pass muster with federal regulators. That may be tricky, given the concerns raised by some environmental and animal-rights groups. Protests have greeted the likely approval by the U.S Food and Drug Administration of biotechnology's first major agricultural product, a natural hormone called BST, which can be mass-produced in genetically altered bacteria. BST injections make cows about a possible oversupply of dairy products that could drive down prices. Moreover, some opponents question the safety of milk from cows with extra BST.

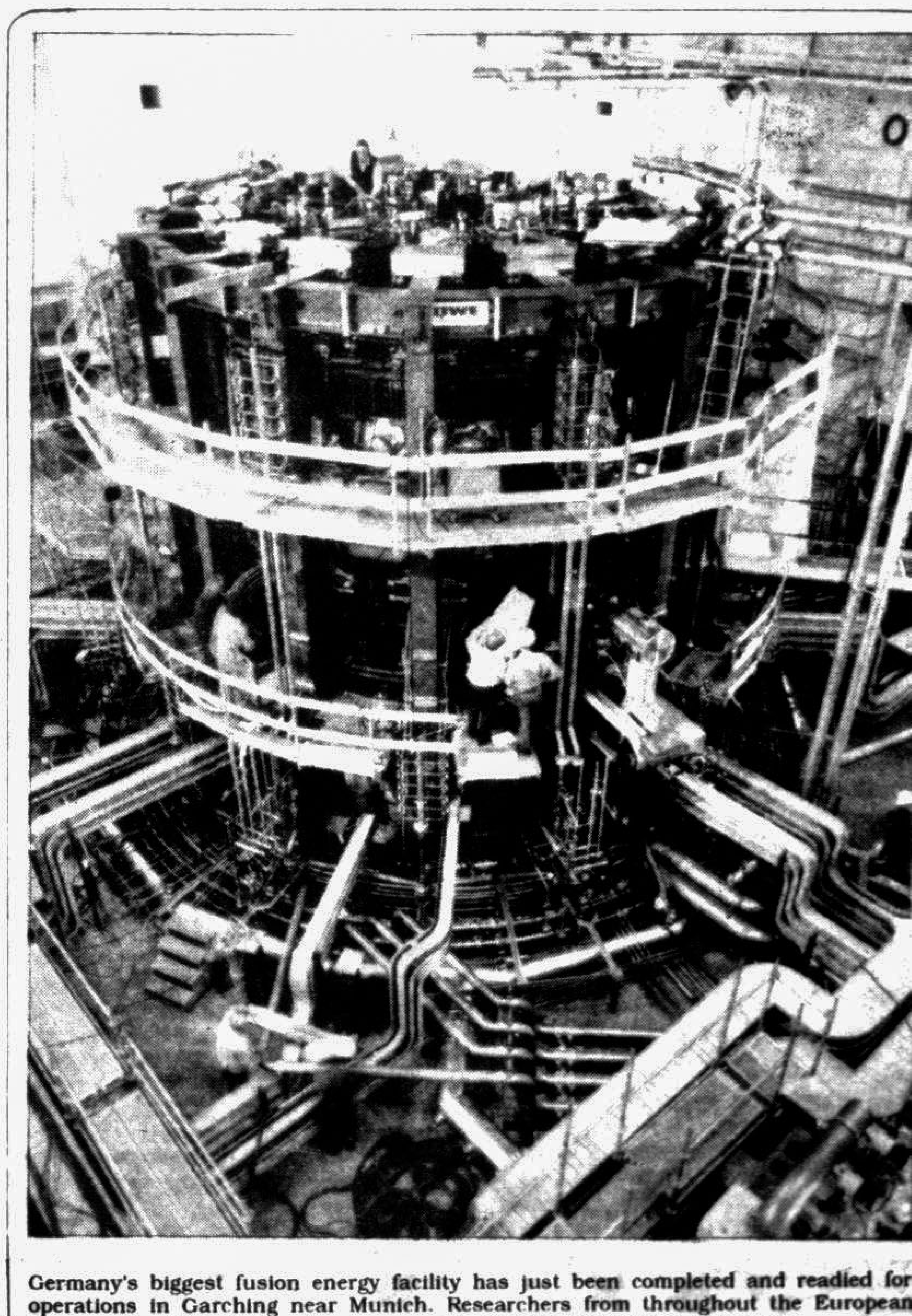
Even bioengineered plants are not immune to criticism, particularly those that have been designed to tolerate herbicides. Monsanto, for example, development strains of soybeans and cotton that grow well when sprayed with the company's Roundup herbicide. Such research may be intended to benefit society, but some enviromentalists see it as a cynical play for profits.

Only the most naive booster would argue that the bioengineering of farm animals and plants poses no risks. With plants, for instance, there is always the posibility that new traits could be accidentally transferred to wild relatives of domestic species. Theoretically, experiments with genes that confer resistance to disease or herbicides could create hardier weeds. Food safety is another legitimate oncern. Products from genetically altered crops and livestock will require rigorous testing to ensure that they are harmless.

On balance, however, bioengineering is likely to be more a benefit than a bane. In the case of cotton, which is heavily sprayed with chemical insecticides, the addition of a bacterial gene that poisons budworms and bollworms could help farmers and the environment alike. Similarly, the discovery that plants can be "vaccinated" against disease by equipping them with viral genes ought to reduce reliance on chemical insecticides. Currently, farmers battle such diseases by spraying the insects that carry them. Genetic engineering could also be used to give livestock more resistance to bacteria.

It is to the hungry Third World that biotechnology offers the greatest hope. Washington University plant pathologist Roger Beachy as working on introducing genes for disease resistance into casava, a critical food source for much of Africa. Scientists at the International Potato Center in Peru and the International Rice Research Institute in the Philippines are applying the tools of genetic engineering to improve the major crops of South America and Asia. Before the middle of the next century, experts warn, wrold population may reach 10 billion, and agriculture had better keep up. By that time the planet's crop and livestock growers will probably have new environmental challenges to meet, among them a changing climate and increasingly salty soils. Asserts Beachy: "Some argue that it is irresponsible to use biotechnology. To me it seems irresponsible not to use it."

— M.N.



Germany's biggest fusion energy facility has just been completed and readied for operations in Garching near Munich. Researchers from throughout the European Community will work here to advance understanding and fusion technology.

Transputer on a Single Chip

INMOS, the company that developed the transputer, the self-contained computer on a single chip of silicon, announced plans for its next generation of processor. These chips will be able to process information 10 times as fast as current transputers, and will have to satisfy the demands of the scientific applications of the next decade. They will also be the first major development to emerge since SG Thomson, the Franco-Italian microelectronics group, bought Inmos in April.

The transputer is now one of the most widely used processors in the scientific community, and was the first to offer parallel computing equivalent to the power of supercomputers, at a fraction of the cost. The first of the new series of transputer, code-named the H1, is a 32-bit processor capable of processing more than 100 million instructions per second. This will be ideal for numerically intensive scientific applications, such as simulation and modelling, since it will be able to carry out 20 million operations every second on decimal numbers to many significant places. It will carry on board its own large memory, and communicate with other chips at 10 times the speed of today's transputers.

The H1 will be the first transputer to be manufactured using a new processing technology which allows its components to sit just 1 micrometre apart on their silicon. Inmos's current transputers are manufactured using a technology which limits this distance to between 1-2 and 1-5 micrometres.

According to Peter Cavill, director of technology at Inmos, the new technology uses two layers of metal placed over the surface of the chip to act as communications links between the components that make tip the computer. Today's transputers use only the extra layer gives Inmos more flexibility in designing the geometry of the links between components, and allows the company to increase the density of transistors on the chip by up to four times.

Researchers 'n the scientific community will be pleased to hear that Inmos has also developed several software packages to ease the task of programming the transputer. The difficulty of writing software to run on parallel processors has been a long- standing bugbear among programmers. The latest software will enable programs written in conventional programming languages to run in parallel on transputers without the programmer having to rewrite them.Other new software should simplify the task of debugging programs on the transputer.

Inmos has also cut the price of all of its transputer chips, by between 40 and 70 per cent.

The lack of cheap, reliable processors has proved one of the most important barriers to running many processors in parallel to speed up computers,rather than using a single processor to carry out one operation after another. Pasquale Pistorio, president and chief executive of SGS Thomson, claims that the price cut should help to overcome this barrier, opening up parallel computing to a far wider audience.

Over the past few months Inmos has strengthened its links with academia, and has helped to set up research facilities at both Yale Universitv in the US and the University of Tokyo in Japan.

—S.W.