From The Green Revolution to The Gene Revolution

by Indra K Vasil and Luis Herrera-Estrella

THE rapidly-growing world population and increasing demand for more and better food are certain to pose serious threats to social, political, economic and environmental stability early in the twentyfirst century. Without a decline in the current rates of growth, today's population of nearly 5.5 billion is projected to nearly double to 10.7 billion by the year 2030. Almost all of this growth will occur in the already overpopulated and impoverished countries of Africa, Asia and Latin America, which will be home to nine out of every ten human beings.

In this near future, additional land for growing food as well as for meeting all the other needs of the expanding population will have to be derived from the destruction of the already dwindling and endangered but precious protected natural areas. Undoubtedly, these changes will place unprecedented strain not only on the global, social, political and economic infrastructure, but will also cause further deterioration of the fragile environment of our already fully occupied planet. It is doubtful that world food production which is barely adequate to meet today's needs can keep pace with current rates of population growth. Indeed in the past few years its crop yields have

Rice seeds are sterilized before being sent to the International Rice Research Institute at Los Banos (Philippines).

generally levelled off or have actually declined in many of the developing countries.

What can be done to reverse or at least forestall these dangerous and suicidal trends? First and foremost it is necessary to bring down the rate of population growth to a sustainable level. In the interim, food production must be dramatically increased. Scientists expect that plant improvement through the use of biotechnology will be an important part of this process.

Plants in the human diet

Ninety-eight per cent of global food production is land-based. Of the total human diet, 92 per cent is derived from plants, with no more than thirty plant species accounting for most of the calories and protein intake. Cereal grains like wheat, rice and maize alone provide more than 53 per cent of the world food supply.

Historically, major technological advances in agriculture have been a driving force for economic growth, political stability and social and cultural development. In recent history, the most dramatic results of agricultural improvement were those of the Green Revolution, which was based on the introduction and adoption of high yielding and otherwise improved varieties of wheat and rice developed at the international agricultural centres in Mexico and the Philippines, in close co-operation with national agricultural programme.

The introduction of these varieties, particularly in Mexico, India, Pakistan, Bangladesh and China, in the mid-to-late 1960s helped not only to save millions from starvation and death but also to prevent widespread social and political unrest.

It was in recognition of this that the Nobel Peace Prize was awarded to Norman Borlaug, the American agronomist who developed varieties of "miracle" wheat in Mexico and played a seminal role in the introduction of such varieties in the developing countries of Asia and Latin America.

The benefits of the Green Revolution continue to be felt in the developing world. During the 1980s, agricultural production in China rose at an annual rate of 8 per cent, making it the largest producer of food in the world. In the developing countries as a whole, wheat and rice production increased by about 75 per cent in the fifteen years between 1965 and 1980. From 1950 to 1980, wheat production increased four-fold in Mexico, while rice production doubled in Indonesia. Similarly, wheat production in India increased three-fold in less than twenty years, from 1965 to 1983. The introduction of similar improved agricultural practices combined with high quality seed on a limited scale in parts of Africa, under the leadership of Norman Borlaug, has increased the yields of maize, sorghum and millet by 300 to 400 per cent.

Plant biotechnology has two important components, one based on the use of tissue culture methods, and the other involving a combination of cellular and molecular biology. Each offers powerful methods for plant production and improvement. Many of the procedures involved are simple and can be practised without substantial investment in facilities and infrastructure for the rapid mass production and multiplication of plants.

One of these technologies is clonal propagation or meristem culture, the process that occurs when shoot buds of plants are isolated and placed in culture in the presence of plant hormones so that many new shoot buds form. Such buds can be separated from each other and induced to form roots and complete plants. Rapid, large scale and economical clonal multiplication is of particular value for many forest and fruit trees, plantation crops, endangered species and medicinal plants.

As a rule, one shoot bud placed in a culture can be made to produce more than a million plants in one year. The rate of multiplication can be further improved — and the costs substantially reduced — by automation of much of the process. It is significant that all the plants produced from the initial shoot bud are identical to each other as well as the source material. This is of paramount importance where a selected and valuable variety is being multiplied and no genetic variation is desired.

The well-established and reliable methods of clonal propagation are simple and do not require elaborate and expensive laboratory facilities. They can be easily and profitably practised as a small-scale industry at the village level, not only to provide quality material for plantings but also as a source of employment and earnings. This technology is potentially most useful for reforestation of vast areas in Asia, Africa, Latin America and Eastern Europe.

Global reforestation using this method can greatly reduce the damaging effects of pollution and acid rain, the dangers of the greenhouse effect, soil erosion and flooding, while preserving precious natural sources of energy and providing a natural habitat for endangered flora and fauna.

Another important use of meristem culture is the elimination of viruses, which cause more than 50 per cent yield loss in many crops, especially those which are propagated vegetatively, such as potato, sugarcane, cassava and banana. Cells at the extreme tip of a shoot are generally devoid of virus particles. Plants obtained from the culture of very small shoot buds are, therefore, free of viruses, and provide maximum yields of quality material. This technology is well established and can be practised on a large or small scale as necessary.

The most powerful and useful methods of biotechnology are those that involve genetic transformation, the transfer of genes, at the level of DNA, from one species to another.

Cassava plants produced by cloning at the Institute of Tropical Agriculture, Ibadan (Nigeria).

Two main strategies have been used for this purpose. The first and most commonly used method is based on a natural system offered by the soil-borne micro-organism, Agrobacterium tumefaciens (crown gall bacterium); the second uses the direct physical delivery of DNA from one organism to another.

The crown gall bacterium contains a circular piece of DNA, called the Ti (tumour inducing) plasmid. During normal infection of a plant by the bacterium, a part of the plasmid called T-DNA (transfer DNA) is transferred to the host plant cell and becomes permanently integrated into its nuclear DNA. The T-DNA contains left and right border sequences which are necessary for its transfer to the plant cell. In between are genes that control the synthesis of certain plant growth regulators that cause the crown gall disease.

For directed plant transformation, the Ti-plasmid is disarmed by removing the genes responsible for tumour induction and replacing them with genes of interest. The useful genes are then transferred by the bacterium to the host plant cell during an infection process that does not result in the crown gall disease. Because of its simplicity and ease of use, this method has been used extensively since the production of the first transgenic plants (plants in which foreign genes have been transferred by genetic transformation) in 1983.

Unfortunately, for a variety of reasons that are still not clearly understood, the cereal grains such as wheat, rice and maize are not amenable to transformation by Agrobacterium. Fortunately, several methods of direct DNA delivery have been developed to produce transgenic cereals.

Currently, the molecular genetic improvement of plants is not limited so much by techniques for DNA transfer as by the relatively low number of agronomically [illegible] genes that have been identified, characterized and cloned at the molecular level. The best characterized and therefore most widely used are the genes that confer resistance to insect pests, to viruses and to broad spectrum herbicides. Such genes have been successfully transferred to crops like wheat, rice, maize, soybean, cotton, oil seed rape and tomato.

Major efforts initiated during the past few years to map the genomes of some important crop plants are expected to provide valuable information about the location and identity of other important genes — those that confer resistance to environmental stresses such as temperature, drought and salinity and those that control yield.

Saving plants from extinction

Thousands of wild plant varieties, which are valuable sources of useful genes, have either been lost forever or face imminent extinction as a result of the increasing destruction of natural forests for agricultural and urban use. Conservation of these irreplaceable resources for future generations and for the maintenance of biodiversity has thus become a global concern. In recognition of this, the Consultative Group on International Agricultural Research, which is responsible for the network of international agricultural centres around the world, has taken a step in the right direction by establishing the International Plant Genetic Resources Institute, with the mandate to conserve plant genetic resources.

Courtesy Unesco Courier

Green Eye in the Sky

by Senthil Ratnasabapathy

WHEN the authorities in the southern Indian state of Andra Pradesh evacuated 170,000 civilians just before a cyclone four years ago, it was owing to technology rather than luck.

Combining information supplied by telecommunications and meteorological satellites, Indian scientists were able to gather enough evidence to predict where the cyclone would strike. They saved thousands of lives by implementing a local disaster warning system.

Most people see satellites either as hi-tech and expensive spying tools used by governments or as the means by which they get their favourite Latin American telenovela even when they live halfway across the world.

But satellites are being used more and more to monitor the environment, enabling experts to anticipate disasters while at the same time monitoring the damage done by both natural and manmade causes.

"For many geophysicists, the prediction of natural disasters can now be seriously envisaged, obviously on a short term basis in the case of volcanic eruptions and, perhaps, also fairly rapidly in the case of earthquakes," said a report presented to the UN Committee on the Peaceful Uses of Outer Space (COPUOS) at its annual conference here recently.

But not all natural disasters are 'natural'. Deforestation, the increased use of pesticides and atmospheric pollution are all leading to changes in weather patterns.

From space, satellites are keeping records of the spread of such of damage, and providing experts with vital data.

For instance, there are now been many international, regional and national projects using satellite data to monitor forest destruction and then control it.

In fact, according to the Indian Space Research Organisation, most of those developing countries currently using space technology in one way or another have forest monitoring and managing as a top priority when using the gathered information.

Brazil's National Institute for Space Research (INPE), for example, last year launched a satellite to monitor the Amazon basin, the world's largest rain forest.

Meanwhile, India has been able to reduce the annual deforestation rate from two per cent to less than one per cent by combining satellite monitoring of deforestation [with] reforestation programmes.

According to the UN Food and Agriculture Organisation (FAO), about 150,000 square kilometres — an area larger than Greece — of tropical forest are destroyed every year.

India owes much of its satellite monitoring activities to several years devoted toward developed an advanced. These days, other developing countries are following its lead and are moving into satellite technology — a field that was once the domain of the industrialised nations.

In fact, the Indian Space Research Organisation says at least 18 countries in the Third World are using space technology for development purposes.

COPUOS, together with the Office for Outer Space Affairs, is trying to increase space technology cooperation between the North and South and within the South itself.

But the developing countries have a long way to go before being able to benefit from exploiting space.

Out of the 18 South countries that use space technology, many cannot build their own satellites. So far, only China and India are able to launch them. Some countries, Like Brazil, get other nations or organisations to launch their satellites while some use data provided by satellites belonging to other nations.

COPUOS holds many training courses for officials and scientists from Third World countries on the use of satellite technology. It also expects future technology would allow satellite data to be distributed in a form that developing countries could interpret and analyse using low-cost personal computers.

Development experts say satellites have become crucial as disasters seem to result in an ever increasing number of fatalities as years pass.

Per Oestermann of the European Space Agency (ESA) says the number of deaths due to natural disasters has increased from 20,000 per year in 1960 to more than 125,000 by 1080, while structural damage had reached US$100 billion by 1992.

Population growth and building density is also making urban regions more vulnerable to disasters than rural areas, expert point out.

"The growing volumes of image data being generated and sold should not be used as a measure of success of satellite remote sensing," says Marc Bied-Charreton head of FAO's Remote Sensing Centre.

He adds, "The ultimate criterion of its success will be the extent to which remote sensing will have contributed to the quality of life on our planet." — IPS

Industrial Revolution — A Social Revolution

Compiled by Naina, S Ahmad

INDUSTRIAL Revolution is a term used to describe the long series of technological, economic, social and cultural changes which took place between, very roughly, 1750-1850 and transformed Britain, and eventually rest of the world, from a fundamentally agrarian to a predominantly industrial society.

The industrial revolution began in England about 1750 and spread, first to France and Belgium, then to Germany and United State, and finally, by 1890, to Japan and to the rest of Europe. Today the effects of the industrial revolution can be seen everywhere in the world.

At the beginning of the period most goods were produced in homes or independent workshops by simple hand-tools or machines. At its end most goods were produced by power driven machines in great factories. Iron and steel had replaced wood for many purposes; steam power had replaced horse-power or human muscle power; coal had become the principle fuel in place of wood; railways had been built; and open field agriculture had given place to much larger farms enclosed by hedges fences or walls. New factory organisation as cottage industry was replaced by the factory system, bringing with it specialisation of function, the division of labour, and new relationships between employer and employee; political changes resulting from the movement of wealth away from the land and towards the new manufacturing classes; and social changes accompanying internal migration, rising population, the growth of towns, and the problems resulting from urban living.

The Industrial Revolution had its root in Great Britain. The British were innovative and inventive, and were strongly determined to overcome whatever difficulties they encountered as they progressed. Their innovativeness enabled them to progress much faster than other countries. It was their inventiveness and desire to progress and develop that brought about the industrial revolution and aided the British to take the lead for a whole century.

In early days, goods were "manufacture" by hand and in small quantities. Most of the goods thus produced were made by skilled craftsmen in their own homes. Each village had its own "army" of craftsmen — a family of potter, a carpenter, a weaver, a few blacksmiths and a few farmers and was independent and self sufficient. Skill workers or a good supply of necessary materials enabled a particular town or village to specialize in the production of a particular good and to be renowned for it. Demand for these products grew and the makers tried to increase their efficiency and output. To do this they had to increase their skills and had to improve their machineries. It may be said that this necessity actually led to the industrial revolution. As the proverb goes, 'Necessity is the mother of invention'.

The industrial revolution affected almost all the industries. Since we cannot possibly cover all the fields, let's focus on the first industry to be affected — the textile industry.

The first step in the industrial revolution brought the many scattered craftsmen together to work in the factory. This came about when the British, then colonizing America, found out that cotton grew well in the northern America. They also discovered that the damp climate in Lancashire was suitable for spinning the cotton thread and weaving it into cloth. Prompt action was taken and cotton was shipped from North America. But the scattered craftsmen could not manage to meet the high demand for the cotton cloth.

Thus the British men tried to find a way to increase efficiency of production. Rich men took advantage of the "economics of scale" where producing on large scale leads to a decrease in costs per unit of product and therefore could increase production. They hired weavers and spinners and paid them regular salaries. The industrial craftsmen could not compete against the big factories where many men were "employed" to spin and weave. These factories had machines set up in rows with men toiling behind each machine. Instead of selling whatever they could make in the market, the craftsmen now worked for fixed wages to produce cloth for their "employers". Thus these craftsmen had to leave their homes and live in crowded slums near the factories if they wanted a job.

But all these workers could not produce as much as expected with their backward machines. So the next step was to improve and develop machines so that more cloth could be produced by fewer workers. The British racked their brains for a solution. At last, in 1738 John Kay invented the "flying shuttle" which automatically sent the shuttle from one side of the loom to the other, and so enabled the weaver working at home to produce much more and to make wider cloth. 26 years later, in 1764, the "spinning jenny" was invented by James Hargreaves, a Lancashireman. This was a frame on which a large number of spindles could be worked simultaneously by a single man turning a handle. It became very popular and was used widely.

But the British were not satisfied. Another Lancashire man, Richard Arkwright, decided to improve upon the spinning jenny. He discovered that the threads with which the cloth were woven could be made much stronger and durable if they were passed between rollers and pressed together. Arkwright used the force of a running stream to run a wheel by the power of which his "water-frame spinning rollers" were operated. Next, Samuel Crompton passed another milestone in the industrial revolution by crossing the jenny with the water-frame spinning roller, to produce the "mule" which spun as many as 16 threads at once and also twisted each one into fine yarn.

25 years later, yet another man, Edmund Cartwright made another important discovery. It was the use of a "power loom" which was a weaving machine worked by mechanical power instead of by hand. Using this power loom large quantities of cloth could be produced in factories with only a few workers. Gradually the power loom also applied to the woolen industry.

The factory produced cloth was durable and could be sold at rates cheaper than at the rates the cottage weavers could afford to sell especially because large scale production had decreased the cost per unit of product. Many people began to demand the cheaper durable factory cloth to the dearer hand woven cloth. The market for hand woven cloth began to diminish and many weavers had to join the factories. This adverse effect also affected the then Bangladesh when the British began to introduce their machines in their overseas colonies. The traditional "tantis" were rapidly put out of work as people began to demand the cheaper and durable "mill-cloth".

Machines given, the problem was the power to run them. That is power supply had to be improved and developed in order to establish an efficient, secure and permanent power supply. Again the British inventors came forward. They suggested the use of steam power to run their factories. Thus the next stride in the development of the industrial revolution was the supersession of water power by steam.

Actually the idea of making machines operate using the power of steam was nothing new. A clever man from Alexandria, Heron, had constructed a simple form of steam engine as early as the 1st century BC. This was, as far as we know, the first steam engine ever invented.

But the Greek could not fully appreciate its uses. Thus Heron's steam engine remained an interesting toy and was never put to any practical use. It was after the Renaissance that people came to know about it through Greek books to Italy.

The actual evolution of the steam engine took a lot of time-about 70 years. Over this long period of time the steam engine slowly emerged and took its form. It was in 1698 that an Englishman named Thomas Savery made an engine to be used to pump water. At about the same time, a French scientist named Denis Papin made the first engine worked by a cylinder and piston, but he never put it to any practical use.

But the first practical pumping machine was constructed by a Devonshire blacksmith named Thomas Newcomen who had been employed under Savery to make parts for his pump. Newcomen had the inventiveness of his ancestors in his blood and he set to think how he could improve upon Savery's engine. In 1712 he succeeded and introduced his form of steam engine which was soon widely used for pumping water out of coal mines.

But the chain of evolution did not terminate here. In 1764, a model of Newcomen's steam engine needed repairs and James Watt, then an instrument worker at the University of Glasgow, was given the responsibility. Watt discovered the chief imperfection of Newcomen's steam engine and set to think how to improve upon it. After about ten years later, in 1774, Watt was able to introduce an engine which worked much better. Not only could it be used for pumping, it would be used to drive machineries in factories. It could do the work of hundreds of men, was much more powerful than water wheels and therefore gained widespread popularity and use.

Now the third step of the industrial revolution was completed. The steam engine was not only used for pumping or driving machines but was used to open up new modes of transportation — namely steam boats and locomotives.

In 1801, William Symington fitted one of Watt engines onto a boat. The engine turned a paddle wheel fixed at the back of the boat and enable the boat to tow a line of barges or flat bottomed cargo boats. This was the first steam boat known in history and a few years later, Robert Fulton made a number of successful steam-boats.

During the same time, in 1801, Richard Trevelthick fitted Watt's engines into a truck which ran on ordinary road. 3 years later, in 1804, he made a similar locomotive to run on rails.

But the major contribution in the field of locomotives was made by the son of a fireman of a mine. This boy was George Stephenson. His parents could not afford to send him to school, so he had to work. His job was looking after a fixed engine which pulled up coal-laden trucks uphill by means of a rope. George started to ponder about the advantages of having a travelling engine pull up the coal-laden trucks uphill on rails. He succeeded in building such a "steam-locomotive" in 1815. His first locomotive completed in 1814 ran successfully at four miles per hour. Soon his locomotives were widely used in coal mines. Stephenson's engine "Locomotive no 1" ran over the Stockton and Darling Railway at its opening in 1825 and was the first ever to draw both goods and passengers. Thus another efficient means of transport was open to the public.

Such development of the industrial revolution brought about much progress in the world. All these inventions and discoveries let to the elimination of the cottage or private worker and to the rapid growth of factories and with them of the manufacturing towns of the north of England.

The industrial revolution was not an unmixed blessing. It involved not merely inventions and discoveries but profound social changes, the effects of which remain with the world to this day. People were uprooted and crowded into unsanitary cities, which were periodically swept with cholera and typhus. Men, women and children were herded together for long hours in large factories — "dark satanic mills" as William Blake called them — and subject to the grim discipline of the machine. Women and children (some as young as five) toiled at fast moving machines for a bare living wage. The conditions in most of the factories were shockingly bad, leading to much hardship and misery for thousands of workers, young and old. Families were separated and holidays and slack seasons were of the past. In the new but grimy industrial towns they were crowded into now upon row of airless, squalid little homes with no gardens and no amenities. Such conditions inevitably gave rise in the masses of employees to a growing resentment against the increased power and privilege of the employers.

Since the invention of agriculture, there has been no change in man's way of living so great as the changes in the nineteenth century AD. This was the industrial revolution — a sudden change in the way of making things. This was the social revolution — a sudden change in the way of living and earning livelihood. The industrial revolution has come and gone but has left its effects — both good and bad in our present progressive world.