

## Science Last Fortnight

### Race to Global Leadership

#### *Is the West at a loss in Science?*

After the Second World War, Europe lost its long-standing position as global leader in science. Since then, the United States of America has been the doyen of scientific research. But the pivot seems to have shifted again – this time to China. Several quantitative indicators show the rapid rate at which China is moving ahead. These indicators include quantitative indicators of science such as number of researchers, papers and patents, besides exchange rate, purchasing power parity, and gross expenditure on research and development. But where exactly is China in the race?

Last fortnight, researchers from the South Asian University, New Delhi, in collaboration with researchers in the USA, reported an analysis. They considered not just quantitative indicators but also qualitative indicators such as strategic investment, long-term plans and science education.

Qualitative indicators are not as easy to interpret as quantitative indicators. The researchers took strategic investment in science and technology as a qualitative indicator. They also relied on anecdotes from the World Technology Evaluation Center, US. The researchers stress the need for such indicators to understand the full picture.

China has been allocating funds to boost research in nanotechnology, biotechnology and information technology. At present, China is the lead manufacturer of carbon nanotubes and boasts some 170 best supercomputers. The country has the capacity to launch humans into space – once an American dream.

Another qualitative indicator favouring China's position as global leader is its effort to bring home Chinese scientists trained in the West. By offering attractive packages and facilities, China has strengthened its scientific and technological workforce. This, in turn, has improved the quality of science education within the country – of vital importance in

the long run. China's march to achieve the goal of indigenous innovation is another qualitative indicator.

The studies by the World Technology Evaluation Center appreciate the level of sophistication achieved by China to perform high quality interdisciplinary research. However, China is still behind the West in terms of number of citations and patents. What is more, high levels of plagiarism plague the country. While China's rise towards global leadership is prominent, it might take another decade or so for it to capture the throne, say the researchers.

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### Rubber Wood Genetics

#### *Girth, flexibility and productivity*

Everything associated with rubber suggests flexibility. The economic life-span of a rubber tree is about 30 years during which it is mainly utilised for extracting latex from its bark. When their latex production capacity declines, rubber trees are felled for their timber. Using the trees for timber has been widely explored in many rubber growing regions. However, potential use in the pulp and paper industry has not drawn as wide attention as has use in the furniture industry.



Image: Kerala State Rubber Co-operative Ltd

Until lately, latex production has been the only focus of rubber improvement programmes. With huge global demand for rubberwood, attention is shifting to selective breeding for wood quality. C. Narayanan and K. K. Mydin from the Rubber Res-

earch Institute of India, Kottayam undertook a study to estimate the variability and inheritance patterns of wood quality traits in rubber trees.

They studied patterns of genetic control of growth and wood traits in fourteen hybrid families of rubber, and their parents. Specific gravity, which influences wood quality, had strong genetic control. Girth showed moderate inheritance. Other important wood traits such as the flexibility coefficient and the Runkel ratio of fibres, crucial in the pulp and paper industry, also showed very strong genetic control. Hence, rubberwood can be genetically altered and tailored for use in the pulp and paper industry, say the scientists.

Fast growth, measured as girth, is an important trait for selection in rubber for latex. Here, girth showed strong positive correlations with fibre traits. This suggests the possibility of improving wood quality by selecting fast growing clones. 'Wood improvement can, therefore, be achieved without affecting rubber yield', says Narayanan.

Rubber breeding must, henceforth, consider both latex-productivity and wood traits. Selecting parents with desirable girth as well as specific wood quality traits will produce improved, dual-purpose smart clones, says Mydin.

Good news for rubber growers! They can now look forward to trees with better wood traits besides ensuring high productivity of latex.

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### Treating Silicosis

#### *Indian jujube*

Silicosis is fibrosis of the lungs caused by inhaling silica dust. It is estimated that three million people, in the mining areas of central and eastern India, are exposed to silica dust. Thousands of mining workers, below forty, die due to silicosis. These figures are expected to increase since the rate of mining and construction is projected to increase tenfold in coming years. In 1995, the WHO and the ILO announced the

need to eliminate silicosis from the world by 2030. However, there is no effective treatment for silica-induced toxicity, so far.

Last fortnight, R. P. Dutta and M. B. Patil, from the R.T.M. Nagpur University, came up with a solution: the Indian jujube. The Indian jujube, *Ziziphus mauritiana* Lamk., is a small shrub, cultivated for its fruits. The stem, root and bark of the plant have anti-inflammatory, anti-allergic, antimicrobial, antioxidative, antiplasmodial, anticancer and hepatoprotective properties. Now the team finds that *Z. mauritiana* extracts alleviate silica-induced toxicity.



Image: Ministry of Environment and Forests

The researchers injected Wistar albino rats with silica for ten days. At the end of the period, they measured cell damage, body weight and mortality. The team found a significant rise in enzymatic activities, serum level and oxidative stress. They also noted that the hepatic membrane structure and function was altered.

The researchers then fed the rats extracts of Indian jujube for twenty-one days. They evaluated blood serum samples for oxidative stress using biochemical and haematological parameters, including pro-inflammatory cytokine levels. They found that extract-treated rats had reduced serum biochemical parameters and liver anti-oxidative enzymes. The effect was more pronounced with the stem bark extract than with the root bark.

The team collected rat liver for antioxidant analysis and histological examination and found that the extract helped reduce the severity of liver and kidney tissue damage.

Phytochemicals in the Indian jujube may have the potential to protect against silica-induced cell damage. But the availability of *Z. mauritiana* is

limited. So, on the one hand, initiatives for mass cultivation may need to be taken up and, on the other, active ingredients in the extracts need to be identified for animal and clinical trials.

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### Alleviating Asthma

*Clitoria ternatea*

*Clitoria ternatea* L., the *shankha pushpi* or butterfly pea, has long found use in folk medicine. Research has established anti-oxidative, antipyretic, anti-anxiety, anti-asthmatic, anti-histaminic and anti-inflammatory properties in the leaves, stem and root extracts of the plant. However, though the butterfly pea has traditionally been used to treat respiratory disorders such as bronchitis, there is no report of the anti-asthmatic activity of *shankha pushpi*.

Asthma ranks twenty-third as cause of global disease burden. Although data on the burden of asthma in India are not consistent, some reports estimate prevalence of self-reported asthma at around 2%.

Recently, Debapriya Garabadu and team from the GLA University, and the BHU, Uttar Pradesh came up with a way to alleviate the problem: extracts of *Clitoria ternatea* L. flowers.



Image: Pavithra Nayak

The researchers used male guinea pigs, albino rats and mice for toxicological examinations. They extracted bioactive components from the flowers with ethanol. These they fed, in increasing concentrations, from 5 to 2000 mg/kg, to albino male rats fasted overnight, to find tolerable doses. This was repeated for fourteen days. The team selected 400 mg/kg, 20% of the maximum dose for further experiments.

They evaluated the *in-vitro* anti-asthmatic activities of the extract on goat tracheal tissue and guinea pig ileum by suspending the tissue in a solution containing ethanolic extract. They found a decrease in histamine-induced contraction. The researchers confirmed the anti-asthmatic activity of the extract on guinea pigs by exposing them to histamine aerosols. They found a delay in the onset of histamine-induced dyspnoea.

Next, to assess the chronic effect of anti-asthmatic activity, the researchers injected mice with ovalbumin to sensitise them to ovalbumin. After exposing such mice to 5% of aerosolised ovalbumin, they collected fluids from around the bronchoalveolar region of the lungs. Quantitatively estimating the number of inflammatory cells, they found a reduction in immunoglobulins and interleukins.

The scientists evaluated the anti-inflammatory activity of the extract by injecting the rats with a 1% carrageenan and acetic acid solution. They found the rate of inflammation decreased. The extract was effective for up to 6 hours.

To examine antitussive activity, the team induced coughing in mice and pigs by exposing them to sulphur dioxide and citric acid respectively. Number of coughs and time spent coughing were noted. The team found that the rate of coughs decreased. The extract was effective for up to 90 minutes.

Considering the economic burden on asthma patients, the butterfly pea could be a cost-effective natural remedy to reduce allergen and cough-induced asthma.

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### Fertility of Crossbred Bulls

*Biomarkers in sperm*

As part of the White Revolution, there were attempts to improve milk production by cross breeding. Soon it was found that the crossbred bulls had limited fertility. So, often, breeding stock had to be culled – to an extent of 50 per cent!

The reasons for the poor fertility of crossbred semen are yet to be fully understood. Even among breeding

bulls selected after evaluating breeding soundness, 20–25% differences in conception rates are observed. What causes these huge variations in the fertility of crossbred bulls?

Alterations in the expression of proteins could affect the fertilising ability of spermatozoa. So, perhaps, the cause of bull infertility and differences in conception rates may be understood from a proteomic analysis of spermatozoa. If protein markers that predict the fertility of crossbred bulls were identified, suitable interventions could be designed.

Researchers from the ICAR-National Dairy Research Institute and the All India Institute of Medical Sciences, New Delhi set about doing just that. They selected 18 crossbred bulls of known fertility for the study. They used frozen semen samples to inseminate more than a hundred cows each, to determine fertility levels. By examining conception rates, they could thus separate the bulls into two groups – those that had less than 30% fertility and those with more than 40% fertility.



Image: <http://www.apwskarnal.in>

The researchers extracted proteins from three high fertility bulls and three low fertility bulls and used two dimensional difference gel electrophoresis to examine the differences in protein expression. They found 17 spots that were overexpressed in the high fertility bulls and four in low fertility bulls.

To be doubly sure, the researchers then used MALDI TOF – new generation technology that quickly separates and characterises proteins. They could thus reduce the number of probable proteins concerned to twelve in high fertility bulls and three in low fertility bulls.

The team did a bioinformatics analysis of these proteins to assess

the kind of roles that they may play in fertility. They found that these proteins are involved in sperm energy metabolism, structural integrity, maturation and the oocyte binding capacity of the sperms. As potential biomarkers, after careful consideration, they selected two proteins: ENO1, from the high fertility group, and BSP1, from the low fertility group. Immuno-blotting revealed ENO1 expression to be positively correlated with bull fertility while the expression of BSP1 was negatively correlated.

Where were these protein markers on the sperm?

The researchers localised the proteins in bull spermatozoa using immunological techniques. In the high-fertile crossbred group, ENO1, a glycolytic enzyme, was located at the tail of spermatozoa. BSP1, expressed more in the low fertility group, was found in the sperm head.

'In addition to regulating a continuous supply of energy for motility, ENO1 helps protect male gametes against oxidative stress, contributing to fertility', says A. Kumaresan, ICAR-National Dairy Research Institute.

'In the low fertile group, higher levels of BSP1 might be responsible for destabilising sperm membranes during cryopreservation', adds his colleague, Savita Yadav.

'With ENO1 and BSP1 as biomarkers, it is now easy to identify bulls that are better at breeding', says Muhammad Aslam, ICAR-National Dairy Research Institute. Failure of fertilisation will reduce when these findings are translated into cost-effective technology.

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### Additives in Composting *Minerals in medical stone*

Compost is used as biofertiliser for soil amendment, as natural pesticide, in landscaping and to eliminate weeds. However, unstabilised compost can be toxic to crops and stop the germination of seeds.

The use of porous materials such as biochar, zeolite and lime are

known to improve compost quality. Many soil bacteria can colonise these pores and thus improve soil characteristics.

Natural ores have also been reported to be useful in enhancing composting efficiency in chicken manure. So, Indian and Chinese researchers collaborated to test medical stone, a mineral additive, for pig manure composting. Medical stone has a spongy, porous structure and thus a large surface area to adsorb/absorb nutrients and moisture.

The researchers combined pig manure and sawdust. Sawdust adds carbon to the mix and balances nitrogen content. The moisture content, bulk density and carbon/nitrogen ratios are important for composting. The team optimised the ratios and added the mineral additive to the compost mixture.



The mixtures were composted for sixty days and the products were spectroscopically analysed. The scientists observed an increase in the molecular weight and aromatic polycondensation of the compost. They found the composting highly efficient. They also observed that mineral additives enhance the bio-oxidation of compost and the amount of humified materials with stable, high molecular weight structures.

The researchers say that the degradation rate of organic matter increases with the percentage of mineral additives.

Compost is a natural alternative to chemical fertilisers. The finding that minerals have a role in composting animal waste can be used to efficiently convert animal waste into manure for agricultural purposes.

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### Booming Electronic-Waste *Recycled to useful products*

Upgrading smartphones, laptops, tablets, and TVs produces large amounts of electronic waste: more than fifty million tonnes globally, every year! And it is expected to increase to 500% in digital India. In India, electronic waste is dumped in landfills. Lead, arsenic, aluminium and nickel leach into groundwater, endangering environment and health.

Last fortnight, researchers from the IIT Madras, developed an efficient method to recycle electronic waste into useful products. They collected keyboards and transistors from dump yards, dismantled plastic and ground electronic parts, such as transistors and printed circuit boards, into fine powder. They mixed the powder with feedstock such as graphite and activated carbon and pyrolysed the mixture at 600°C in a micro-oven.

Thus, the researchers converted the electronic waste into usable compounds such as tar and char. Tar is used to seal ships and boats, for roofing and to paint walls. Char is used as adsorbent to remove dyes and toxic compounds from wastewater. The method yielded more specific phenols, tars and chars than conventional pyrolysis, say the researchers.

The government has a key role in regulating electronic waste. The Indian government proposed regulations for electronic waste management in June 2015. However, there is an urgent need for a national policy to reduce electronic waste. To make electronic waste management sustainable, people must acquire new devices only when needed.

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### Perovskite Solar Cell Efficiency *Anomalous behaviour to UV*

Perovskite solar cells show high efficiency in converting sunlight into electricity and production is low cost, making them attractive for various applications. However, the perovskite crystal is susceptible to moisture and tends to degrade. Experimental

results are ambivalent about the effect of humidity: some say humidity increases the photocurrent, and others that it reduces. Moreover, some studies also point out that oxygen can degrade perovskite solar cells exposed to ultraviolet light.

Recently, Atikur Rahman and team from the IISER Pune provided key insights into the relationships between humidity, UV light, oxygen and the efficiency of perovskite solar cells.

The group rigged an isolated chamber and the required electronics from locally bought materials.

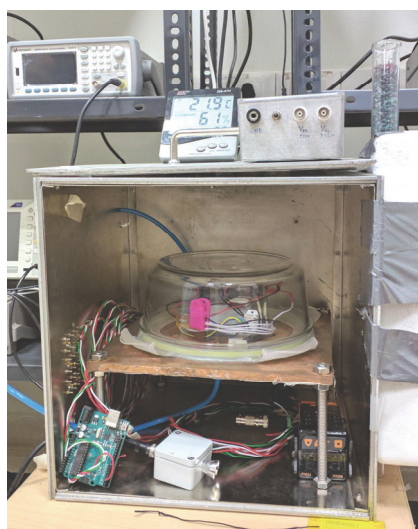


Image: STEAMIndiaReports

They stimulated the solar cells with white light and humidity and checked responses. Then they pumped dry nitrogen into the chamber to remove humidity. They found that, as humidity decreased, the photocurrent increased in a linear manner. But when they used UV light instead of white light, initially, as the humidity decreased, the photocurrent generated by the solar cells increased. However, when humidity was reduced even further, the photocurrent reduced.

They put forth a hypothesis to explain the anomalous behaviour. Water vapour in the air forms hydrated perovskites in the crystals. When water vapour is removed completely, it creates defects in the crystals, increasing recombination. 'Removing

water reduces traps in the crystals. Thus, less recombination, which leads to an increase in the photocurrent', says Ankit Kumar, the first author of the study.

But further removal of humidity decreased the photocurrent generated by UV light. Why? The team suspected that perhaps oxygen is playing a role. So they removed humidity from the chamber using dry air instead of nitrogen. Now, the photocurrent of the solar cells under UV light increased even after draining humidity.

'Titanium oxide is a commonly used electron transporting molecule for the perovskite cells. When we use nitrogen to remove water vapour, it removes oxygen also from the surface of titanium oxide. Desorption of oxygen from the titanium oxide layer creates trap states in the crystals. This creates vacancies in the oxide film, hindering electron transport in the solar cell', explains Satishchandra Ogale, IISER Pune.

Thus, the team has cracked the problem of the ambivalence of perovskite cells under UV radiation in the presence of different levels of humidity. 'The anomalous behaviour of the cells under UV is due to the complete removal of oxygen along with humidity when nitrogen is used. When dry air is used instead, the performance of solar cells improves', says Umesh Bansode, IISER Pune.

But the team refuses to rest on the laurels of the results. 'We are on to something bigger', smiles Atikur Rahman: 'a flexible solar cell'.

So we can look forward to more from the team soon.

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**Reports by: G. Sharath Chandra, A. Siva Shakthi, Pavithra Nayak, Sushmitha Baskar, Nihar Ranjan Sahoo, Rekha R. Warriar and Manish Kumar Tekam**

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scienceandmediaworkshops@gmail.com