Spotlight on saving earth

Three out of the '10 people who mattered' for science during the year are related to issues of saving the planet, says s ananthanarayanan

THE journal *Nature* has featured the profiles of 10 people who had an impact on science during 2011. The list includes Dario Autiero, the physicist at Lyon in France whose team describes neutrinos that may be moving faster than light; Sara Seager, astronomer at MIT, Cambridge, USA, who is leading a different tack in the quest for exoplanets; Diederick Stapel, the dubious Dutch social psychologist who published over 150 fake research papers; Mike Lamont, who maintains the Large Hadron Collider, at Cern, Geneva; and Tatsuhiko Kodama, head of the Radio-isotope Centre at the University of Tokyo, who took on the Japanese government to get the facts about the Fukoshima disaster.

Also included are Danica May Comacho, the Philippines newborn whom the UN has identified as the seven billionth person on earth, to underscore the importance of population as an issue; Lisa Jackson, head of the US Environment Protection Agency who steered a formal declaration of the danger of greenhouse gases as a "triumph of science after years of delay and obfuscation…"; and Essam Sharaf, the short-lived Prime Minister of Egypt's government

after the overthrow of Hosni Mubarak, who saw science and engineering as the way for the Arab world to advance and reform society.

Population

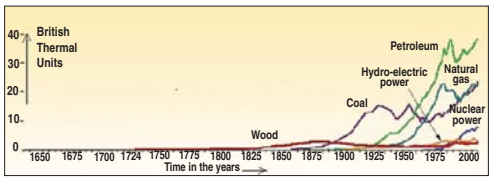
Malthus' catastrophe has not struck for two centuries because of the industrial revolution — while the world's population grew sixfold, the average per capita income rose tenfold. But prosperity did not come free — it strained the earth's resources and if the population keeps rising the world may choke within our lifetimes. The UN, in highlighting Danica May Comacho, the seven billionth inhabitant of the earth, waves the red flag — we have a crisis on our hands! Runaway population growth was perhaps inevitable — only prophetic foresight and coercive social planning could have staved it — and it is not wholly clear whether the march of science has increased or mitigated the consequences. The good news is that population growth has shown a dramatic deceleration since 1990, when annual births were around 135 million.

This is mostly because of economic growth and better family planning in poorer countries, and the birth rate is slowly dropping to the no-damage rate of two children per woman. "Annual population growth has already dropped from 1.8 per cent around 1950 to 1.1 per cent in 2010 and is expected to reach zero around 2060-80," says the *Nature* report (see box).

But avoiding further growth is not the solution as we already have more people than the planet can support. The next decades need to find ways to feed these seven billion, grow more food without encroaching on land or using up the water, to generate power without ravaging the environment and to use less power. And also to reverse the direction of population growth.

Pollution

The single great resource that this large population consumes is energy. The graph



shows the tremendous increase in the use of coal, petroleum and natural gas in the last century. Burning coal and petroleum or gas creates carbon dioxide and the global warming that this leads to will alter the face of the earth itself. But the great bulk of business, industry and governments act as if they have not heard about it! Nations continue to pursue high growth rates and encourage consumption. A government official once said airconditioning large spaces could be an answer to global warming!

Like controlling population, curbing energy use is not easy in an interconnected world. *Individual* efforts must bring home to the seven billion inhabitants that the free ride is over. It is not for nothing that Al Gore was awarded the Nobel for his work of blowing the whistle. And still there are skeptics, either real ones or driven by greed. The work of Lisa Jackson, to create explicit state policy and then to pursue its implementation — for conserving energy use and eco-friendly generation — is what responsible people need to emulate the world over.

Science

The 59-year-old Essam Sharaf, an engineer and professor at Cairo University, was a fierce critic of erstwhile Egyptian President Hosni Mumbarak. As an active participant in the uprising earlier this year, he was elected Prime Minister of the new government. Sharaf believed that the answer to Egypt's problems, from water security to energy, lay in science. His cabinet lost no time in revamping the education system and took up creating a university of basic and applied science – the "Zewail City for Science and Technology" (after Ahmed Hassan Zewail, the Egyptian-origin winner of the Nobel for Chemistry in 1999).

But good intentions do not carry the day and in November Sharaf and his cabinet had to resign. When Egypt will resume the work to bring science on board is uncertain. Popular governments, by definition, rely on the support of the majority — illiterate in many parts of the world and unlettered in science in most. And yet it is a world that is driven by science. Electricity, communications, food, housing, health, even warfare depend on science and the global web of technology. A few moghuls hold the strings, all the others are consumers — soon to be consumed by problems of their own making. Vulgarisation of science — both for science practices in daily life as well as to understand where government policy is leading — is the answer to bring the survival instinct of the species into the act. The great divide between "science" and "non-science" persons needs to break down. Science needs to be seen as important, it needs to be seen as "cool".

Else, short-term commercial interest will lead us over the brink.

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Capital cost of growth

AT a presentation in Mumbai last week, of the "lessons from two decades of economic reforms", Erstwhile finance secretary and now deputy chairman of the Planning Commission Montek Singh Ahluwalia was a picture of moderation and erudition. He described with clarity the world economic crisis, particularly in Europe, the slower response and recovery now than after the first landslide of 2008, and what it means to India. India had avoided the zero growth of the West, and despite the fall in the current quarter has registered 6.9 per cent.

Dr Ahluwalia pointed out the need for growth to be inclusive and laid emphasis on poverty eradication and indicators like facilities for girls and health care, which were doing better, he said, than shown by the published indices, which were over two years old. In the drive for sustained and inclusive growth, he said major concerns would be the need for power and to conserve water resources. And he spoke of the rising "fertility rate"

S Ramadorai

Montek Singh Ahluwalia

or the number of children a woman could expect to have and the advantage of more people in the productive age that India would soon have over the world, even over China.

And to capitalise on this, he spoke of the need for education and development of skills. S Ramadorai, erstwhile head of Tata Consultancy Services and now adviser to the Prime Minister, had also stressed, while speaking in Mumbai a few weeks ago, that "skilling" of Indian youth was vital to leverage the "demographic advantage" – which is that in 2020, the average age in India would be markedly less than in Europe and the USA.

But Dr Ahluwalia said the big lesson learnt was that India did have the capacity to grow and the emphasis was on getting back to the nine per cent growth of 2003-08. As worldwide slowdown also affected India's growth and markets, the emphasis was on growth itself, not only faster growth than others.

Both presentations seemed to miss out the need, for India specifically, apart from the rest of the world, to keep its population down. To a question about visas, for India to capitalise on disappearing manpower elsewhere, Ramadorai responded that work could come to India over the Internet, like in IT services or call centres! The subject was skilling tidal waves of population.

Without schools or teachers, as we are, is it a priority to create personnel for niche sectors? No doubt if demography presents an opportunity we should grasp it, but it may be poor compensation for the cost of the advantage itself. And the talk by Ahluwalia gave the impression that the pursuit of "growth" and the perception of population as an asset may push the target of zero population growth, far as it is, further away! sa

The nucleolus

tapan kumar maitra **dwells on the cellular factory where ribosomes are produced**

MOST cells have within the nucleus at least one RNA-rich body called the nucleolus. This is the cellular factory where ribosomes are produced. It is especially large in cells in which protein synthesis is a prominent feature, such as secretory cells or oocytes.

The nucleolus is formed around the nucleolar organiser, a segment of DNA that contains many repeats of the genes coding for 18S, 5.8S, and 28S rRNAs. This ribosomal DNA becomes uncoiled and is actively transcribed. The nucleolar organiser is usually located in a secondary constriction on the chromosome — ie, in a chromosomal site that becomes less condensed during mitosis.

The synthesis of a eukaryotic ribosome is a complex phenomenon in which several regions of the cell are involved. The 18S, 5.8S and 28S RNAs are synthesised as part of a much longer precursor RNA molecule in the nucleolus; 5S RNA is synthesised on the chromosomes outside the nucleolus; and the 70 ribosomal proteins are synthesised in the cytoplasm. All these components collect in the nucleolus where they are assembled into ribosomes and transported to the cytoplasm. Ribosome biogenesis is thus a striking example of coordination at the cellular and molecular levels.

Direct evidence that the nucleolus is responsible for the synthesis of rRNA was obtained when it was discovered that a mutant of the South African frog, *Xenopus laevis*, that lacks nucleoli was unable to synthesise rRNA. Diploid cells of wild-type *Xenopus* have two nucleoli (2-nu); the heterozygous mutant has only one nucleolus (1-nu); and the homozygous mutant is a anucleolate (0-nu). When two 1-nu heterozygotes are crossed, 25 per cent of the progeny are 0-nu. This condition is lethal and the tadpoles die after a week.

It was observed that all organisms have multiple copies of rRNA genes. A few are present in bacteria, but in eukaryotes the rDNA is highly repetitive. In the case of *Xenopus*, each nucleolar organiser contains 450 rRNA genes. These are tandemly repeated along the DNA molecule (ie, head-to-tail) and are separated from each other by stretches of spacer DNA which is not transcribed. These linear repeats of genes can be visualised clearly, which shows a nucleolar organiser spread for electron microscopy. These RNA genes are being actively transcribed and the nascent RNA chains are spread perpendicularly to the DNA axis.

The genes coding for 5S RNA are not located in the nucleolus and, therefore, are transcribed normally in the Xenopus anucleolate mutant. The 5S genes are also present in multiple copies — Xenopus has 24,000 5S genes which are located in the tips (telomores) of most chromosomes, as shown by *in situ* hybridisation of ^{3}H-5S RNA to chromosome preparations. As with rDNA in the nucleolus, the 5S genes are arranged in the tandem repeats separated by segments of spacer DNA. Tandem repeats of genes separated by spacers seem to be a general organisational feature of the eukaryotic genome. The 5S RNA is transcribed by RNA polymerase III and is then transported to the nucleolus, where it is incorporated into the immature large ribosomal subunits.

Gene amplification is the process by which one set of genes is replicated selectively while the rest of the genome remains constant. The clearest example of gene amplification is seen in the rDNA of amphibian oocytes, such as those of *Xenopus*.

Oocytes are in meiotic prophase and therefore contain a tetraploid amount of DNA; ribosomal DNA is amplified to 1,000 times more than expected for that amount of chromosomal DNA. Amplification takes place in very small oocytes that are in the early stages of meiotic prophase. During pachynema, excess DNA begins to accumulate on one side of the nucleus, forming a cap that can be stained. This cap incorporates 3H thymidine intensely (while the chromosomes do not) and by the end of the amplification process it contains 25 pg of DNA, an amount equivalent to 2,000,000 rRNA genes. As the oocytes grow, the extra DNA is accommodated in 1,000-1,500 extrachromosomal nucleoli. The amplified DNA is not inherited by the embryo but is lost in the course of development.

The newly synthesised DNA is indeed rDNA. This can be shown by an *in situ* hybridisation procedure in which ^{3}H-ribosomal RNA is hybridised to cytological preparation of Xenopus oocytes that have been previously treated with alkali to denature the DNA. The hybridised material can then be located by autoradiography. rRNA hybridises to the cap of amplified DNA.

Unlike the genes coding for the large ribosomal RNAs, the 5S genes are not amplified during oogenesis. Oocytes meet the increased demand for ribosomes by activating all 24,000 5S genes. The amplification of genes at specific developmental stages is not a common event. The only instance where this is known to occur, other than in oocyte rDNA, is in the DNA puffs of insects. In both cases, the amplified material is not passed on to future generations.

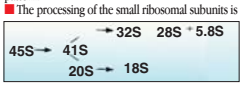
The biogenesis of rRNA provides an important and clear example of RNA processing. The rRNA genes are transcribed into a long precursor RNA which must be cleaved into 18S, 28S, and 5.8S RNA. In this cleavage process about 50 per cent of the precursor RNA is degraded within the nucleus. Several events can be distinguished in the course of processing.

■ Within the 45S or 40S primary transcript the rRNA are separated by stretches of spacer RNA. On a fully active gene, about 100 RNA polymerases are transcribed simultaneously on the ribosomal DNA cistron (ie, gene).

■ 45S RNA is methylated rapidly, even before transcription is completed. Methylations occur primarily on the ribose moiety and occur only in the 18S and 28S sequences that will be conserved; those segments that will be degraded remain non-methylated.

■ The 45S RNA has a lifetime of about 15 minutes, after which it is cleaved into smaller components in the nucleolus, according to the following general pattern:

■ The processing of the small ribosomal subunits is



faster and these appear in the cytoplasm before the large ribosomal subunits have been assembled.

■ The 45S RNA becomes associated with proteins at the same time as it is being transcribed, and all the subsequent processing events occur within nucleolar ribonucleoprotein particles. The end products are eukaryotic ribosomes, which are assembled in the nucleolus. The other ingredients (5S RNA and ribosomal proteins) are imported from other parts of the cell into the nucleolus, where they become bound to the ribosomal RNAs in an orderly fashion.

Under the light, microscope nucleoli appear as strongly refringent bodies due to high concentrations of solid materials (both RNA and proteins). This high RNA content can be demonstrated by staining with basic dyes, both with and without digestion with ribo-nuclease.

The electron microscope makes it possible to distinguish two characteristic components in most nucleoli: the granular zone and the fibrillar zone. The granular zone consists of granules 15 to 20 nm in diameter and frequently occupies the peripheral region of the nucleolus.

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Eureka moments

The discovery of an HIV drug treatment, steps towards a malaria vaccine and alien solar systems all feature in a list of scientific achievements

A CLINICAL trial that demonstrated beyond doubt the benefit of anti-retroviral drugs in curbing the transmission of the Aids virus, in addition to treating the disease, has been named "the scientific breakthrough of 2011" by the journal *Science*.

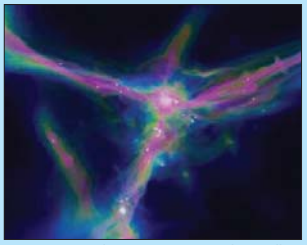
For several years, scientists have suggested that anti-retroviral drugs given to Aids patients may also lower the risk of them transmitting HIV to sexual partners who are free of the virus. A report on an HIV-transmission trial in Africa in *The Independent* in 2010, for instance, hinted at such a major side-benefit of anti-retroviral drugs. But it was not until this year that researchers were able to prove it conclusively with a properly controlled clinical trial.

The £50-million trial, known by its code HPTN 052, was supposed to have gone on until 2015 before scientists compared couples taking anti-retrovirals to those who were not. But monitoring this year showed the benefits of the drugs were so clear-cut in terms of preventing HIV transmission that the researchers decided on ethical grounds to give all participants access to anti-retrovirals.

At the end of each year, *Science* lists 10 scientific breakthroughs that its board of experts believes could be considered among the greatest achievements of the past 12 months.

Giant leaps

■ The Hayabusa mission: After some near-disastrous technical difficulties and a stunningly successful recovery, Japan's Hayabusa spacecraft returned to earth with dust from the surface of a



Astronomers using the Keck telescope in Hawaii to probe the faraway universe wound up discovering two clouds of hydrogen gas that seem to have maintained their original chemistry for two billion years after the Big Bang. Simulation by Ceverino, Dekel, and Primack.

large, S-type asteroid – the first direct sampling of a planetary body in 35 years.

■ Unravelling human origins: Studies of the genetic code of both ancient and modern humans revealed that many humans still carry variations in their DNA that were inherited from archaic humans who lived tens of thousands of years ago, such as the mysterious Denisovans in Asia and still-unidentified ancestors in Africa.

■ Capturing sunlight: In vivid detail, researchers in Japan have mapped the structure of the photosynthetic protein used by plants to split water into hydrogen and oxygen atoms. The finding may lead to a powerful source of clean energy.

■ Pristine space gas: Astronomers using the Keck telescope in Hawaii to probe the faraway universe wound up discovering two clouds of hydrogen gas that seem to have maintained their original chemistry for two billion years after the Big Bang. The discoveries show that pockets of matter persisted unscathed amid eons of cosmic violence.

■ Microbes in the gut: Research into the countless microbes that dwell in the human gut demonstrated that everyone has a dominant bacterium living in their digestive tract. The findings helped to clarify the interplay between diet and microbes in nutrition and disease.

■ Malaria vaccine breakthrough: Early results of a pioneering clinical trial of a malaria vaccine, known as RTS,S, involving more than 15,000 children from seven African countries showed that discovering a malaria vaccine remains possible.

■ Alien solar systems: Astronomers had their first good views of several distant planetary systems and discovered that things are pretty weird out there, including a star system with planets orbiting in ways that today's models cannot explain, a planet caught in a rare "retrograde" orbit, a planet circling a binary star system and 10 planets that seem to be freely floating in space. They are all unlike anything found in our own solar system.

■ Designer zeolites: This year, chemists designed a range of new zeolites, porous minerals used as catalysts and molecular sieves, that are cheaper, thinner and better equipped to process larger organic molecules.

■ The elixir of youth? Clearing senescent cells, or those that have stopped dividing, from the bodies of mice can delay the onset of age-related symptoms, such as cataracts and muscle weakness. Mice whose bodies were cleared of these loitering cells did not live longer than their untreated cage-mates – but did seem to live better.

The Independent, London