EVERYMAN'S SCIENCE

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COVER PHOTOGRAPHS

Past General Presidents of ISCA

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4. **Dr. H. N. Sethna (1977)**
5. **Dr. S. M. Sircar (1978)**
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EDITORIAL

MAS BIOTECHNOLOGY

While global cultivation of genetically modified (GM) crops reached 160 million hectares in 2011, consultations among stakeholders including scientists, regulators, NGOs and civil society are still on for wide-scale use of GM technology, in particular for food crops, in India[1, 2]. It is hoped that priorities would be set and measures to satisfy biosafety concerns undertaken *via* informed dialogue to help realize potential of GM technology for crop improvement and societal benefits. At the same time, biologists are engaged in generating powerful tools and rich genomic resources by using high throughput technologies for molecular knowledge-based breeding of crops. A combination of genome-wide sequence information and marker-assisted selection (MAS) has greatly enriched the basket of biotechnology with options for crop improvement[3, 4].

MAS in the present day context generally refers to the use of DNA markers associated with desired trait that show polymorphism in the intra-specific or sometimes inter-specific germplasm deployed to introgress or combine target trait(s) by sexual crossing. The need for MAS in plant breeding arises due to complexity of inherited trait, or expense and time required to undertake phenotype-based selection. Certain traits can be evaluated only at a particular developmental stage (e.g. late in life during reproductive phase) or in a specific, difficult to simulate, environmental condition. MAS hastens up backcross breeding by allowing rapid foreground and background selection and monitoring of even a recessive gene (allele) as early as seedling stage. It also allows pyramiding of multiple genes for the same trait like disease resistance.

The upsurge of activity in MAS biotechnology of crop plants is largely due to cost-effective Next Generation Sequencing (NGS) approach and high throughput genotyping. Such platform technologies have become part of plant breeding laboratories in many countries and are also being accessed by breeders through a Regional Platform Hub. As a result of >10,000 folds reduction in sequencing cost, projects on 135 plant species have already been undertaken. It should, however, be noted that only 3 genomes (*Arabidopsis*, rice, maize) have been completed and 27 assembled. The assembly and annotation of NGS data has thrown up a great challenge to informatics and anchoring the assembly to chromosomes requires arduous efforts of genetic mapping. A reference genome is ideal to study variation, which allows identification of markers like Simple Sequence Repeats (SSRs) or Single Nucleotide Polymorphisms (SNPs) by comparing resequenced genes/genomes of various genotypes. In particular, SNPs can be cost-effectively genotyped in a large number of individuals from a diversity panel or breeding population by using platforms like Golden Gate and Infinium assay or Sequenom Mass array. These, in turn, help construction of dense genetic maps, which are further useful to establish relationship to physical maps.

MAS is being widely used in breeding programmes today[5]. The retention of quality Basmati rice traits was ensured by marker-assisted background selection along with foreground selection for bacterial blight resistance, amylose content and fertility restorer genes in rice. Further, tightly linked markers could help break linkage drag in canola for low level of erucic acid as well as oil content. Once loci for useful traits are identified either by using mapping populations or diversity panels, their allelic variation within the germplasm of a species can be unraveled by high throughput genomics approach in combination with phenomics platforms or multi-location trials allowing accurate phenotyping in simulated environment or natural conditions, respectively. This could help design breeding of crops by marker-assisted selection for desirable combination of alleles in the crosses made. The need of prior knowledge of a marker associated with desired trait can be done away with in genomic selection approach. This requires genome-wide information on markers for each phenotypically assessed individual and development of a model to predict the value of phenotypic variations in relation to markers leading to assignment of a breeding value to the individual. These values when applied to a breeding population by using marker data alone can be used to predict phenotypic outcome and can help combine genes for minor effects as well. The assessment of the concept in maize has shown considerable acceleration of breeding cycle and genetic gain.

The MAS biotechnology allows to uncover and deploy hidden treasure in the germplasm for breeding superior genotypes. The advances in the concept in the last 25 years and its application to crop plants in recent years hold great promise in taking the benefits of agricultural biotechnology to the door steps of farmers on a mass scale. The immediate need for effective use of MAS biotechnology is to organize accessible genomic resource assistance centres for common plant breeders.

Akhilesh K. Tyagi

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"If a man's wit be wandering, let him study the mathematics."

— Francis Bacon

PRESIDENTIAL ADDRESS

SCIENCE AND INTEGRATED RURAL DEVELOPMENT

Dr. M. S. Swaminathan

This is the second time during the last five years that Members of the Science Congress Association have chosen an agricultural scientist as their General President. I regard this an an index of the importance attached to Agricultural Sciences by our scientist community. On behalf of scientists in agriculture I would like to assure the Members of our Association that we shall strive to prove worthy of this trust and honour.

Since our last meeting at Delhi in January 1975, we have lost one of our most distinguished Past Presidents, Prof. T. R. Seshadri. Prof. Seshadri worked in his laboratory till the last day and was the embodiment of all that is best in Science. It was in Andhra University that his scientific genius flowered. We deeply mourn his demise and pay homage to his memory.

I personally feel highly privileged to be the President of this Session for several reasons. First, the Andhra University, which has completed nearly 50 year's of distinguished service to education and Science, is hosting a Science Congress session for the first time. As an honorary alumnus of this University, I share the joy and pride of this occasion. Secondly, the State of Andhra Pradesh has been known for long for the skills of its farming community. Whether it be the cultivation of rice, sugar-cane, tobacco, chilli, mango or grapes or animal husbandry, the Andhra presant has proved to be an expert.

Thirdly, this is the first session of the Science Congress when, in addition to discipline-centred papers and symposia, there will be a cross-disciplinary examination of a topic of national relevance. The aim is to utilise the vast inter-disciplinary expertise present at the Congress for a deeper understanding of a specific national problem. "Science and integrated rural development" was chosen at our last session held at Delhi as the focal theme for this session. Scientists, both from our country and abroad, and our Sectional Presidents have taken much trouble to articulate their thoughts on what scientists can and shuld do to promote rural development and agrarian prosperity, and I am confident that we will have a useful discussion on the various facets of this theme. The exhibition has also been suitably restructured. For the first time we will have a Forum on Home Science and Nutrition and will give special attention to Fisheries. The major suggestions arising from our discussions will be summarised on the last day when the Deputy Chairman of the Planning Commission, who is also the Chairman of the National Comittee on Science and Technology, has kindly agreed to receive them personally.

Finally, we have the privilege once again of having our Prime Minister Shrimati Indira Gandhi with us at this opening session. By holding charge of the portfolios of the Departments of Science and Technology, Atomic Energy, Space Research and Electronics, in addition to serving as the President of the Council of Scientific & Industrial Research,

* General President, 63rd Indian Science Congress held during January, 1976 at Waltair.

you, Madam Prime Minister, have shown your firm commitment to the harnessing of Science for national development. To the concept of economic growth with social justice, you have also added the dimension of growth with ecological balance so as to harmonise the short-and long-term goals of development. On behalf of the scientific community. I thank you for your presence and for your clear policy direction for the promotion of a symbiotic interaction between Science and society.

The various initiatives taken by our Central and State Govenment since 1947 have now placed our country in the third position in the world in Scientific and technical manpower. On the other hand, we were included at the World Food Congress held in Rome in 1974 among the "most seriously affected" (MSA) countries with regard to food, which is the first requisite in the hierarchical needs of man. Why do we fine this mismatch between our position in the world of Science and the quality of the lives of a majority of our people.

It seems to me that a basic deficiency of our developmental system is our inability to emulate our genes, in each one doing his or her specific task properly and well and everyone working together in a coordinated manner. Let me elaborate this further. I wonder how many of us realise that the total weight of the chemical substance of heredity, de-oxyribose nucleic acid (DNA), for our entire population is only about 4.2 mgs, if we add up the weights of DNA present in the single cell embryo of each individual from which we grow. By the same method of calculation the present population of *Homo sapiens* would have a DNA content of about 28 mgs. In these 28 mgs of DNA, the specifications for the heritable characteristics of our entire species are inscirbed. How has the genetic system combined economy with such remarkable efficiency and precision ?

Genes have three essential properties. Each gene has a specific function; each is capable of replication or making exact copies of itself; and each is capable of mutation or heritable change. The function of a gene is regulated both in terms of its particular location on a chromosome and also in terms of a particular time sequence in development. During the reproductive phase, genes are able to combine in different ways and this process of recombination followed by segregation generates wide variability. Thus, in practice, except for identical twins, no two individuals are exactly similar. Mutation, or heritable change, adds to the capacity to respond to changing selection pressures.

Another remarkable property of genes is the system of vertical and horizontal coordination to which they subject themselves. Thus, each gene performs its specific function and is able to replicate itself, to change and to work cooperatively and sometimes competitively with other genes. Integration of vertical and horizontal coordiation has invested the heredity system with precision and power. If only everyone of us was aware of the way in which our own bodies function and applied the lessons learnt from it in our daily life, we might be more successful in achieving what individually and collectively we wish to accomplish.

What is it that we want to accomplish? In my view, the most important task is to draw the greatest benefit from our existing human resource and to limit its further unplanned growth. Past experience suggests that human resource cannot be effectively used by traditional approaches to "creating jobs", which often tend to degenerate into doles. What is needed is the growth of employment policies from an overall strategy of resources utilization designed to convert sunlight, soil, water, mineral, plant, animal and other resources into wealth meaningful to people. Instead of devoting undue attention to the brains to other countries, we should pay serious attention to the utilization of brains within the country. The starting point is obviously the village, which is where both, untapped assets and native brains exist. This is why the Science Congress has chosen integrated rural development as its first focal theme.

Eighty per cent of our population now live in rural areas. Some experts have calculated that this percentage will be 71 in 2000 A.D. Even if the percentage goes down, the rural population is expected to grow in number from 441 million in 1971 to 662 million by 2000 A.D. Of the existing rural population, nearly 50 per cent is believed to suffer from poverty. Rapid rural development based on the scientific utilization of all our resources, both natural and human, is therefore a must.

It is worth noting that countries which have gone too far on the road of urbanization are now repenting this choice. Rapid urbanisation has generated a steep rise in the consumption of non-renewable forms of energy. For example, the transport needs of large cities have grown so vast that the number of motor vehicles in the world increased by 120 million during the 1960s, generating problems of atmospheric pollution and human temper. There is today a marked movement back to the countryside, but with the integration of some of the basic benefits of urban life with rural living. A planned re-clustering of jobs, services and amenities more widely throughout the country in accordance potential and socio-economic needs of each area will facilities this movement.

RURAL-URBAN RELATIONSHIP

Gandhiji stressed that only a marriage between intellect and labour could lead to rural regeneration. Education, in the past, particularly at the university level, unfortunately tender to promote the concept that rural jobs which were mostly related to agriculture, required only brawn and not brain. The exodus of the educated caused neglect of the hinterland. Yet we now know that unless life in a rural community is made tolerable for all, the problem of poverty can not only be solved but will get worse. Therefore, a national policy of scientific rural-urban development as an integrated package is essential.

So far we have generally to pay only lip service to the cause of rural development. People living in cities talk about the freshness and beauty of nature but would not like to go and enjoy them even after retirement. Similarly, public policies have tended to promote an interest in urban living. For example, today if a scientist or a public servant moves from a Class "A" City to a smaller place, he loses in his total emoluments. It is only in the case of the Defence Services that the principle of serving all parts of the country has been developed with appropriate provisions for non-family posting. Recently, the Indian Council of Agricultural Research has introduced the concept of compulsory service for a specific period in a tribal or neglected area by all members of the Agricultural Research Service. Compulsion alone cannot yield the desired results. What is important is to incorporate in personnel policies, appropriate provision for the education of children and for medical facilities to enable qualified scientists and technologists to work in areas where these facilities do not yet exist.

RURAL ASSETS AND LIABILITIES

An important task for this year's Science Congress is to review our rural assets and liabilities and the present state of the art of harnessing Science to improve rural economy and living. On the basis of such a review, central broad guidelines are to be developed for using the tools of Science to enhance the assets of rural life.

Though our assets are well-known, it is worth repeating them because they are so impressive. First, we have the second largest human population in the world, most of whom are young. Although a considerable proportion of the adult population is classifed as illiterate in the formal sense, they have shown a great capacity to absorb, adapt and benefit from modern technology. There are abundant recent examples to justify this statement. The doubling of wheat production within a span of five years, the progress made in improving rice and wheat production in areas where they were unimportant before the spread of maize, formerly regarded as a *kharif* crop, in the *rabi* season along the Indo-Gangetic Plains, the spurt in long staple cotton production, the availability of apples everywhere in the country, the progress in the production of potato, tapioca and other tubers, the development of low-cost ground water exploitation technology like bamboo tubewells, the spread of Gobar gas plants and the growing diversification of export products from the rural sector are all indices of rural capability. Striking changes are visible in several parts of our country in farming systems and animal husbandry is beginning to get more efficient. Our farmers have thus shown their readiness to adopt new technology provided it is economically viable and low risk in character and if appropriate packages of services and public policies help to ensure a reasonable return for their labour and investment.

Our animal wealth is also vast. We have over 16 per cent of the world's cattle population. 45 per cent of the buffalo population, over 69 million goats representing the largest population in the world, over 43 million sheep occupying the sixth position in the world, and rich populations of poultry and inland and coastal fisheries. We are also endowed with excellent wild life resources. Our soils are by and large robust and productive, although in some areas lack of care has led to considerable erosion and the development of salinity, alkalinity and other problems. Shifting cultivation is still the major source of living for nearly two million people in the north-eastern Himalayan region. The method of handling the soil was developed hundreds of years ago as the only then available answer to the law of the diminishing return from the soil. There is however no place for it now.

Our water resources are vast and varied, and the National Commission on Agriculture has calculated that the area under irrigation can almost be doubled during the next 25 years from the present 42 million hectares. In the gross sown area of about 164 million hectares, regions with high (1150 mm and above), medium (750 to 1150 mm) and low (less than 750 mm) rainfall occur in almost equal proportion. Thus, over 45 per cent of the net sown area in the country has a reasonably assured water supply. Even in the arid zone of Rajasthan there is fortunately a good underground water reserve. The water quality is by and large good, although there are areas where the groundwater is saline. An integrated strategy for the utilization of ground and surface water and for harvesting all rain water in each ecological and topographic area will help to transform our agriculture and rural economy.

The high priority accorded to irrigation, command area development and ground-water exploitation in the Fifth Plan and in the 20-point economic programme should help to make our

Table-1 : Estimated yield potential and percent achieved in four rice-growing countries*

Country	Approximate duration of effective grain-filling period (days)	Average sunlight (Cal. $cm^{-2}day^{-1}$)	Estimated yield potential *(t/ha)*	Average yield** *(t/ha)*
Spain	35	500	17.9	6.27
Australia	35	600	21.1	6.25
Japan	35	350	12.1	6.02
India *(Karif)*	25	300	7.3	1.85
(Andhra Pradesh)				
(Rabi)	25	500	13.4	2.20

* Efficiency for solar energy utilization is assumed to be 2.5%.

** FAO Production Yearbook 1973.

agriculture self-reliant and provide considerable resilience in crop planning. If we consider only light duration (energy), water availability and temperature, which are three of the major factors regulating crop production potential, the period of maximum insolation in the tropics and sub-tropics unfortunately coincides with low availability of water and high temperature. The latter would lead to high evapo-traspiration and consequently greater demand for water. In the absence of irrigation, water becomes the chief limiting factor in crop productivity. Thus, the period of potential maximum yield unfortunately becomes in reality a period of minimum productivity. In contrast, in the temperate zone the period of maximum day length fortunately coincides with periods of precipitation and temperatures conducive to growth (see table-1). The high and stable yields obtained with irrigation during *boro* and summer seasons in our country with several crops have fortunately focussed attention on this problem.

Our plant resources are vast and we have nearly 20,000 plant species, a greater number than in countries with a much larger geographical area. This is yet another index of the varied agro-climatic conditions prevalent in our country which offer scope for a wide range of plant species to thrive.

Thus, if one draws an agricultural balance-sheet purely in quantitative terms, our assets are great. It is an irony therefore that we should still find it difficult to provide for the basic minimal needs of our population and that we should face problems of unemployment and underemployment both in rural and in urban areas. Since I consider the population-food supply equation and the population-employment equation equally important and interdependent, I would like to dwell briefly on certain scientific aspects of these two equations.

FOOD REQUIREMENTS

According to the estimates of the National Commission on Agriculture our population by 1981 may be about 668 million. The total food needs for the present population and estimated population of 945 million by 2000 A.D. are about 122 and 220 million tonnes respectively. The major nutrition problem of our country is inadequacy of calories in the diet of the economically handicapped. Under-nutrition, in turn, has been attributed in many instances not so much to lack of food in the market as to lack of purchasing power in the hands of the urban and rural poor. Therefore, the food problem in many areas needs to be stated not just in terms of a certain quantity of foodgrains alone but also in terms of certain person-years of jobs which would provide the wherewithal to buy food.

If we separate the problem of increasing food production from the ability of the market to absorb it at remunerative prices we will find that there should be no difficulty in producing the food we need. In several countries of Asia, an increase or decrease in food production by a margin of about 5% may make all the difference between an uncomfortable glut and acute scarcity. Consequently, price fluctuations tend to be high, thus making it difficult for poor farmers to decide how much to invest in inputs. Some form of crop insurance will help, but this presents many operational difficulties. Ideally, there should be a global solution to this problem. The World Food Congress had recommended the establishment of an International Food Security system through a nationally or regionally held but internationally financed grain reserve of about 80 million tonnes. If implemented, this will provide a mechanism for channeling adequate external resources for the purchase of home-grown food. Both an uneconomic depression in prices and considerable loss of surplus produce in poor home storage structures can be prevented in this way.

IMPROVEMENT IN PRODUCTIVITY

Ultimately, the only real mechanism for achieving improved standards of living is increased productivity both in farms and factories. In the area of crop productivity, we occupy an unenviable position in the world.

The National Commission on Agriculture has calculated that even by 1985 the above average yield of rice and wheat in our country would be only of the order of 1.6 and 2.1 tonnes per hectare respectively. The position with regard to jowar, pulses and oilseeds is even worse. For these crops, the National Commission feels that the average yields in 1985 will range only between 8 and 9 quintals per hectare. We have only to compare this with the average yields of rice of 5 to 6 tonnes per hectare prevalent even now in countries with small holdings like Japan and Taiwan to see the large gap between what seems to be possible and what we are able to accomplish. Unless we take speedy action to identify the major constraints to productivity in each cropping pattern and remove them, ours will be a very inefficient farming system. Further, there is a positive correlation between productivity and stability of yield — the higher the average yield, the greater is the stability.

In my view, the keys to achieving a comfortable position on the food front in our country in the near future are rice and *jowar* (sorghum), which occupy over 50 million hectares. I would hence like to refer briefly to some institutional arrangements which will have to be made to achieve a higher growth rate in productivity in these crops.

The following are some of the serious problems affecting rice production during the south-west monsoon period.

1. Inability of farmers to raise nurseries and transplant at the optimum time.
2. Lack of availability or application of improved technology for direct-seeded and upland rice.
3. Difficulties in efficient water management, resulting either in too much or too little water.
4. Inability to control pests effectively and in time.
5. Poor fertilizer use efficiency.
6. Poor post-harvest technology.

HOW CAN WE TACKLE SUCH PROBLEMS ?

In several of our rice-growing areas and more particularly in the tribal areas, a farmer spends over two months in preparing rice seedlings for transplanting. He collects cowdung and other organic refuse and often burns this material in the place intended for raising seedlings. He uses a thick seed rate and thereby gets thin seedlings. As a result, he plants a bunch of weak seedlings together and places them rather deep in the puddle. Such practices need to be almost reversed if the yield potential of the new strains is to be realised. Community nurseries provide an institutional solution to this problem. The timely supply of healthy seedlings to farmers enables not only transplanting at the optimum time but also correct varietal choice, according to the particular situation of the farm in the village and the supply of nutrients like phosphorus and zinc at the seedling stage.

Scientific water and pest management would also need community endeavour. The new plant varieties form a dense crop canopy. This kind of crop canopy also promotes the greater incidence of some pests which were not important before, such as the brown plant hopper, which has played havoc with rice production in Indonesia and also in some parts of our country like Kerala. It would be difficult for each small holder to undertake the necessary tasks himself, even if he has the requisite will. According to the National Sample Survey, farm holdings below one hectare increased from 19.9 million in 1961 to 26.1 million in 1971. In fact, the Agricultural Census of 1971 estimates that holdings below one hectare are 35.7 million. Whatever be the correct figure, the trend is towards an increase of small holdings, which is in accord with the national policy. It would be necessary to match the national policy on size of holdings with appropriate institutional arrangements for helping small farmers not only to overcome their economic handicaps but also the biological handicaps beyond the control of an individual farmer. Devices like farmers' service societies, small and marginal farmers' agencies and more recently rural banks have been set up to tackle the economic and input supply aspects of this problem. However, in my view, unless we approach the problem in its totality, it will be difficult to achieve substantial jumps in productivity which are otherwise well within our reach purely on scientific and ecological considerations. This is particularly urgent since the technology of the future will be increasingly based on recycling principles and integrated approaches which will demand collective action by farmers in a village or watershed for efficient adoption.

As in rice, there is immense scope in jowar, a major food crop of un-irrigated areas, for improving yield and production. Our average yield today is only about 500 kgs per hectare, while in many countries where *jowar* is grown for feeding cattle and pigs, the average yield is about ten times higher. A breakthrough in rainfed agriculture can be expected only by planning for large quantum jumps rather than for slow and graded annual targets which are within striking distance of environmental fluctuations. The predominantly black soil belt of *jowar*, as in Madhya Pradesh, Maharashtra, and parts of Karnataka and Andhra Pradesh, usually grows tall varieties of 5 to 6 months' duration. By substituting such varieties with a 3-month hybrid or variety, assured yields can be expected even during years with sub-normal rains. However, if the rains are plentiful as happened during 1975, a ratoon crop of *jowar* can be taken up or alternatively a second-crop like safflower, sunflower or chickpea can be grown. It has been estimated that nearly 4 million hectares out of about 18 million hectares under *jowar* would provide opportunities for taking a double crop in years of normal rainfall, provided short-duration varieties and hybrids are grown. The establishment of single maturity *jowar* zones with regard to varietal distribution would help to minimise pests like midge.

Scientists should make, block by block, a detailed analysis of the factors impeding biological and industrial productivity. Even in a crop like sugar-cane, which is one of our great botanical assets, we find that our yields are low for a variety of reasons. The National Commission on Agriculture has calculated that even by 1985 the gur yield will only be 6 tonnes per hectare as against about 5 tonnes per hectare now. Sugar-cane is the most efficient natural quantum converter that we know today as a collector and storer of solar energy in a useful form. The efficiency of quantum conversion to sugar is about 0.25 per cent, which is very good for a field crop. Countries like Brazil where land is not a limiting factor are trying to exploit the botanical efficiency of sugar-cane, even to produce ethanol and thereby cut down the import of petroleum products. For example, it has been calculated that in the San Francisco River region of Brazil, where yields are high, only 1,50,000 hectares of sugar-cane will be needed to meet 10% of the annual gasolene requirements of Brazil. Why are we lagging behind in exploiting the yield potential of this wonderful crop ?

Some answers to this question have been provided by the district of Visakhapatnam, where our Congress is being held. The yields in this district were formerly poor. But by a correct varietal choice such as the variety Co. 997, and by extending the needed help to growers through cooperative societies which run all the sugar-cane factories in the district, there has been a steady increase in sugar production. Similar cooperative endeavour in the supply of disease-free planting material, scientific nursery and planting practices and pest management will have an immediate beneficial effect on sugar-cane yield in States like Uttar Pradesh and Bihar.

SCIENTIFIC DISCOVERY, PRODUCTION ADVANCE AND PROSPERITY IMPROVEMENT

In my view, a few basic steps are needed. If we want to convert the scientific breakthrough now taking place in most crops, farm animals and in inland and coastal aqua-culture into a production advance, and a production advance into improved prosperity for all sections of the rural community. First, all groups must accept the concept of productivity. For this purpose, minimum productivity targets will have to be fixed and a farmer who does not achieve the target continuously for a few years without valid reasons should stand every chance of losing his land. Minimum targets such as 3 tonnes per hectare per year from two crops on irrigated land and 1 tonne per hectare per year in areas with over 1000 mm rainfall are neither ambitious nor unrealistic if proper institutional arrangements are made for supporting farmers. Appropriate Agricultural Productivity Acts by our State Governments could provide the social compulsion for cooperative efforts in areas like soil and moisture conservation and pest control. As an ingredient of such legislation, consideration deserves to be given to minimum limits to operational land holdings, below which the holding should not be fragmented as a unit of management, whatever be the ownership pattern.

The second need is to match the obligations .of farmers under Agricultural Productivity Regulations with corresponding obligations on the part of State-Governments. For this purpose, the Gram Sabhas or Panchayats may have to be restructured in such a manner that every member of the Panchayat assumes specific responsibility to organise the social support necessary for the effective adoption of a technological innovation. Unless there is a link between those who move society and those who move Science and technology, it will be difficult to achieve the ends we desire. Every prospering experiment in our country in rural transformation owes its impact to a combination of these two factors.

Unlike in industry, no depreciation can be allowed on the basic assets of agriculture. The land-man ratio has already reached critical limits in several parts of our country. The history of agricultural advance of the past century has shown that in many countries productivity has continuously risen through scientific farming without any harm to the long-term production potential of the soil. As productivity increases, the area under a specific crop can go down and more land could become available for energy plantations and silvi-pastoral systems, which are essential for meeting rural fuel and feed needs. In a few states like Karnataka, there is evidence (that total production is going up in a few major crops side by side with a reduction in area. This trend should become national.

NEED FOR ACCELERATED RESEARCH

I have talked so far of the institutional and policy packages needed for increasing the feasibility and efficiency of adoption of new technology in our villages. Emphasis on this does not mean that all that needs to be done on the scientific front has been accomplished. On the contrary, every change produces several reactions, some favourable and some adverse. Scientific vigilance and vision will be needed to maximise the beneficial effects and minimise the negative consequences of new technology. I have already referred to the undesirable association between a "high-yield environment" for plants and a corresponding favorable atmosphere for pests. Unscientific multiple cropping and monoculture of the same genetic strain of a crop over large and contiguous areas compound the problems of pests, which are even otherwise serious in the tropics and sub-tropics. Not only annual crops but perennial crops like citrus, mango, coconut and sandal, are affected by serious disease problems which are still evading solution. Besides pest management I shall refer to a few more obvious areas where research work needs to be stepped up speedily.

Of the highest priority is more intensive work on the preparation of an integrated inventory of land, water, mineral and other natural resources, area by area, and the development of scientific land and water use plans. Such an inventory should indicate the steps needed to reclaim large areas now stricken by salinity, alkalinity and acidity, as well as to conserve water, soil fertility and germ plasm of plants and animals. A second area is more careful examination of weather in relation to crop and animal productivity. Fortunately, a close coordination has of late been developed between meteorologists and agricultural research and extension workers. Day-to-day decisions by farmers require the correct interpretation of short-range weather outlook. We have a good mass-media network and we can easily develop the capability to convey accurate and timely advice to farmers. Meanwhile, research on soil-crop-weather correlations, weather modification, hail dispersal and efficient forms of utilising dew should go on. A third area relates to the efficiency of conversion of cultural energy (i.e. all forms of energy introduced by man after he domesticated plants and animals) into digestible energy. The most important components of cultural energy are implements and farm power, water and nutrients, particularly fertilizer. In the technology developed so far in the affluent countries, the ratio of conversion of cultural energy into digestible energy became less coincident with an increase in productivity. For example, David Pimental and co-workers in a recent article in "Science" (Vol. 190, 754-761) point out that by the use of U.S. agricultural technology to feed a world population of 4 billion a high-protein calorie diet for one year would require the equivalent of 5000 billion litres of fuel. If petroleum were the only source of energy for food production and if we used all petroleum resources solely to produce food, the estimated reserve of 66053 billion litres would last a mere 13 years. The challenge therefore lies in developing techniques which will help to improve productivity continuously without a concurrent loss in the efficiency of conversion of cultural energy. This will need a stepping up of research on tillage, water use, integrated nutrient supply and recycling of recoverable sources of energy. Also, this needs support from well-defined public policies. For example, the conservation and use of all organic wastes would need the introduction of a rural supply policy based on a combination of steps such as raising energy plantations, organisation of community bio-gas plants, supply of coal or lignite at subsidised prices and supply of electricity and other forms of energy at reasonable rates.

Fourthly, as mentioned already, research relating to the control of the menace posed to crops through the triple alliance of pests, disease and weeds must be stepped up. It is obvious that for the foreseeable future chemical pesticides will continue to be used. For applying them with due care caution, surveillance and early warning systems need to be developed more extensively which will facilitate the timely application of the minimum quantity of pesticide needed. Simultaneously, work on genetic resistance through screening at "hot-spot" locations and through collaboration with International Agricultural Research (Centres needs to be stepped up. Diverse genes for resistance will have to be indentified since biotypes occur in many serious pathogens and insect pests, leading to the breakdown of host resistance.

Fifthly, all aspects of production physiology aiming at the improved utilization of solar energy and reduction of photo-respiratory losses by genetic or chemical means will have to receive greater attention. Sixthly, the whole area of biological nitrogen fixation both by symbiotic and non-symbiotic mechanisms requires more attention. Nitrogen Fixation Research and Development Centres might well be established at State level jointly by Agricultural Universities and State Departments of Agriculture. Here, collections of nitrogen-fixing micro-organisms, both symbiotic and free-living, could be maintained. Such Centres could distribute pure cultures of recommended strains for further multiplication and also administer quality control programmes. Since considerable basic work involving sophisticated instruments is also needed, the establishment of a National Nitrogen Fixation Research Centre supported by all the major scientific agencies might be desirable. Seventhly, we need more work on fertilizer technology in order to prevent the loss of fertilizer taking place during the *kharif* season through leaching. Some work has been done on reducing losses through blending nitrogenous fertilizers like urea with neem and other cakes and by using shellac-coated urea and sulphur-coated urea. What we need is a low-cost method involving locally available material which could simultaneously help us to reduce leaching losses and provide the needed micro-nutrients. Fertilizer technologists should concentrate on local problems and local solutions. Fertilizer is the most effective as well as most expensive input, and our requirement will grow not only for crop production, but also for animal and fish production. A national grid of small, medium and large fertilizer plants and compost units and an expanded soil testing service will hence be needed for sustaining agricultural advance. Since data on the fertilizer needed for specific yield targets are becoming available for major crops, fertilizer could be used as an effective trigger in any national policy of stabilising food production.

Eighthly, all aspects of forestry research, including the development of quick-yielding fuel and pulp trees such as annual strains of bamboo, need more intensive attention.

Finally, increasing the production of domestic animals, poultry and fish by breeding, reduction of infertility, better nutrition and health care requires much closer study. The exploitation of hybrid vigour in cattle and fish deserves more attention. Disease problems of new genetic strains of cattle and sheep, and the harnessing of non-conventional sources of feed, particularly call for more scientific work. Recent research on fish culture in both inland and coastal waters has opened up new vistas of production. This will have to be supported by vastly expanded research on fish diseases and nutrition.

As for the future, genetic engineering involving the transfer of genes from one species to another is being increasingly regarded as a potential tool for achieving recombination of favourable genes. Basic research in this area requires expensive facilities. A recent symposium on basic research as relevant to agriculture, organised by the Indian National Science Academy, has stressed the advisability of creating such facilities.

A serious lacuna in our present research and developmental efforts is the inadequate attention to problems of post-harvest technology. An uneven match between production and post-harvest technology has resulted from our relative neglect of the latter. Even in areas where rice is cultivated with improved varieties and fertilizer, the harvested crop has to be dried most times by small farmers on paved roads. The high moisture content of grains at the time of harvest and inadequate drying prior to storage, particularly during the *kharif* season, are resulting in increasing problems of food toxins. Studies by scientists of the Central Food Technological Research Institute at the Gurupur village in coastal Karnataka revealed a heavy fungal growth and high levels of aflatoxin in rice consumed by the population. Hepatitis outbreaks due to toxins in food have been reported by scientists of the National Institute of Nutrition (Proceedings of the Nutrition Society of India, No. 12, 1975) Thus, appropriate post-harvest technology is essential—both for the farmer to get the maximum return for his labour and investment and the consumer to get food of good quality.

POPULATION GROWTH AND OPPORTUNITIES FOR GAINFUL EMPLOYMENT

The next area to which I wish to refer is the population-employment equation, which, in my view, will assume even greater importance in the coming years than the population-food supply equation. The obvious first step is a vast intensification of our research and developmental efforts in the area of population stabilisation. Recently opened areas of research, such as vaccination against fertility, male contraceptives and immunisation with specific placenta proteins, need to be extended full support. The cultivation of improved strains of plants containing certain steroids is now part of our strategy for reducing the cost of oral contraceptives.

The Bhagwati Committee had estimated that total employment opportunities of the order of 22.52 million man-years would have to be created in rural areas in 1969, if full-time employment was to be provided to all the available labour force. Other calculations have shown that at least 10 million man-years of employment need to be provided immediately in the rural areas. If we measure unemployment by the criterion of productivity per person-day, the figure becomes very high, as several economists have pointed out. Ultimately, it is only productivity per person-day that can provide the basis for true prosperity. Thus, rural employment, productivity and prosperity are all interdependent. Nutrition, in turn, is related to this triangle.

The National Commission on Agriculture has calculated that to generate full employment, at least 30 per cent of the rural labour force may have to be employed in the non-agricultural rural sector, including processing, textiles and other village industries. The Commission has hence suggested both agricultural and non-agricultural programmes for generating the needed number of jobs. Rapid generation of non-agricultural, though agro-based, sources of employment is also essential if a minimum limit to operational holdings is to be introduced.

Among non-agricultural occupations in the rural sector, the development of infrastructure such as roads, housing, irrigation works, electrification and agro-service centres, has been important in the past. As agriculture advances, marketing, trade, processing, storage, distribution and transportation will demand more labour as has already been observed in north-west India where the rice-wheat rotation and mixed farming practices are making substantial progress. There has been much talk of the growth of village and small-scale industries and the planned allocation of labour-intensive industries to run areas, but in practice it has been difficult to make such projects viable. The non-availability of improved management and marketing techniques has rendered sustained advance difficult. Thus, wherever sericulture or honey production or any other such occupation makes progress in a village, marketing problems soon become overwhelming and farmers are unable to sustain their interest in the new vocation. There are, of course, outstanding exceptions to this trend and these are usually associated with either well-organised cooperatives or exceptional selfless individuals who command the respect of the rural society and are able to organise the entire production system efficiently. Considering the fact that about 75 million people may have to be employed in the non-agricultural sector during the next two decades, we need to pay urgent attention to the development of self-replicating models of rural growth. All the calculations mentioned by me take it for granted that children need not look for jobs and that they can be spared for schooling. Today, child and woman labour, much of it unpaid, constitutes a dominant component of the rural work force. While steps have been taken to ensure that women and men get equal wages, only economic progress can result in the child being freed for school.

Steps have been taken recently through the establishment of rural banks to channel more credit to rural areas. Similarly, rural agro-industrial complexes are being developed. In addition to the various pilot employment schemes of the Central Government, different State Governments have initiated programmes to meet the objective of full employments. Thus, Maharashtra is operating an Employment Guarantee Scheme and Gujarat a "Right to work" project. Other projects include the Labour-cum-Development Banks of Kerala, organisation of a Land Army in Karnataka and Mobilization of Labourers in the Rajasthan Canal Project area. The Small Farmers, Marginal Farmers and Agricultural Labourers Development Agencies aim to generate more opportunities for self-employment through a diversified farming structure. A weakness of some of these programmes is the lack of detailed scientific attention to resource use. Little benefit has generally been derived from the data available from different surveys including the recent rural engineering surveys. Scientists, technologists, educationists and rural communities have not been involved in an organised manner in such exercises. In the Maharashtra Employment Guarantee Scheme, a nutritional dimension has been incorporated and this process of integrating scientific approaches with human resource use needs to be fostered.

EDUCATION FOR RURAL DEVELOPMENT

The ultimate success in achieving balanced rural-urban growth will depend much upon the nature of our educational system and its integration with other developmental inputs. Different countries have approached this problem in different ways and case studies from 17 countries compiled recently for the World Bank by Manzoor Ahmed and P.H.Coombs indicate that the greatest success by any criteria has been achieved where there is a clear and overpowering national ideology and strong leadership committed to this ideology. Also, success has been assured where education, formal or non-formal, has been developed as an ingredient in a package where economic initiatives are central. Two other points emerge.

1. Women as a group have been almost universally neglected, and so too the landless, since most of the agriculture-based education programmes benefit only those with ability to farm land.
2. The danger of internal stratification developing between formal and non-formal education is very great. This could further strengthen undesirable urban-rural, elite-masses and educated-illiterate dichotomies.

Our country has been a leader in many areas of educational thought and endeavour. What are our assets? We have

1. a huge and by and large well-organised infrastructure of formal education which can be re-oriented to new needs and objectives;
2. a large reserve of educated manpower, especially at the high levels, though insufficient at the middle levels; and
3. well-developed mass media which can be geared to educational purposes.

Our major liability is that the imperial legacy has tended to withstand too well the encroachments of innovation.

When we became independent in 1947, it was generally assumed that quantitative expansion of the formal system of education at all levels, with suitable diversification, and qualitative improvement would be sufficient to take care of the needs of both economic development and social transformation. A radical change of consciousness is today evident for it is now recognised that the vast mass of human beings outside the formal system of education constitutes and will continue to constitute the majority of our citizens for a considerable time to come. As a result, non-formal education is now seen as the major task for the future. The new role for formal education in this larger context will be to underpin, support and contribute to the development of non-formal education in a variety of ways. The blend of both approaches will depend upon local needs.

Our attempts to equalise educational opportunities for children of all strata of society have also not been fully successful. While incentives like mid-day meals have been of some help, the main tool for equalisation has been the scholarship schemes. A drawback of these schemes is that the child who has dropped out is not considered, while selection by tests tend to leave out the very persons whom it should help. Unfortunately, culture-free tests to evaluate natural abilities by unconventional approaches in villages and urban slums are to be devised. We could enrich Science with unusual talent and skills with effective talent-scouting.

VOCATIONALISATION AS A RESPONSE TO UNEMPLOYMENT

The assumption behind vocational education has been that it will equip a person with certain technical knowledge and skills to enable him to makes a livelihood through a vocation. The absence of a close linkage between the available avenues of employment on the one hand and the training on the other has invalidated this approach. For example, though agriculture, forestry and fisheries account for the employment of over 80% of the labour force, the fewest number of vocational courses are available in these areas. There is a shortage of teachers who can effectively teach these subjects even if courses were offered, and there has been no serious effort to train teachers on a large scale in these skills. Agro-industries too have been neglected.

Another lacuna is training for self-employment. Very few courses are offered in the skills needed for self-employment on a small or medium scale at the middle levels of education. Only recently, the Indian Council of Agricultural Research has started establishing *Krishi Vigyan Kendras* which will cater to the needs of practising farmers and fishermen. Nearly all non-formal educational programmes for women undertaken by welfare agencies in the last twenty-five years have concentrated on teaching skills like sewing, embroidery and tailoring. Women tailors however are notoriously few. More recently, non-formal education programmes for women have emphasized home-based skills related to health, nutrition, child care and kitchen gardening. Schemes for training women in skills related to agriculture, forestry and fisheries are still few, despite the fact that 50% of the agricultural labour force are women, and 80% of all women in employment are engaged in the production and post-harvest aspects of agriculture.

EXPANSION OF HIGHER AND PROFESSIONAL EDUCATION

The pattern of higher education and professional training in the past, has evolved from colonial models on the assumption that quantitative expansion and high "quality" ("quality" being measured according to hypothetical "world" standards rather than in relation to national needs or objectives) would automatically take care of our scientific manpower needs. It is now recognized that the "brain drain" is in part an outcome of a mismatch between the type of specialised education offered and the types of employment available. In retrospect, it appears as though unconsciously we have trained our scientific manpower to meet the requirements of Western industry, Science, technology and society. That "content" is an important ingredient in "quality" is now being realized. The recent committee on the restructuring of medical education has made a breakthrough in the subject by beginning from the needs and goals of the country for medical care and analyzing the ingredients of a medical education suited to meet them. Similar exercises are needed in other areas. Agricultural education has generally tended to remain close to the field. Such nearness to field problems has a pay-off in research, as is evident from the fact that we are the first nation to cultivate hybrid cotton on a commercial scale, using labour-intensive technologies. Agricultural Universities which have not yet done so should develop experimental and demonstration farms which will inspire farmers and serve as windows into our agricultural future.

SOCIAL RESPONSIBILITY OF SCIENCE

Though lip service is often paid to the ideals of social commitment, our system of selection, training and evaluation of scientific personnel at all levels, or of the teaching profession, does not provide for it. For instance, selection and later promotion are mainly based on academic records and attainments and publication of papers. Job requirements rarely include such elements as participation in developmental activities. These could take a variety of forms, ranging from the writing of textbooks and preparation, of kits, toys, games and educational materials to participation in mass media programmes, demonstration and extension campaigns for the popularisation of Science, and work in teacher training and lower-level education and training programmes. Such elements could be built into the system if the relevant activities with "social" value that a scientist could legitimately engage in were spelt out.

SOME SIGNIFICANT INNOVATIONS IN EDUCATION

Lest the foregoing should give the impression that we are not trying to change, I would like to cite a few significant recent innovative approaches.

1. The recent introduction of compulsory work experience in schools, which has its roots in earlier aspirations expressed in Basic Education, has a great potential for making education more meaningful and relevant to life. For its proper handling, however, the active assistance of all scientific agencies in the country will be essential.
2. The introduction of 10 + 2 + 4 + 3 pattern has as its major objective the task of making secondary education terminal and reducing the rate of expansion of higher education. Earlier attempts in this direction have not met with success chiefly because of a lack of positive correlation between educational content and employment possibilities. Detailed planning will have to be done on this, if this scheme is also not to fail for the same reason. Until this gap is bridged, there may be some merit in linking education and employment in the same Ministry of Government.
3. The Farmers' Functional Literacy Project and similar schemes in adult education and their success in the last decade have indicated the tremendous potential for need-based and functional adult education.
4. The National Social Service for youth and the experimental mass programmes for youth, such as Youth Against Famine and Youth Against Dirt and Disease, are others with potential for increasing the contact of students with the realities of our rural life.

Some smaller programmes which are still in an experimental or pilot stage but which need to be watched carefully for their possible use as prototypes for change are:

1. The establishment of Nehru Yuvak Kendras in 100 districts to channelise the energies of rural youth.
2. The Bhumiadhar experiment in non-formal education carried out by the National Council of Educational Research and Training.
3. The Science Education Centre of the Bombay Municipal Corporation launched and supported by the Tata Institute of Fundamental Research and the Community Science Centre, Ahmedabad.
4. The programme for improvement of primary science education, primary curriculum

development and community participation in education being developed in certain areas with UNICEF/UNESCO support.

5. The establishment of Krishi Vigyan Kendras by the ICAR for imparting the latest technical skills to practicing farmers, fishermen, rural youth and women.

In the non-official or voluntary sector, some significant experiments have been made. They have many lessons to teach in regard to planning, supervision, methods and objectives, and a careful evaluation of such programmes would be rewarding. Often, such programmes tend to be linked inevitably with certain dedicated individuals and their fate also becomes linked with the face of those individuals. We should hence evolve an organised way of institutionalising such innovative procedures.

CRITERIA FOR A SUITABLE INFRASTRUCTURE TO RELATE SCIENCE AND EDUCATION TO RURAL DEVELOPMENT

Taking the existing institutional and educational patterns as given, I shall try to indicate the directions in which they need to move to become a force for the regeneration of our rural economy and life. A satisfactory system should

1. Enable the formal education system and all scientific laboratories to become instruments which can further the non-formal education of the masses. Ways can be found, but the first essential is that institutions accept the servicing of the non-formal sectors as one of their basic objectives.

2. Encouraging group effort and group development in contrast to the attempt to lift individuals from one level to another. Acharya Vinoba Bhave's concept of simultaneously fostering a spirit of cooperation and competition among students by making a "group of students compete with their own past" has to be translated into curricular and extra-curricular procedures.

3. Relate vocational education and training to the job requirements of the present and the future through intensive local studies.

4. Spell out the goals of professional education at all levels — from paraprofessional through middle level to high level specialists — in terms of the objectives and needs of our country.

5. Spell out the social responsibilities of scientists (in both research and education) and of academics in all disciplines in concrete terms of job requirements. People should be enabled to understand and fulfil their responsibilities to development through professional contributions and not merely by being associated in their leisure time with political, social welfare or educational organisations.

With these as guiding principles, let me now indicate briefly the necessary mechanism to get the system moving.

1. Every institution of higher education (including university departments, colleges, research and training institutions, junior colleges and schools) should incorporate some form of development activity into their regular teaching — learning programme. This could take the form of placements of students in projects as part of their field practical work, or as apprentices; involvement of the staff or the institution itself in "action or operational research" and other possible studies. Such participation should be a condition for the receipt of financial assistance from Government. I would like to stress that this involvement be not thought of merely in terms of "adopting a village", holiday work camps and other sporadic activities, or different forms of "Sunday social work" but be a part and parcel of the regular programme of work and be regularly budgeted for. As an example of what can be done, the ICAR had

submitted to Vice-Chancellors of our Universities a programme for student and faculty involvement in rodent and pest management, control of noxious weeds like "carrot grass", and tree planting. The response has so far not been encouraging, except from a few Agricultural Universities.

2. Projects taken up will have to be extremely localised in character so that in each case it would be possible to have some kind of coordination between the various agencies concerned.
3. Grant-giving agencies and Government departments funding scholarship schemes should introduce more group awards as recognition of contributions of inter-disciplinary groups to society in any walk of life, and group scholarships to enable institutions to strengthen themselves and provide better education and services to a whole community.
4. Academics and research organisations should start honouring those who have done good work under difficult circumstances, for example in tribal and neglected areas.
5. Curriculum planning at +2 level should incorporate a period of field work placement as an integral part of the course for both academic and non-academic streams. Several ways are possible including :
   (a) Employment for specific period in an appropriate development project in the area.
   (b) Survey or field study.
   (c) Apprenticeship in a working agency.

These may sound fairly small steps to be taken now. However, the task is enormous and requires intensive work in localised studies, planning, working out of details field surveys, coordination of a number of agencies, and learning new ways of working together. The involvement of students in the planning exercise is vital, as unless they are convinced of the utility of such an approach for their future, the attempts are unlikely to prove successful. Few of the steps that I am advocating, for instance, are new. They have been advocated many times before, separately and by many persons, including myself. Yet movements in this direction seem pitifully small in comparison to the magnitude of the effort needed.

Let us not multiply differences but seek common denominators for action. Formal and non-formal education are both essential and mesh with each other in real life. While writing this lecture, I asked myself how I learnt the principles I value most. The answer was clear — through informal education in childhood. My late father inspired by Gandhiji was then (in the early nineteen thirties) engaged in a battle against untouchability, which took different forms, including an agitation for opening the gates of Hindu temples to Harijans. He was also involved in collecting and burning foreign clothes since he was convinced that a swadeshi movement was essential for our economic well-being. Finally, he succeeded, through a combination of scientific technique and social action, in eradicating filariasis in a short time from a town which was then notorious for mosquitoes. These examples fostered in me an awareness of the injustice of irrational prejudices, the need for self-reliance and the pivotal role of community action in accomplishing great tasks in a way which no formal teaching could have done. The experience of everyone here with regard to "education" must be similar.

SPREADING THE INNOVATIVE PROCEDURES

All over our country, there are hundreds of little programmes pursuing innovative approaches. We are not short of ideas or the men to carry them out. But to transform these myriad efforts into part of an organized plan and to involve the entire academic community in this effort is the task I see before us now. It is a task of an order of magnitude which is probably unprecedented in the history of our education or scientific endeavour. Time is short. We may have.forestalled the prophets of doom who predicted a future of starvation for our country, but shall we be content to drag the spectacle of our misery into the next generation? How mucn longer shall we drift, making valiant uncoordinated individual efforts here and there to hold back disaster but seemingly unable to gear up the total organism to the challenge? This is the question to which the scientific community gathered here must address

We need to fully exploit our human ability to create rational patterns of collective activity. Such patterns will continue to be coloured by personalities, but the basic structure should lend itself to replication, like the DNA molecule. It is easy to state this principle but the pathways of achieving it are by no means within easy reach, since they encompass our entire working culture. Nevertheless, we should begin by applying ourselves to the question of the basic common requirements that would enable us to move in the right direction and evolving the appropriate legislation that would serve as a framework for action. Legislative measures for integrated rural and urban development designed to promote the symbiotic growth of the village and the city can take into consideration the following needs.

1. the setting up of scientific and administrative consortia for each block and town which can help to develop and implement ecologically sound rural works and urban growth programmes (in the scientific consortium, all scientific and technical institutions in the area as well as colleges and schools should be involved, and in the administrative consortium appropriate representatives of all rural community, industry and input supply agencies will have to be members);
2. minimum limits for land productivity and operational holdings for irrigated and un-irrigated land in each area to provide the social compulsion for cooperative endeavour and proper use of land;
3. reservation of specific industries, credit and energy for the rural sector;
4. an employment guarantee scheme as "an integral part of an overall resource utilisation strategy;
5. reservation of unproductive land for non-agricultural uses like brick-making, construction of buildings, etc. and banning the use of good soil for such purposes;
6. a rural drinking water and fuel supply policy;
7. a scientific plant-animal-man food-chain policy for each agro-ecological area based on long-term considerations of the fertilizers feed, water and land requirements of each production system;
8. soil and water conservation and tree plantation; and
9. an integrated formal and non-formal educational system involving participation by students and teachers in appropriate rural/ urban development programmes.

A beginning towards providing ecological guidelines for development has been made through the Water (Prevention and Control of Pollution) Act of 1974. Comprehensive legislation for integrated rural-urban development will be a continuation of this process. However, we should also guard against the tendency to feel that once a law has been enacted all that is necessary has done. Good administration and implementation of policies alone can make the legislation worthwhile.

KNOWLEDGE AND HUMILITY — BASIC EQUIPMENTS FOR RURAL SERVICE

Before the era of Science and technology and of population explosion, life was probably simpler, although often precarious. The following verse[1] for example, illustrates how farmers once felt totally independent of government :

From sunrise I work,
Till sunset when I retire;
I drink the water from the well
That I have dug;
I eat the food from the field
That I have tilled.
Kings and emperors,
What have they to do with me?

When the pressure of population on finite resources was not heavy, such individual autonomy was well within the realms of possibility. Nevertheless, under such a situation life was not free of trouble. For example, in the last two decades of the last century alone, the then British Government had to set up several Famine Commissions to go into serious problems of hunger and unemployment, although population pressure was not high at that time.

You, Madam Prime Minister, expressed this in a different way when a few years ago you said in reply to a critic who attributed recent agricultural progress solely to good monsoons, and I quote: "For a long time, God was working alone in our fields. Later, God and man combined together and did their best, but today God, man and Science have joined, and the results are there to see".

There are at present many areas in human life and endeavour which are beyond our comprehension and control. Darkness and light, unrelated to Science, alternate in our lives. This in my view, is a desirable state of affairs since it instils in us that humility which leads to understanding and enquiry and thereby to progress. Gandhiji described humility as a basic equipment for those who wished to serve the villages. Let us discuss various aspects of "Science and integrated rural development" with humility but with the awareness that humility must be followed by both enquiry and action. Our collective future depends upon how fast we act to bridge the gap between exception and the rule in all areas of development.

1. Quoted from Chi-wen Chang's "A Strategy for Agricultural and Rural Development in Asian Countries"-1974.

FLUORIDE TOXICITY

Neha Jaiswal, Chhavi Sharma, Pooja Suhalka, Piyu Sukhwal, Ayushi Jain and Maheep Bhatnagar*

Industrialization and change in life style have incorporated lot of unwanted chemicals, which shows toxicity and annihilate the normal functioning of biological molecules. Fluoride being one of them shows adverse effects on not only the calcarious tissue (skeletal and dental fluorosis) but also on almost all soft tissue including liver, brain, kidney, reproductive organs, endocrine glands etc. Day by day increasing level of this chemical in the food chain has increased the need to realize its noxious effects.

FLUORIDE GENERAL

Fluoride (F^-) the anion with oxidation state -1 is a reduced form of fluorine, a gas that never occurs in Free State. Fluoride is mainly found in the form of hydrogen fluoride (HF), sodium fluoride (NaF), fluorosilicic acid or hexafluorosilic acid (H_2SiF_6). To an estimate, 20% of pharmaceutical and nearly 30-40% agrochemicals are organo fluorines. Fluorosilicic acid, sodium hexafluorosilicate and sodium fluoride are used in municipal water fluoridation schemes. Although sodium fluoride is soluble in water, aluminium, calcium and magnesium fluorides are only sparingly so. Small amount of fluoride (< lppm) in diet helps preventing dental caries and strengthening of bones but at higher levels i.e. above permissible limit (l.5 ppm, by WHO), shows cumulative toxic effects. Prolonged ingestion of fluoridated water or consuming high fluoride (i.e. in excess of 10 mg/l) leads to dental fluorosis, skeletal fluorosis and non skeletal fluorosis. The dental fluorosis is characterized by dental mottling and loss of coloration of teeth, while skeletal deformation and rigidity in joints was observed in case of skeletal fluorosis. Fluoride also affects cells of soft tissues including renal, endolithial, gonadal and neural cells.

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FLUORIDE AND ITS SOURCES

Day by day the concentration of fluoride is increasing in our food chain. Previous studies indicate drinking water as main source of fluoride exposure in humans. Contamination from geological sources such as leaching from agriculture, industrial and the municipal solid waste polluted surface and ground water, raising the level of fluoride. Use of phosphate fertilizer and industrial waste from ceramic industries and burning of coal also contribute to high fluoride concentration. Adding to it, a pronounced percentage of fluoride enters in the body through canned foods, drinks processed with fluoridated water and some fluoride supplements using sprays and CFC in refrigerators and air conditioners[1].

FLUORIDE AND OXIDATIVE STRESS

Antioxidant treatment to the animal in case of fluoride intoxication was found to decrease its toxic effect, thus showing that the main mode of action of fluoride in body is by causing oxidative stress[2]. Due to electronegative nature of fluoride, it readily forms strong hydrogen bonds with OH^-

and NH^+ species and thus contributes in the induction of free radical generation hence increasing oxidative stress.

FATE OF FLUORIDE IN BODY

The dietary fluoride in gastrointestinal tract, due to its electronegative nature receives a negative charge and converts into ionic form. Such ingested fluoride is converted to hydrofluoric acid (HF) due to acidic conditions in stomach. As HF is easily absorbed this leads to GI irritation or corrosive effect on intestinal wall. The penetration of HF is much faster than dissociated fluoride ions. Also, fluoride seems to cross membrane by a F^-–H^+ co-transporter or F^-–OH^- exchangers in an inward-directed proton gradient. The overall absorption is reduced by calcium and certain other cations and by elevated plasma fluoride levels. When concentration of fluoride in stomach increases, the fluoride load is passed to the small intestine. From there it is passed over to the blood stream where it's level increases quickly within 20-60 minutes. From here fluoride gets distributed throughout the body, majorly in calcium rich areas such as bones and teeth.

Fluoride which is not absorbed is then excreted out of the body *via* faeces. Fluoride is concentrated at high levels within kidney tubules, so kidney has higher concentration of Fluoride than plasma. Fluoride is freely filtered through the glomerular capillaries and re-absorption takes place due to diffusion of HF. Among all the halogens, the renal clearance of fluoride is unusually high. Though the rate of renal clearance is low in children than adults.

FLUORIDE AND CALCARIOUS TISSUES

After absorption, blood fluoride gets distributed throughout the body, with maximum amount engrossed by calcarious tissues. Ingestion of fluoride causes decrease in ionized calcium. This lowering of calcium levels (hypocalcamia) leads to secondary hyperparthyroidism which activate membrane bound 3′5′ cAMP ultimately causing increase in osteoclast activity. This rise the level of citric acid and lactic acid from ruffled border of osteoclast causing increase in hydrogen ion concentration and lysis of lysosomes. Lysosomal lysis release hydrolase enzymes, causing depolymerisation of glycoprotein of bone and cartilages. Hydroxiproline is responsible for stablisation of collagen triple helix collapse due to this glycoprotein depolymerisation. As the protein polymer disintegrate and dissolves, the mineral binding capacity is also reduced and calcium is liberated. This event simultaneously leads to elevation of serum mucoprotein or polysaccharide levels. The net result of this degradation of ground substance in bones and other calcified tissues leads to symptoms of non skeletal fluorosis.

The absorption rate of fluoride by calcarious tissues is highest in children and this rate decreases with the increase in age. After a certain age (above 55 years) the rate of this fluoride intake by calcarious tissues impedes. Fluoride is difficult to retrive back, if integrated in hard tissues. It could be retrieved back by a very slow process of osteoclatic resorption that occurs over many years.

DENTAL FLUOROSIS

Long term exposure to fluoride causes mottling of teeth or enamel and presence of white chalky patches on teeth. In case of mild fluorosis teeth becomes yellow, brown or sometimes black. Excessive withholding of this enamel protein leads to porosity in teeth. Fluoride concentration above 2mg/l in drinking water cause dental fluorosis in 60% of the affected population, whereas concentration above 6mg/l affects 100% of the population[3].

SKELETAL FLUOROSIS

During high intake of fluoride, it bounds with the calcarious tissue and replaces hydroxyl and bicarbonate ions and accumulates there causing crippling of bones. Early signs of fluorosis are pain in joints and bones, ultimately leading to increased bone density (osteosclerosis) and rigidity of joints[4].

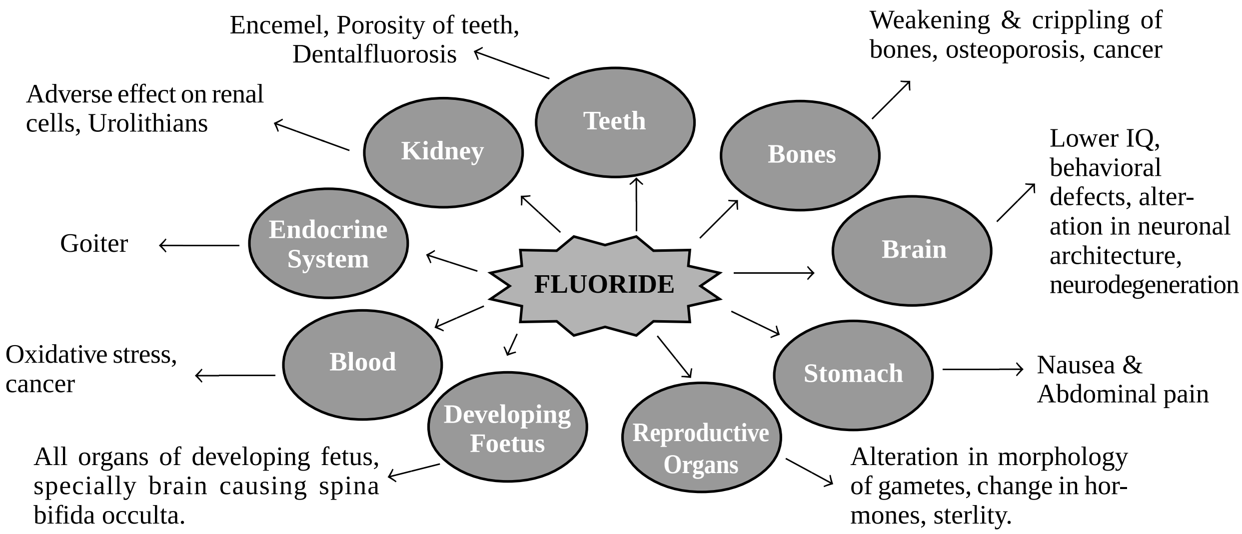
EFFECT OF FLUORIDE ON SOFT TISSUES

Large number of studies are published which shows that fluoride not only affects the calcarius tissues but also has adverse effect on soft tissues including liver, kidney, brain and reproductive organs[5-7] in both male and female organisms. In males' fluoride affect the mobility and morphology of sperms, and alteration in levels of certain hormones such as testosterones and follicle stimulating hormones, causing decreased birth rates. Fluoride is also found to affect the developing fetus. In pregnant mother's body fluoride easily passes through placenta and causes prenatal birth defects in offspring. Spina bifida occulta a developmental congenital disorder caused by the incomplete closing of the embryonic neural tube was found to be common in fluoride prone region. Fluoride also shows its adverse effect on renal cells. Studies conducted in regions where fluoride concentration was high showed increased rate of occurance of urolithiasis (kidney stones).

Similarly, studies on florotic patients also confirm neurotoxic effect in most of the cases as fluoride can easily cross blood brain barrier. Due to high electronegative nature, fluoride forms strong hydrogen bonds with –OH and –NH moieties causing oxidative stress that results in neurodegeneration[8]. Synergistic effects of fluoride with other metal toxic compounds such as aluminum, affect G-protein couple receptors and disturb second messenger system in brain. Studies revealed reduced learning and memory, reduced motor co-ordination, lower IQ levels and short term memory loss including behavioral symptoms like nervousness, depression, tingling sensations in fingers and toes, frequent urination, excessive thirst in the subjects suffering from fluorosis. With that long term intakes of high fluoride disturbs metabolic functions of brain, brain cell architecture[9], level of neurotransmitters[9], growth factors, enzymes and to a great extent affect the endogenous antioxidant level of brain[10] causing oxidative stress.

With this, acute fluoride poisoning also affects thalamic and hypothalamic area of brain thus affecting endocrine system of the body. A very good evidence is the presence of a large number of goiter patients in high fluoride areas. In chronic fluoride poisoning nausea, vomiting, diarrhoea and abdominal pain demonstrate adverse effects of fluoride on gastronitestinal tract. High fluoride is also responsible for causing cancer conditions rooting different types of cancer most, important being blood and bone cancer.

FLUORIDE AND HUMAN HEALTH



In conclusion we can say that high concentration of fluoride is hazardous for our teeth, bones, liver, stomach, kidney, brain and even to the developing fetus. Thus necessitating knowing more about this slow white poison for a safe and healthy life.

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NANOTECHNOLOGY FOR MEDICAL DIAGNOSIS, THERAPY AND PREVENTION

Sujata Jana[1] and Manjurul Haque[2]

Nanotechnology is a new and highly potential area of science. Principally it works by manipulating matter on anatomic and molecular scale. It deals with the development of nano-particles whose size varies from 1 to 100 nanometres. It has been observed that the applicability of nanotechnology in disease diagnosis, treatment and prevention has immense benefits. Nanomedicine ranges from the medical applications of nanomaterials, to nanoelectronic biosensors, and even possible future applications of molecular nanotechnology.

INTRODUCTION

Nanotechnology is a new area of science that involves working with materials and devices that are at the nanoscale level. That is, about 1/80,000 of the diameter of a human hair, or ten times the diameter of a hydrogen atom. It manipulates the chemical and physical properties of a substance at molecular level. Nanotechnology alters the way we think and blurs the boundaries between physics, chemistry and biology, the elimination of which will pose many challenges and new directions for the organisation of education and research.[1]

This technology is expected to create innovations and play a vital role in various biomedical applications not only in drug delivery and gene therapy, but also in molecular imaging, biomarkers and biosensors. Target-specific drug therapy and methods for early diagnosis of pathologies are the priority research areas where nanotechnology would play a prominent role. Nanotechnology is of great use for medical diagnosis and various nanoparticles have exhibited tremendous potential for detecting disease markers, precancerous cells, fragment of viruses and other indicators. Various metal coating and metal nanoparticles functionalized with different biomolecules had been found useful in detecting specific proteins, antibodies and other disease indicators.[2]

USE OF NANOTEHNOLOGY IN DISEASE DIAGNOSIS

Medical diagnoses with appropriate and effective delivery of pharmaceuticals are the medical areas where nanosize particles have found practical applications.

BIOASSAYS

Bioassays are used to detect the presence of disease. This can be either infectious disease (such as viruses or bacteria) or genetic disease (such as cancer).[3] The choice of biomolecule depends on the nature of the disease which could be a protein, DNA or RNA. All bioassays work by using the selective binding of one biological molecule to another. Through linking the biomolecule with a nanoparticle, bioassays have become more sensitive, easier to perform and able to detect more target biomolecules. Nanoparticles of different materials

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can be used, such as quantum dots (which are made from semiconductor materials) and can emit different colours of light depending on their size; gold which can be used in an electrical or colour chanding test; and even nanoparticles made up of layers of different materials which give a "barcode" effect and can be easily read using a microscope.

Scientists have used a biomolecule coated untra small paramagnetic iron oxide particles for detecting cancer cells. The particles are injected in blood stream and the presence of a specific antigen (target molecular marker) induced a specific signal that was detected by MRI (magnetic resonance imaging). With the technology scientists are hopeful in detecting cancer cells months or years earlier than the conventional diagnostic tools.[4]

MONITORING

Monitoring of a patient's health status is important not only for those recovering from operations and treatment, but also for the routine check-up of healthy individuals. Point-of-care (POC) devices or nanorobots offer an unprecedented degree of flexibility through the measurement of many different physiological factors such as blood pressure, blood chemistry (e.g. levels of sugars, hormones, antibodies in the blood), heart rate, and body temperature at the patient's location without the need to send samples off to the lab.

For more complicated tests, POC devices can incorporate Lab-On-A-Chip devices which allow tens or hundreds of different biomolecules to be measured rapidly[8]. By measuring quickly and at the patient's location, doctors avoid the risk of losing samples, waiting days for results to come back from the lab, and misdiagnosing due to samples being stored or treated incorrectly. In the future such devices may be linked wirelessly to a computer in the doctor's office, allowing patients to monitor themselves from the comfort of their own home and only attend the doctor if a change in treatment is required.

IMAGING

Medical imaging allows to observe the effects of disease and damage to the body, however in the past it has been limited to certain tissues (e.g. bone), with soft tissues in particular being very difficult to image.

Nanotechnology developments have allowed new imaging agents to be created which can efficiently "light-up" the desired tissues. These imaging agents consist of a targeting molecule, which can bind specifically to the diseased or damaged tissue (as described in the diagnostics section) and an imaging molecule, which can be detected by MRI, X-ray, ultrasound or any of a number of other imaging techniques in use in hospitals today.

USE OF NANOTECHNOLOGY FOR TREATMENT OF DISEASES

At present, treatment of illness tends to use quite old-fashioned, well-established methods. These methods are obviously not always entirely successful, with general solutions and treatments often being applied to very specific problems. Furthermore, current healthcare can often cause additional problems such as rejection or a bad reaction to a transplant. Nanotechnology can help to address some of these issues, in a number of ways.

PERSONALISED MEDICINE

Most treatments today rely on clinical data taken from "average" patients. However, the way individuals respond to different drugs can vary remarkably even to the point where an effective dose tolerated by one person could be completely ineffective or even toxic to another. In many cases this is due to the Cytochrome P450 (CYP450) family of proteins which are responsible for the metabolism of most drugs into active forms and /or forms that can be excreted from the body. The CYP450 family is not only large, but different people can express different members of the family and /or express the same members at different levels. Knowing this information is the first step towards delivering personalised medicine, where drug doses are tailored to the individual.

The sequencing of the human genome, identification of gene families (such as CYP450) and a greater understanding of the genetics behind disease and responses to drugs means that doctors are nearer to delivering personalised medicine. New diagnostic tools based on nanotechnology can rapidly and reliably analyse samples from a patient to determine the presence of specific genetic sequences which predispose them to disease or sensitivity to specific drugs, and also the levels and types of proteins that they are producing (such as CYP450 family members).

NEW DRUG DEVELOPMENT

Many potentially useful drugs are never developed because, they have side-effects or are too difficult to manufacture in a form that can be easily given to a patient. Nanotechnology can offer solutions to these problems by combining the active ingredient of the drug with stabilising molecules or by new processing technologies to produce the drug as a much finer powder. For example, companies such as Nanotherapeutics now manufacture asthma drugs and painkillers as nanoscale powders which are taken using an inhaler and are more quickly absorbed into the body than traditional methods. VivaGel is a an anti-HIV drug based on nanoscale particles called dendrimers.

Finally, new cancer treatments are being developed by MagForce Nanotechnologies. These are based on magnetic iron nanoparticles which can be made to heat up by altering an applied magnetic field, causing cancer cells, which are more temperature-sensitive than normal cells to die.

NEW MEANS OF DELIVERY

Making sure that a drug reaches the intended tissue or organ in a patient and is given at the correct dose is two of the most important issues in modern medicine. This is particularly important for cancer treatment, as most chemotherapy drugs are toxic to both normal and cancer cells. Nanotechnology offers solutions to these problems. For example, coating a drug in different molecules can make it more soluble in water (for easier application), allow it to penetrate cell membranes more easily or even target it to a specific tissue or organ.

In addition, new devices such as iMEDD incorporate nanoscale pores which, by varying their size and length, control the release of drugs such as insulin. Such devices can be implanted and allow continued release of a drug over the period of weeks, thus avoiding the need for regular injections. Example of drugs that use nanotechnology for improved delivery include ABRAXANE which is a nanoparticle formulation of the chemotherapy drug paclitaxel and the protein albumin, and is more effective and less toxic than the free form of the drug.

IMPLANTS

Implants can perform a number of different functions: from joint replacement, to stents which keep arteries open, to active implants such as cardiac pacemakers and cochlear implants (to restore hearing loss). In all cases such implants must interact closely with biological tissues. One of the key issues is encouraging the patient's cells to stick to the implant where required (e.g. for bone grafts) thus assisting in the repair of a damaged tissue, while in other cases ensuring that no cell or biological material sticks (such as the interior of arterial stents).

Over the last few years it has become clear that both chemical signals and physical characteristics of materials affect the ability of cells and biomiolecules to stick. For example, nanoscale bumps and grooves can increase cell adhesion, whereas completely smooth surfaces are very poor at allowing cells to stick. Decorating surfaces with similar molecules to those that are found in tissues also increases "stickiness". The applications are seen for example in titanium bone implants that have a coating of nanostructured titanium dioxide which improves integration in the bone, and diamond-like coating of stents and catheters which are smooth and have marked decrease adhesion of blood proteins and cells.

VACCINATIONS

Scientists from Japan's Osaka University have successfully carried out a study on the application of nanosphere and have reported that these can be used to deliver nasal vaccinations. The tetanus antigen has attached to the surface of nanosphere and it was introduced to the human immune system through the mucous membrane. The scientists reported a significant more pronounced results with the nanosphere containing tetanus antigen alone.

TISSUE ENGINEERING

Nanotechnology can help to reproduce or to repair damaged tissue. "Tissue engineering" makes use of artificially stimulated cell proliferation by using suitable nanomaterial-based scaffolds and growth factors. Tissue engineering might replace today's conventional treatments like organ transplants or artificial implants. Advanced forms of tissue engineering may lead to life extension. For patients with end-state organ failure, there may not be enough healthy cells for expansion and transplantation into the ECM (extracellular matrix). In this case, pluripotent stem cells are needed. One potential source for these cells is iPS (induced Pluripontent Stem cells); these are ordinary cells from the patient's own body that are reprogrammed into a pluripotent state, and have the advantage of avoiding rejection (and the potentially life-threatening complications associated with immunosuppressive treatments).

GROWTH OF NEW ORGANS

Nanoscale building of cells can be accomplished by their programmed replication. The signals are transmitted back and forth with the instruction for the desired size and shape form the construction site. When complete instructions are finished, the organs can be grown according to the prerequisite specifications. These organs could have the necessary DNA encoded to be compatible with the required human body immunological status. This can enhance integration of artificial structures with living tissues, presenting a more appropriate interface to biological systems. With the advantage in absence of immune reaction unlike today's donor organ transplantation. In the years to come this can accomplish a Quantum leap in the management of organ failure disorders.

USE OF NANOTECHNOLOGY FOR PREVENTION OF DISEASES

The majority of the medicine is reactive rather than preventative. In some cases this damage can be irreparable, in others permanent reminders remain (such as loss of function of that body part or scarring).Therefore, possibly the most important aspect of nanomedicine in the future will be its potential to prevent illness, rather than simply treating it. Nanotechnology will contribute to this through more effective monitoring of individuals' health (allowing diseases to be caught in their infancy) and more sterile hospital environments (limiting the opportunity for bacteria, viruses and other microbes to cause secondary disease).

FILTERS

One of the most important means of preventing disease is preventing exposure to pathogenic microbes. As well as providing sterile surfaces, this can take the form of filtration of air and liquids that a patient is exposed to during treatment. The trouble is that many viruses are smaller than the pores of these filters and so can penetrate them, making them useless.New filters have nanoscale pores that are able to remove even the smallest of viruses.[5] Inclusion of active materials, such as silver nanoparticles or titanium dioxide nanoparticles and UV light sources, can enhance this effect by killing the trapped viruses, bacteria and fungi. Such systems are already being employed in the fight against SARS, to prevent the spread of the virus from infected patients to medical staff.[6]

ANTIMICROBIAL COATINGS

Antimicrobial coatings can give major benefits in areas of healthcare, by helping to minimise the persistence and spread of microbes such as viruses, bacteria and fungi. Such coatings are seen as an addition to, and not a replacement for, the procedures in place for decontaminating and sterilising surgical equipment and operating theatre surfaces (such as disinfectants, autoclaving etc). Coatings can help minimise the ability of microbes to bind and start growing on surfaces that are exposed to patient body fluids during normal operating procedures. This can be achieved passively (through "non-stick" coatings) and actively through the inclusion of coatings such as silver and titanium dioxide nanoparticles that can kill microbes directly. Such coatings can also help minimise the accidental spread of disease from surface to surface to patient.[7]

The multidisciplinary field of nanotechnology's application for discovering new molecules and manipulating those available naturally could be dazzling in its potential to improve health care. The spin-offs of nanobiotechnology could be utilised across all the countries of the world.

In the future, we could imagine a world where medical nanodevices are routinely implanted or even injected into the bloodstream to monitor health and to automatically participate in the repair of systems that deviate from the normal pattern. However, nanotechnology in medicine faces enormous technical hurdles in those long delays and numerous failures are inevitable. Likewise, it should not be taken for granted the dangers and negative consequences of nanotechnology when applied in warfare, in the hands of terrorists.

However, it should be appreciated that nanotechnology is not in itself a single emerging scientific discipline but rather a meeting point of traditional sciences like chemistry, physics, biology and materials science to bring together the required collective knowledge and expertise required for the development of these novel technologies.

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KNOW THY INSTITUTIONS

THE INTERNATIONAL ADVANCED RESEARCH CENTRE FOR POWDER METALLURGY AND NEW MATERIALS (ARCI), HYDERABAD

The International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) is an autonomous R&D Centre of Government of India's Department of Science and Technology (DST) located in Hyderabad. ARCI has been setup with a mission to develop unique, novel and techno-commercially viable technologies in the area of advanced materials and subsequently transfer them to Indian industries. Though the seed, which later led to the genesis of ARCI, was sown way back in 1985-86, ARCI became a full-fledged, autonomous R&D Centre of DST only in 1997. During the past decade, ARCI has witnessed explosive growth and made rapid strides to establish itself as a premiere Centre of world repute for development, demonstration and transfer of materials related technologies.

THRUST AREAS

- Nanomaterials
- Enginered coatings
- Ceramic processing
- Laser materials processing
- Fuel cells

The most unique feature of ARCI's mandate relates to the fact that it is industry centric. In the interest of their eventual commercialization, ARCI demonstrates the technologies developed by it on a sufficiently large scale, not only to prove reliability/ consistency of the technology but also to carry out effective market sensitization. This also ensures that the subsequent transfer of technology to the industry has a greater chance of commercial success. ARCI's technology transfer efforts have already met with substantial success. It has, so far, transferred 17 technologies to 30 entrepreneurs throughout the country and these technologies currently find use in diverse industry segments.

Translating Research to Technology has been ARCI's motto and the Centre has set for itself the task of striving to bridge the gap between conventional research institutes & laboratories and the high-technology industries. Consistent with this overall goal, ARCI has primarily dedicated its efforts towards the following :

- Development of high performance materials and processes for niche markets.
- Demonstration of technologies at prototype or commercial-intent scales.
- Transfer of technologies to Indian industry.
- Establishment of jointly operated demonstration centres with foreign partners to showcase emergent technologies.

Based on the thrust areas of research and technology development, and the key support groups warranted, the following **Centres of Excellence** (CoEs) have been created at ARCI :

Centre for Nanomaterials was established to concentrate on the development of technologies for production of nanopowders and also explore their utilization for applications which cater to either a large Indian market or a market unique to India. The Centre has made substantial progress not only in establishing a vast array of synthesis, processing and characterization facilities, but also in application development in the areas of nanosilver for drinking water disinfection, nano-ZnO for electrical varistors, nano alumina-based cutting tool materials and nanotungsten carbide as non-noble catalyst in PEM fuel cell electrodes. New projects related to functional textile finishes, utilization of aerogels for thermal insulation applications, synthesis of inorganic fullerenes and establishment of pulse electrodeposition to make nanostructured coatings and catalysts have also been recently taken up.

Centre for Engineered Coatings–As far as the field of surface modification technologies are concerned, India has matured significantly in recent years. The conspicuous upward trend in the adoption of surface modification technologies by the Indian industry has also been catalysed by several initiatives taken by the Government of India's Department of Science & Technology (DST). ARCI scientists have played a prominent role in piloting these initiatives and the organization has consistently tried to identify coating technologies of national relevance and consciously pursue those that are unavailable elsewhere in the country.

Centre for Ceramic Processing is involved in the development of innovative processing techniques for technology oriented product development. Over the years, the Centre has been quite successful in the development and transfer of technologies in diverse field of advanced ceramics. Some of the major technologies include ceramic honeycombs for a variety of applications, low and high alumina Refractory Cements, Spinel Aggregates, Crucibles for Carbon and Sulphur Analysis and Furnace Coats and Sealants. Equipped with state of the art infra-structural facilities in combination with the expertise gained in advanced ceramic processing over the years and with dedicated manpower the centre is continuing its efforts in pursuit of indigenous technologies leading to globally competent products.

Centre for Laser Processing of Materials (CLPM) works towards development and promotion of application of laser-based solutions in the Indian industry through:

- Application oriented R&D towards demonstrating feasibility of laser processing route for specific industrial applications
- Research towards better scientific understanding of various processes
- Job works of specialized nature
- Consultancy

Centre for Non-Oxide Ceramics is engaged in the development of process technologies for various non-oxide ceramics. Advanced non-oxide ceramics constitute an emerging class of materials with considerable potential to address a very broad base of current and potential applications. These ceramics span an ever-growing list of material compositions, which include carbides, nitrides, borides and silicides. Among them, the most promising materials include silicon carbide, silicon nitride, aluminum nitride, titanium diboride, boron nitride and boron carbide. ARCI is vigorously pursuing R&D activities in the area of engineered non-oxide ceramics and its composites for a wide range of applications. The emphasis is on indigenous development of high value products for niche market applications through adoption of cost effective process routes. This Centre has successfully developed technologies for a range of products, such as reaction bonded and pressure-less sintered silicon carbide for mechanical seals and wear parts, titanium silicon carbide composites for wear resistance applications, and silicon nitride and SiAlON materials for diverse requirements demanding low dielectric constant properties. Large diameter CVD coated SiC parts are also being used for many applications due to their relatively low thermal expansion coefficient and excellent thermal conductivity. Since there is no facility available in the country for making large diameter CVD coated SiC parts, this Centre has taken the initiative to establish suitable infrastructure for this purpose. The Centre has initiated R&D activities on SiC based ceramic foams for various applications like high temperature insulations, molten metal and industrial hot gas filtration, catalyst substrates etc.

Centre for Fuel Cell Technology–Fuel Cell Technology has been the subject of enormous interest during the past two decades. Apart from their relevance in realizing the Hydrogen Economy, fuel cells are considered promising due to their high efficiency irrespective of the size of the System, Modular Nature, Simple Operation, Wide Range of Operating Temperatures and Flexibility in using various fuels with reformer or direct use etc. The fuel cell business is expected to grow substantially in the coming years and the projected spending on R & D and application development related to fuel cells is expected to reach US$ 18.9 billion in 2016 according to a report published recently. Although it will take time for fuel cells to penetrate markets now serviced by other power devices, the efforts accompanying the above investments are certain to take fuel cells closer to actual utilization.

Centre for Sol-Gel Coatings–Sol-Gel derived nanocomposite coatings can be tailored such that different functionalities can be incorporated into a single matrix, resulting in a multi-functional composite coating. Such coating technologies have a great scope in India because of their simplicity of deposition and their obvious utility. However, the Sol-Gel coating technology on a commercially relevant scale has not yet been available in the country for exploitation by the industry.

In realization of the above, a comprehensive facility to demonstrate the wide-ranging capabilities of this technology has been established by ARCI in collaboration with Engineered nanoProducts Germany Inc. (EPG), a management buyout company of the Institute for New Materials (INM) in Saarbrucken, Germany.

Centre for Carbon Materials–Carbon is always attractive material for researchers and technologists due to its exceptional inherent properties. Therefore worldwide efforts are going on to develop new materials and processes which shows better specific performance and can replace conventional materials. Carbon is a unique material which finds applications in various technological areas ranging from heavy industries (as electrodes in metallurgical furnaces) to automotive industries (Sports, Car and Aviations Brakes), biomedical to highly sophisticated nuclear reactor (moderator & first wall materials in nuclear reactor).

The up-coming class of materials launched initially by the discovery of the buckminister fullerenes and boosted by the discovery of the carbon nanotubes. In most of the areas of Research and development, be it nuclear or alternative source of energy (Fuel Cell, Primary Batteries), Defence, Space, Automobiles, Electronics etc. Carbon is known to play a dominant role. The Centre for Carbon Materials (erstwhile Graphite Section) was established to carry out research in the area of Carbon Materials.

Centre for Chemical and Structural Characterisation–Among the many testing and characterization equipment acquired by ARCI during the past decade, one of the more important facilities is the X-Ray Diffraction (XRD) system. ARCI procured a model PW 1840/01 XRD system with PW 1830/40 Compact tabletop 3 kW X-ray generator system from Philips, The Netherlands. This system has been used regularly for XRD investigations of materials that were developed at ARCI till around 2,000.

As ARCI's spectrum of activities gradually expanded to include new surface modification techniques, including laser surface treatment, the need for a more precise XRD method to quantitatively identify the presence of stable as well as metastable-phases was increasingly felt. Hence, it was decided to procure a more advanced XRD system, capable of suppressing the fluorescence radiation emitted from the substrate materials and reducing/averaging out the preferred orientation of grains in coated samples so as to quantify the phases observed in the pattern. A Bruker AXS make, D8 Advance model XRD system was installed at ARCI. The above XRD system, along with other facilities such as the Inductively Coupled Plasma-Atomic Emission Spectrometer (ICP-AES), X-ray Fluorescence Spectrometer (XRF), Electrochemical Corrosion Testing Equipment and Cyclic Corrosion Chamber, have enabled the Centre for Structural and Chemical Characterization to provide requisite support to various programmes taken up at ARCI.

Centre for Mechanical and Microstructural Characterization, along with the Centre for Chemical and Structural Characterization, provides state of art materials characterization facilities for ARCI internal and sponsored research activities, as well as to external users. The experimental facilities in the Centre are broadly divided into two areas, namely microscopy and mechanical testing. Electron, surface probe and optical microscopies are well represented in the Centre, with a stronger emphasis on electron microscopy. The recent addition of a 200 kV transmission electron microscope and a FIB-SEM has provided the extra-edge needed to characterize materials over a wide range of length scales from nano to macro

Centre for Technology Acquisition, Transfer and International Co-operation (CTATIC) plays a pivotal role in accelerating the process of transition of intellectual property from ARCI to the marketplace and continuously strives to expeditiously transfer commercially relevant technologies developed at ARCI to appropriately selected ventures. With growing emphasis on International Cooperation to co-develop technologies and establish jointly operated technology demonstration facilities at ARCI, CTATIC is entrusted the responsibility of coordinating these collaborative efforts.

- Centre for Automotive Energy Materials.
- Centre for Solar Energy Materials.

Over the years, ARCI has developed various state-of-the-art technologies employing varied approaches: (a) on its own (b) in collaboration with academic institutions/R&D laboratories within India or abroad or (c) through establishment of a strategic alliance with an industry. More recently, ARCI has initiated the concept of establishing jointly operated centres for demonstrating specific technologies of relevance to India in collaboration with hi-tech companies located elsewhere in the world, as a prelude to transfer of the technology to Indian Industry. In addition, ARCI has been undertaking numerous sponsored projects with a variety of government agencies to develop specific products and/or associated technologies, besides carrying out contract research for both foreign and Indian companies. ARCI has also been carrying out basic R & D in collaboration with renowned institutes/laboratories worldwide within its areas of core competence.

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Conferences / Meetings / Symposia / Seminars

4th International Conference on Stem Cells and Cancer (ICSCC-2013) : Proliferation, Differentiation and Apoptosis, 19–22 October 2013, Mumbai, Maharasthra

Organized by : International Centre for Stem Cells, Cancer and Biotechnology (ICSCCB), Pune, India

Topics :

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- Other stem cells
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- Proliferation, differentiation and apoptosis of stem cells
- Proliferation, differentiation and apoptosis of cancer cells
- Clinical research and trials in stem cells and cancer
- Hematopoietic malignancies
- Myeloid leukemias
- Lymphoid leukemias
- Breast cancer
- Oral, head and neck cancer
- Cervical cancer
- Lung cancer
- Other cancers
- Cancer genomics and proteomics
- Caner diagnostics and biomarkers
- Cancer therapeutics
- Immune systems in stem cells and cancer
- Nanotechnology applications in stem cells and cancer
- Ethical issues in stem cells and cancer research
- Molecular Biology of stem cells
- Molecular biology of cancer cells
- Molecular medicines for cancers
- Mathematical modeling and bioinformatics in stem cells and cancer
- Other topics related to stem cells and cancer

Contact : *Prof. Dr. Sheo Mohan Singh*, Director, International Center for Stem Cells, Cancer and Biotechnology (ICSCCB), A-304, Orange Province, Vishal Nagar, Pimple Nilakh, Pune – 411027, India Tel: +91-9545089202, Email: icscc2013@gmail.com, Website: http://www.icscc.in

Earth Sciences in India : Challenges and Emerging Trends, 7–9, November 2013, Roorkee

Organized by : Department of Earth Sciences

Deadline for abstracts/proposals : 15th July 2013

Contact : *Prof. Sandeep Singh*, Department of Earth Sciences, Indian Institute of Technology Roorkee, Roorkee - 247 667, Phone : 01332-285559, Fax : 01332-285638, E-mail : des.iitr@gmail.com
Website : http://www.iitr.ac.in/departments/ES/pages Activities+National_Conference_on_Earth_Sciences_in_India_Challenges_and_Emerging_Trends_ESICET.html

2nd International Conference on Industrial Engineering (ICIE-2013), 20–22nd November 2013, Surat, Gujarat

Organized by : S.V. National Institute of Technology

The international conference on Industrial Engineering is being organized to bring researchers and experts from academia and industry on a common platform to discuss the latest technologies and managerial tools in the field of Science & Technology.

Deadline for abstracts/proposals : 1st June 2013

Contact : *Dr. Ravi Kant* Website: http://www.icie2013.com

International Conference on Science, Technology and Management, 16–17th August 2013 Chittoor, Andhra Pradesh

Organized by: SITAMS & WAIRCO
Deadline for abstracts/proposals : 30th June 2013

Contact : Mr. Sarath , E-mail: info.icstmaug2013@gmail.com

Website : http://www.worldairco.org/ICSTM%20Aug%202013/ICSTM.html

S & T ACROSS THE WORLD

LARGEST-KNOWN SPIRAL GALAXY REVEALED

The spectacular barred spiral galaxy NGC 6872 has ranked among the biggest stellar systems for decades. Now a team of astronomers from the United States, Chile and Brazil has crowned it the largest-known spiral, based on archival data from NASA's Galaxy Evolution Explorer (GALEX) mission. GALEX has since been loaned to the California Institute of Technology in Pasadena, Calif.

Measuring tip-to-tip across its two outsized spiral arms, NGC 6872 spans more than 522,000 light-years, making it more than five times the size of our Milky Way galaxy.

This composite of the giant barred spiral galaxy NGC 6872 combines visible light images from the European Southern Observatory's Very Large Telescope with far-ultraviolet (1,528 angstroms) data from NASA's GALEX and 3.6-micron infrared data acquired by NASA's Spitzer Space Telescope. A previously unsuspected tidal dwarf galaxy candidate (circled) appears only in the ultraviolet, indicating the presence of many hot young stars. IC 4970, the small disk galaxy interacting with NGC 6872, is located above the spiral's central region. The spiral is 522,000 light-years across from the tip of one outstretched arm to the tip of the other, which makes it about 5 times the size of our home galaxy, the Milky Way. Images of lower resolution from the Digital Sky Survey were used to fill in marginal areas not covered by the other data. Credit: NASA's Goddard Space Flight Center/ESO/JPL-Caltech/DSS

"Without GALEX's ability to detect the ultraviolet light of the youngest, hottest stars, we would never have recognized the full extent of this intriguing system," said lead scientist Rafael Eufrasio, a research assistant at NASA's Goddard Space Flight Center in Greenbelt, Md., and a doctoral student at Catholic University of America in Washington. He presented the findings Thursday at the American Astronomical Society meeting in Long Beach, Calif.

The galaxy's unusual size and appearance stem from its interaction with a much smaller disk galaxy named IC 4970, which has only about one-fifth the mass of NGC 6872. The odd couple is located 212 million light-years from Earth in the southern constellation Pavo. Astronomers think large galaxies, including our own, grew through mergers and acquisitions — assembling over billions of years by absorbing numerous smaller systems.

Intriguingly, the gravitational interaction of NGC 6872 and IC 4970 may have done the opposite, spawning what may develop into a new small galaxy.

"The northeastern arm of NGC 6872 is the most disturbed and is rippling with star formation, but at its far end, visible only in the ultraviolet, is an object that appears to be a tidal dwarf galaxy similar to those seen in other interacting systems," said team member Duilia de Mello, a professor of astronomy at Catholic University.

The tidal dwarf candidate is brighter in the ultraviolet than other regions of the galaxy, a sign it bears a rich supply of hot young stars less than 200 million years old.

The researchers studied the galaxy across the spectrum using archival data from the European Southern Observatory's Very Large Telescope, the Two Micron All Sky Survey, and NASA's Spitzer Space Telescope, as well as GALEX.

By analyzing the distribution of energy by wavelength, the team uncovered a distinct pattern of stellar age along the galaxy's two prominent spiral arms. The youngest stars appear in the far end of the northwestern arm, within the tidal dwarf candidate, and stellar ages skew progressively older toward the galaxy's center.

The southwestern arm displays the same pattern, which is likely connected to waves of star formation triggered by the galactic encounter. A 2007 study by Cathy Horellou at Onsala Space Observatory in Sweden and Baerbel Koribalski of the Australia National Telescope Facility developed computer simulations of the collision that reproduced the overall appearance of the system as we see it today. According to the closest match, IC 4970 made its closest approach about 130 million years ago and followed a path that took it nearly along the plane of the spiral's disk in the same direction it rotates. The current study is consistent with this picture.

As in all barred spirals, NGC 6872 contains a stellar bar component that transitions between the spiral arms and the galaxy's central regions. Measuring about 26,000 light-years in radius, or about twice the average length found in nearby barred spirals, it is a bar that befits a giant galaxy.

The team found no sign of recent star formation along the bar, which indicates it formed at least a few billion years ago. Its aged stars provide a fossil record of the galaxy's stellar population before the encounter with IC 4970 stirred things up.

"Understanding the structure and dynamics of nearby interacting systems like this one brings us a step closer to placing these events into their proper cosmological context, paving the way to decoding what we find in younger, more distant systems," said team member and Goddard astrophysicist Eli Dwek.

The study also included Fernanda Urrutia-Viscarra and Claudia Mendes de Oliveira at the University of Sao Paulo in Brazil and Dimitri Gadotti at the European Southern Observatory in Santiago, Chile.

The GALEX mission is led by the California Institute of Technology in Pasadena, which is responsible for science operations and data analysis. NASA's Jet Propulsion Laboratory, also in Pasadena, manages the mission and built the science instrument. GALEX was developed under NASA's Explorers Program managed by NASA's Goddard Space Flight Center. In May 2012, In May 2012, NASA announced it was loaning GALEX to Caltech, which continues spacecraft operations and data management using private funds.

HEAT-RESISTANT CORALS PROVIDE CLUES TO CLIMATE CHANGE SURVIVAL

Some corals are tougher than others when it comes to standing up to the warming ocean temperatures brought on by climate change. Stanford researchers have found a genomic basis for this coral resilience, helping make it possible to save the toughest breeds as temperatures continue to rise.

In a future shaped by climate change, only the strong – or heat-resistant – will survive. A study published in the *Proceedings of the National Academy of Sciences*, January, 2013 opens a window into a genetic process that allows some corals to withstand unusually high temperatures and may hold a key to species survival for organisms around the world.

"If we can find populations most likely to resist climate change and map them, then we can protect them," said study co-author Stephen Palumbi, a senior fellow at the Stanford Woods Institute for the Environment and director of the Hopkins Marine Station. "It's of paramount importance because climate change is coming."

Coral reefs are crucial sources of fisheries, aquaculture and storm protection for about a billion people worldwide. These highly productive ecosystems are constructed by reef-building corals, but overfishing and pollution plus rising temperatures and acidity have destroyed half of the world's reef-building corals during the past 20 years. The onslaught of climate change makes it imperative to understand how corals respond to extreme temperatures and other environmental stresses.

Although researchers have observed that certain corals withstand stresses better than others, the molecular mechanisms behind this enhanced resilience remain unclear. For their study, Palumbi, Stanford postdoctoral scholar Daniel Barshis and other researchers looked at shallow-reef corals off Ofu Island in American Samoa to determine how they survive waters that often get hotter than 90 degrees Fahrenheit during summer-time low tides.

Utilizing cutting-edge DNA sequencing technology, the scientists examined the corals' gene expression when subjected to water temperatures up to 95 degrees. "These technologies are usually applied to human genome screens and medical diagnoses, but we're now able to apply them to the most pressing questions in coral biology, like which genes might help corals survive extreme heat," Barshis said.

Heat-resistant and heat-sensitive corals had a similar reaction to experimental heat: hundreds of genes "changed expression," turning on to reduce and repair damage. However, the heat-resistant corals showed an unexpected pattern: 60 heat stress genes were already turned on even before the experiment began. These genes are "frontloaded" in heat resistant corals – already turned on and ready to work even before the heat stress begins.

"It's like already having your driver's license and boarding pass out when you get close to the TSA screener at the airport, rather than starting to fumble through your wallet once you get to the front of the line," Palumbi said.

The findings show that DNA sequencing can offer broad insights into the differences that may allow some organisms to persist longer amid future changes to global climate. "We're going to put a lot of effort into protecting coral reefs, but what happens if we wake up in 30 years and all our efforts are in vain because those corals have succumbed to climate change?" Palumbi said.

As with strong corals, finding species most likely to endure climate change – "resilience mapping" – is the first step toward protecting them, Palumbi said. "The solutions that we're looking for must, at least partially, be out there in the world."

NUTRITIONAL SUPPLEMENT MAY HELP PREVENT ALZHEIMER

A nutritional supplement available over-the-counter may offer protection from Alzheimer's disease, a study by the University of Virginia (U.Va) and Northwestern University suggests.

Researchers at Northwestern and U.Va.'s School of Medicine set out to evaluate the effectiveness of chiro-inositol, a compound that occurs naturally in certain foods and is available as a nutritional supplement, in protecting the brain from beta amyloid toxins, which cause Alzheimer's. They conclude, in a paper published in *The FASEB Journal,* January 2013, that chiro-inositol "greatly enhances" insulin's ability to prevent damage to neurons by toxic peptides called ADDLs. The damage and loss of neurons is believed responsible for Alzheimer's.

The findings indicate potential for a new strategy for developing Alzheimer's disease treatments based on compounds already regarded as safe for human use, the researchers write.

"In Alzheimer's, it's been known for many years that the brain does not utilize glucose very well," U.Va. pharmacology professor emeritus Dr. Joseph Larner said. "Insulin is required to utilize glucose in the brain, just as it's required by muscle, liver and fat to stimulate glucose metabolism. What has not been realized until very recently is that this inability of the brain to utilize glucose is caused by insulin resistance. This insulin resistance in the brain has been referred to as type 3 diabetes."

Chiro-inositols essentially help overcome insulin resistance in the brain, the researchers believe. The study showed chiro-inositols greatly improved glucose use in primary cultures of neurons, significantly improving insulin's ability to prevent synapse damage when the cells were challenged with ADDL peptides.

"Chiro is a nutraceutical that we believe sensitizes your brain to the effects of insulin," said David Brautigan, U.Va. professor of microbiology, immunology and cancer biology. "This would presumably enhance insulin action and protect the brain from Alzheimer's."

"It's been shown that chiro-inositol is very safe," added Larner, a pioneer in the field of pharmacology. "It's been used in humans for quite a number of years now. I take it myself."

Encouraged by their findings, the researchers call for further investigation of chiro-inositols, including a clinical trial in humans and further development of drugs containing chiro-inositols. The research also opens new avenues to explore.

"There's been a big argument going on for years about whether insulin is made in the brain and how important insulin is in signaling in the brain. It was thought that glucose uptake in the brain was passive, not regulated by insulin," said U.Va.'s Michael Thorner, David C. Harrison Medical Teaching Professor of Internal Medicine. "It is now appreciated that insulin is in the brain and important for its metabolism. There may even be special forms of insulin in the brain to stimulate neurons and other cells."

The research team was led by William L. Klein of Northwestern University's Department of Neurobiology. The findings were published in a paper written by Klein and Jason Pitt, a student at Northwestern, in collaboration with Thorner, Brautigan and Larner.