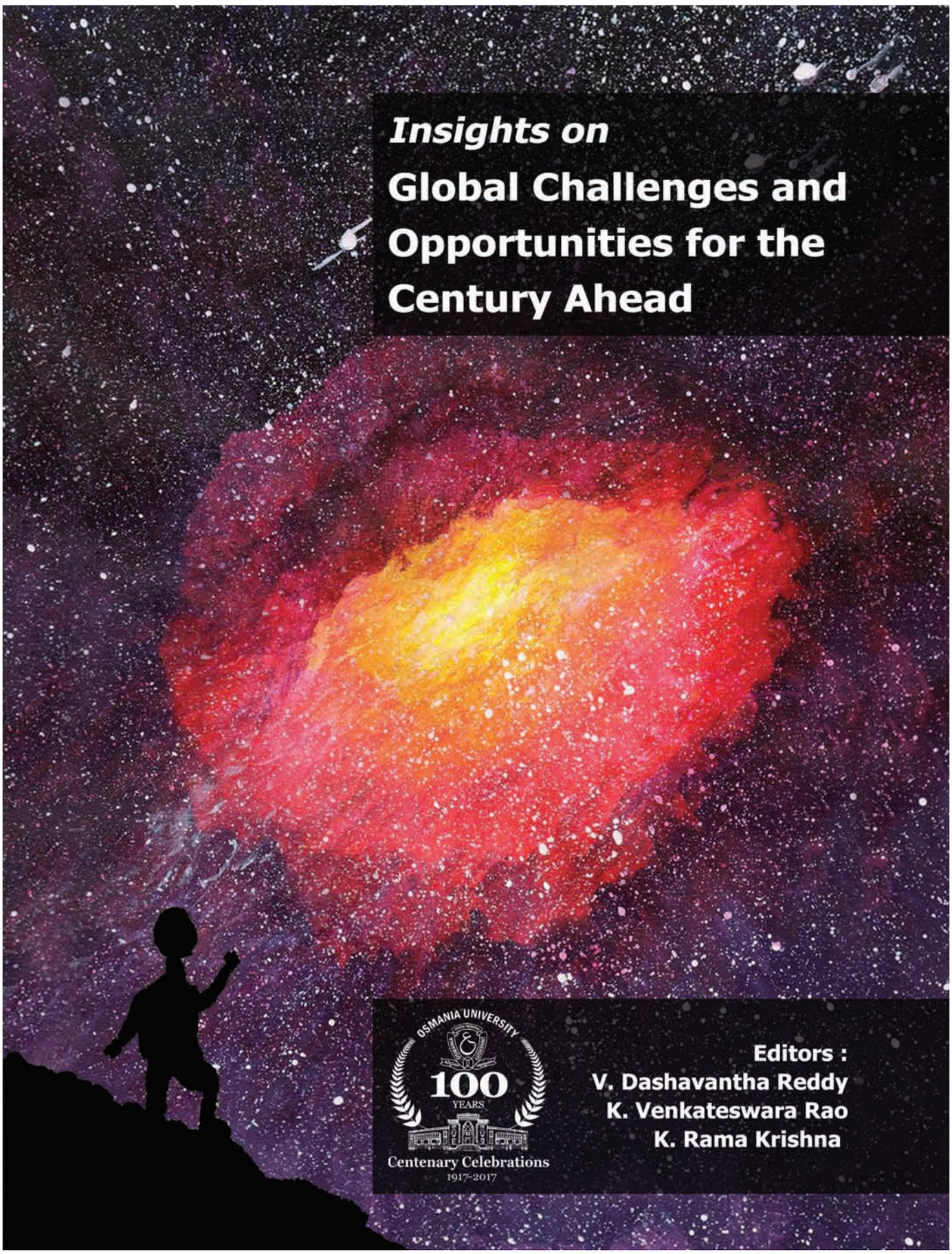
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Global Challenges and Opportunities for the Century Ahead
OSMANIA UNIVERSITY
100
YEARS
Centenary Celebrations
1917-2017
Editors :
V. Dashavantha Reddy
K. Venkateswara Rao
K. Rama Krishna

Insights on
Global Challenges and Opportunities for the Century Ahead

Editors
V. Dashavantha Reddy
K. Venkateswara Rao
K. Rama Krishna

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Dedicated to
TEACHERS and STUDENTS

Prof. S. RAMACHANDRAM
Vice-Chancellor

University with Potential for Excellence

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FOREWORD

It's my privilege to provide the foreword for the volume entitled "Insights on Global Challenges and Opportunities for the Century Ahead". The Osmania University came into existence on April 26, 1917 through a *firman* (a Ruler's Order) from His Exhalted Highness Mir Osman Khan, the seventh Nizam of Hyderabad. Over the hundred years of its existence, more than ten million students graduated from this multi-faculty university. Its Alma mater is distributed across the globe several of them occupying senior positions in key sectors. Further the Department of Genetics and Centre for Plant Molecular Biology (CPMB) have completed 50 and 25 years, respectively of their establishment. Commemorating these glorious occasions, this volume is brought out. The volume comprises insights of eminent personalities (Nobel Laureates, World Food Prize Winners, Padma awardees, former/present heads of national and international institutions) across disciplines such as education, economics, arts & social sciences, science & technology, spirituality and peace. This volume can serve as a knowledge resource for students, teachers, educationists, scientists and policy makers.

April 26, 2017

PROF. S. RAMACHANDRAM

PREFACE

Presently, humanity is facing the crisis of quality of living despite astonishing developments in science and technology. This apparent paradox can be attributed to the existence of extreme economic, educational and cultural disparities across communities and countries. The challenges are enormous and need strategic planning and proper implementation with commitment. In this context, Universities have to play a crucial role in building human resources with comprehension and competence to resolve such issues. On the occasion of the establishment of hundred years of the Osmania University and fifty years of the Department of Genetics as well as twenty five years of the Centre for Plant Molecular Biology (CPMB), it is envisaged to bring out a resource volume covering various academic disciplines. The volume entitled "Insights on Global Challenges and Opportunities for the Century Ahead" contains 81 articles with insights from eminent personalities including Nobel laureates, World Food Prize winners, Padma awardees, Heads of national and international organizations, distinguished scientists, social workers, and spiritual leaders.

The article by Prof. SARPV Chaturvedi envisions a mission for universities to achieve harmony and welfare for the coming years. Suggestions regarding improving the quality of life by strengthening the education system are elaborated by Dr. C. R. Bhatia, Former Secretary, Department of Biotechnology, Government of India. The importance of education for basic life as well as transforming the society was explained by Dr. Dame Asha Khemka, while Prof. John Brennan, London School of Economics, recommends considering the social context of the student whereby the disadvantaged can be brought into the main stream. Francesca Severini (The Reggio Emilia) emphasized inculcating the idea of education as a right and a responsibility. Dr. Scott Gray (The Sudbury Valley) shared experiences regarding the importance of practicing democracy during school years and the effectiveness of experiential-based learning. Renowned educationist Prof. Ronald Barnett, University College London Institute of Education, proposed the development of dynamic and ecological curriculum for Universities, while Dr. Clif Kussmaul, Muhlenberg College, USA, highlighted the deployment of technological tools for strengthening the pedagogy aimed at improved learning outcomes. Prof. Gautam R Desiraju (IISc Bangalore) suggested measures to be taken to improve education and science in India. Dr. N D Reddy, Founder & CEO, Suti Soft Inc., USA, listed opportunities for outgoing graduates becoming entrepreneurs and Dr. Cris Wilbur, Head, HR, Holffmann-La Roche, emphasized the need for developing a global mindset for a successful career. Nobel laureate Dr. Muhammad Yunus discussed various ways to minimize the gap between the rich and the poor. Dr. Y V Reddy (former Governor, Reserve Bank of India) described different factors that influence global economy and plausible options for overcoming challenges. Prof. Philip G. Altbach, Director, Centre for International Higher Education, Boston, USA, dealt loopholes of ranking systems of academic institutes.

Prof. Goran Therborn, University of Cambridge, UK, analyzed the ideology of Marx and its increasing relevance in the present day society. Topics covering social issues such as heritage professionals (Prof. Hester Dibbits, Director, Reinwardt Academy, Amsterdam University), poverty and punitive regulation (Prof. Loic Wacquant, University of California, Berkeley, USA), uplifting the marginalized women (Dr. Brindeshwar Pathak), entrepreneurship (Dr. M Shesheer Kumar), pollution hazards (Dr. Maria Gunnoe, North American Goldman Prize Winner), language issues (Prof. Vijay Kumar Tadakamalla; Prof. Vasanta Duggirala, Osmania University) justice delivery system (Prof. A. Lakshminath, Pro Chancellor, Chanakya National Law University, Patna) and human dignity (Prof. David C. Yamada, Director, New Workplace Institute, Suffolk University Law School, USA) are discussed. Technological advances such as space mission (Dr. A S Kiran Kumar, Chairman, Indian Space Research Organization), artificial intelligence (Prof. S Sameen Fatima, Osmania University), global navigation satellite systems (Prof. A D Sarma, Osmania University), remote sensing (Dr. Y V N Krishnamurthy, Director, National Remote Sensing Center), renewable energies (Prof. D N Reddy, Former chairman, Recruitment and Assessment Centre, Defence Research Development Organization; Dr. B R Reddy, Aramco Research Center, USA), material science (Prof. T. Radhakrishnan, University of Hyderabad; Prof. S. V. Suryanarayana; Prof. P. Venugopal Reddy, Osmania University), green buildings (Mr. Gregory Kats) and water management (Prof. Asit K. Biswas, National University of Singapore; Dr. Sumith Choy, Rubicon Waters) are presented. Prof. Harsh Gupta (Former Director, National Geophysical Research Institute) elaborated on options for coping with earthquakes.

Nobel laureate Dr. Roger Guillemin elaborated the developments of neuroendocrinology and described the importance of basic research in unforeseen medical applications. Further, topics covering recent developments in biology and medicine such as genomics and public health (Dr. Lalji Singh, Former director, Center for Cellular and Molecular Biology), genome editing and 3D printing (Dr. Seyed E. Hasnain, Former Director, Center for DNA Fingerprinting and Diagnostics), nutrition and health management (Dr. Sesikeran Boindala, Former Director, National Institute of Nutrition), personalized medicine (Dr. Raju Kucherlapati, Harvard Medical School), stem cells and regenerative medicine (Dr. Nibedita Lenka, National Center for Cell Sciences), nutrigenomics (Dr. G. Bhanuprakash Reddy, National Institute of Nutrition), nutrition and epigenome (Dr. Mohammed A. Junaid, New York State Institute for Basic Research in Developmental Disabilities), biotechnology for diagnostics/therapeutics (Prof. Ramareddy V Guntaka, University of Tennessee, USA), neutraceuticals (Dr. Appian Subramoniam), ethnopharmacology (Dr. P. Pushpangadan, Former director, National Botanical Research Institute) and food preservation (Dr. Prasad S. Variyar, Bhabha Atomic Research Center) are included.

Dr. T. Mohapatra (Director-General, Indian Council of Agricultural Research) emphasized that the agricultural research in India must have a global vision for solving national problems. Dr. B. Venkateswarlu (Vice Chancellor, VNMK Vidyapeeth, Parbhani) listed the challenges for the 21st century in meeting food and nutritional security. Prof. C. Manoharachary and Prof. L Venkateswar Rao elaborated the significance of fungi and microbes for diverse applications. Dr. P. Suprasanna (Bhabha Atomic Research Center) enumerated the role of induced mutations in

crop improvement. Dr. Suhas P. Wani (ICRISAT) described strategies for breeding biofortified millets and balanced nutrient management as a way for nutrition revolution. Dr. P. Brabeck-Letmathe (Chairman, Nestle) outlined the haunting problems of malnutrition and lifestyle diseases, and emphasized the need for nutrition secured world. Prof. Arjula R. Reddy (Former Vice Chancellor, Yogi Vemana University) narrated developments in genetics, genomics and genome editing technology and their applications in crop improvement. Dr. Ramesh V. Sonti (Center for Cellular and Molecular Biology) elaborated biotechnological applications in crop improvement. Dr. P. Ananda Kumar (Indian Institute for Rice Research) described the essentials of genome editing and crop improvement. Dr. Rajeev K Varshney (ICRISAT) presented a perspective on legume genomics while Dr. M. Sujatha (Indian Institute of Oilseeds Research) gave an overview of genomics and genomic resources in oil seed crops. The World Food Prize laureate Dr. Gurdev S Khush (University of California, Davis, USA) opined that the public-private partnership in agricultural biotechnology is crucial in food and nutritional security of the future. Dr. Vijay Gupta Modadugu (World Food Prize laureate) expressed the importance of aquaculture for food and nutrition security in the coming years. Prof. PSN Reddy explained in brief chiral pharmacology and natural product chemistry. Dr. S Chandrasekhar (Director, Indian Institute of Chemical Technology) described advances in synthetic organic chemistry. Dr. A. V. Rama Rao (Former Director, Indian Institute of Chemical Technology) conveyed congratulatory message to the Osmania University and shared his association with the University. The editors take pride in receiving the message from Dr. A.V. Rama Rao who is having a unique distinction of an Indian academician becoming a successful entrepreneur following his superannuation. On spiritual front, insights on introspection and guiding forces (Dr. Deepak Chopra), the idea of one humanity (Dr. Domen Kocevar), Islamic spirituality in present day's context (Mr. Shaykh Hamid Hasan), Swamy Vivekananda's influence on spirituality today (Swami Bhajananda), Universal brotherhood (Chinna Jeeyar Swamyji) and harmony and peace (The Dalai Lama) are presented. The information embodied in these articles is highly useful for the student community, teachers, researchers and policy makers.

We convey our profound thanks to all the contributors for their enthusiastic response and commitment. We express our special thanks to Mr. Mittapelli Suresh Reddy, Technical Officer, CPMB, for his constant involvement and valuable inputs from conception till publication.

Editors

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Challenges and opportunities for the century ahead

S.A.R.P.V. Chaturvedi

Global status assessment

It is not easy to provide a definite answer to a question on the present 'health and welfare' status of our planet. We see contrasting extremities around us; 'high level education and research' and 'illiteracy and ineffective education', 'high end technologies' and 'environmental degradation and life-extinction threats', 'sports and entertainment' and 'terrorism and wars', 'resources, produce and market fortunes' and 'hunger deaths and poverty', 'space colonization efforts' and 'debates on future liveability on Earth' and so on.

Can we claim that the world is 'developed or developing', considering the unimaginable heights of 'expanding knowledge and innovative achievements' and 'sophisticated living status and standards' that we have achieved today? Should we decide that the world is misery-dominant as there are rampant struggles and unrest of many forms that are still haunting the surface? Among these two sections; 'development and decline', which one is active and influencing the other? Is the 'development' force effectively working or trying to settle the misery grounds or the 'crisis' force interrupting and nullifying the sustainability and merits of developments?

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Is suffering an essential and inerasable program of the global system? What is our planetary future? Is it a great revolutionary positive 'U' turn or a drastic or gradual collapse? Does the foundation of the global functioning itself facilitate survival of the smartest and bravest?

Global destiny and optimism

Findings of analysts favour both the sides; a 'prosperous and harmonious future' and a 'perilous one'. Global destiny is not a subject of prediction or plain scrutiny but a product of collective introspection, realization and action. Optimism is not imagining or dreaming about undeserving and illogical benefits or welfare. Prudent and active optimism drives our acumen to design our welfare and qualify ourselves to receive, restore, preserve and distribute welfare. To be 'cautious about and prepared for fighting against evils in us, with us and around us' and to 'assess and accept reality', are components of 'practical or dynamic optimism'. To be brief and simple, the slogan of optimism is not "Something good will happen" but "I will or should make that good thing happen".

As per this view, the century ahead will be decided eventually by the nature of 'ongoing processes and issues' and their 'intruders, balancers, rectifiers and boosters'. It is widely accepted that our present response mechanism needs more vitality and velocity; 'Issues need more attention, due prioritization and muscular

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action' and our solutions should be more 'eco and demo' sensitive, endowed with enhanced reach and impact. Time has come for us to build our next century as the '**century of harmony and welfare**', making all the positive efforts and achievements of earlier centuries meaningful and fruitful.

Challenges and opportunities

Every growth and issue is inherently accompanied by challenges on one side and opportunities on the other. Challenges fall under two categories; that 'exist naturally in tasks and targets; that trigger and intensify human inquisitiveness, focus and action' and challenges that 'are fostered by ill-organization and invigorated by neglect'. Similarly, there are opportunities to 'adhere with and accelerate growth and sense and settle issues' on one side and to 'deter growth and extend crisis for personal favour and flourish' on the other. We are facing more challenges that are designed by our own fellow men and witnessing 'opportunities' being used to suck the spirits of victims of crisis.

It is easy to enlist the challenges that exist and emerge. Environmental degradation and global warming, disasters, food insecurity, water crisis, health hazards, energy demand and deficit, nuclear abuse, radioactive wastage, weapons of mass destruction and terror, human rights violations, border disputes, all pervading corruption, crime rates and 'their associates and by-products'. But all of these disorders or challenges are just derivatives of some fundamental challenges, without addressing which, attending only to their mere reflections and manifestations is as quixotic as the attempt of caging or chaining the shadow of the culprit.

Fundamental challenges

Neglect, hatred and greed are the fundamental challenges to humanity. These forces fuelled by **ignorance, arrogance and authority** of the infected and '**fear and inaction'** of the affected, reaches the monster level from micro-levels and fashion irrepressibly devastating effects. The coalition of 'few, many or all' of these factors runs the 'turmoil' industry.

Apart from the malicious and mighty, even the wise and simple equally get their 'senses and prudence' clouded by forces of avarice, nescience and insensitivity. **Alarming imprudence quotient** or idiocy quotient' and **'vigour deficit'** are conspicuous in the society. Everyone is aiming at sustainable development without bothering about sustainability in concern, action and design. Lacking of 'Vision and undiminishing vigour' are major threats to solution-designing and success-making adventures.

For all issues, over action is seen in the remedial side rather than due action for awareness and prevention. Parallel functioning of both 'problem and remedy' mechanisms provokes us to redefine 'civilization and development' terms and concepts. Premature delivery of sensitive and powerful progress gadgets without foresight and insight facilitates unsustainable, unilateral and risky benefits.

For example, 'health awareness and maintenance are infinitesimal' and 'drugs, devices, doctors are hyper-produced'; 'pollution and its control activities' still travel together; 'continuous disaster-friendly ventures are being carried out'; 'drugs and treatments are delivered without assessing their long term effects' and 'high level energy reactors are being installed without ensuring reliable safety and waste management measures'. Increased efficiency and stocks of weapons, in an already frictional and vulnerable society, are proofs for cocktail effect of intelligence, cruelty and lunacy.

Any solution that 'emerges from' and 'passes through' and 'reaches' the 'disqualified' will be a retainer of, additive for and eyewash to the issue.

Role of educational institutions

Education is not a special gift for a chosen community; those who are shrewd, sharp, studious and diligent. It is the property of all. Apart from being a tool for the smart, to enrich their knowledge, potential, image and resources, education has got other serious responsibilities also; empowerment of the weak, transformation of the misdirected, correction of the aberrant and rehabilitation of the realized. Benevolence in the forms of mutually beneficial social investment and productive charity is also an education-effect. Unfortunately, only the conventional 'degree-employment-salary-settlement' division is popular and all other facets of education mentioned above are either inactive or marginal.

Education and research centres produce voluminous think-tanks, scientists and policy designers and makers, who are relentlessly engaged in solving the derived issues or effects. But fewer efforts are made in handling the fundamental issues or causes. Our centres are not just meant for imparting 'way of learning' but also 'way and will of living'. Hence educational institutions should realize their wider responsibility of 'life-instruction and command' rather than 'subject information and job-directions'. Campus is the second uterus for mankind, where 'concern for others', 'empathy and affinity', designing development without 'isolation and exploitation' and 'comprehensive vision' blossom from the innate nature. Institutions that deliver reformers, transformers, leaders and social revolutionaries and architects, to solve primary challenges, are designated as 'Super Campuses'.

Every opportunity is a herculean challenge for the capricious, fragile and impassive and every challenge is a fascinating opportunity for the determined, bold and committed. Campus should also remain as incubator of courageous visionaries and vigorous missionaries who can create opportunities and combat challenges unlike the present trend of the society; struggling for and with opportunities and creating forceful and fresh challenges. Campus experiences; both academic and spiritual (inner), should make an everlasting impact throughout the lives of the learners and permeate every field and environment they occupy.

In order to provide all the benefits discussed above, educational campus should have an apposite environment; motivational, energizing and basically tranquil. Every capable abode of knowledge, structures discipline in the beneficiary and makes him 'worthy of his rights' and 'deserve freedom'. Students should streamline their involvement in sensitive systems such as religion and politics after a thorough view of their values and vices and also should be equipped to shield and safeguard the society from their disorderly forms.

Robots, computers, books, curiosity and scrutiny can teach the subjects but the 'object or goal for living as a good and great denizen' can be fashioned only by the impactful intervention of a special or super-human agent, teacher or master. Faculty training and selection, student-teacher interaction and relations, curriculum and character designing, instruction and evaluation methodology, all these areas need redesigning and implementation. Earnest and incessant efforts by efficient good-souls only will bring the impact.

I pray that the 'topic' of this article should culminate as 'mission and accomplishment' instead of ending as a formal attractive 'title of interest and discussion'. I hope that this centenary year of the illustrious Osmania University will play a remarkable role in preparing and arming the student community to design and engineer a rich, righteous and rewarding century ahead and I offer my choicest wishes for the same.

Exploring higher education in India

C. R. Bhatia

Congratulations to the past and present faculty, students and staff of the Osmania University for completing 100 years. My association with the University started with Late, Professor G. M. Reddy of the Genetics Department in the late 1960s, and currently continues with the Centre for Plant Molecular Biology (CPMB) and its distinguished faculty. Prof. Reddy, along with his students, whom he had inducted and trained, created the CPMB, which was the first of its kind at any University, at that point of time. It led to establishing many other centers for plant molecular biology. Both the Genetics Department and CPMB have made outstanding contributions towards developing excellent, well trained human resources and published in high impact journals. Many of the former students occupy senior positions, not only in the country, but globally. In rapidly changing economic and technological scenario, at present, the future challenges and opportunities are enormous. I would like the University to focus on some of the most compelling problems the nation faces today. This has to be based on excellent past experience and expertise of the faculty.

Formerly Secretary, Department of Biotechnology, Ministry of Science and Technology

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To my mind, the most important problems that India currently faces are: population, jobs, poverty, food, water, energy security, environment, health care and education. In fact, all these are inter-related, with population as the compelling driving force. Increasing population needs more of jobs, food, water, energy, housing, and enlarged educational, health care, transport and leisure facilities. Besides, the country must move out of the present low per capita GDP (US$ 1800), to at least, medium GDP (US $ 12,000); in other words, an increase in average income. Higher income enhances consumption that generates more demand for the above mentioned needs, and increased adverse effect on the environment. Tradeoffs are involved in all of the above, and the society must aim for the right balance. This is elegantly summarized in the well known IPAT equation given by Ehrlich and Holdern (1971; Science, 171, 1212-1217):

I = P x A x T

Where **I** is the environmental impact; **P** is the population; **A** is affluence; and **T** is the technology.

In a poor country the prime aspiration of the people is for increased affluence and a better life; all desire it. With finite land, water and other resources, a sustainable society with clean environment - air, and water, we have limited choice, either to reduce population or to improve the

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technologies. Osmania, with its large and diverse faculty and young, dynamic students can contribute to:

(1) Increase awareness of the population and related problems of finite resources, climate change in the public and political leaders.
(2) Innovate and improve technologies, including social and management technologies.

Biotechnologies, digital technologies and artificial intelligence are projected to contribute to human welfare, and create jobs in years to come. Social engineering would be crucial for acceptance and wider adoption of the change and new technologies. The University can contribute to human resource development in such areas, and their management, designed in a way that the output of the trained persons gets job offers soon after completing their studies. Teaching of entrepreneurship development can change some of the job seekers into job providers in new enterprises. Setting up incubators on the campus, with ready to use infrastructure, hand holding and business guidance, can create new entrepreneurs and new business opportunities.

Ph.D. research programs can be designed to aim at development of new products and processes, beneficial to the society, that can be scaled up for commercialization and profit by the researchers turned to entrepreneurs, as happened in the Information Technology sector.

Visualization of Indian education system for changing times

Rama Krishna Kancha, Venkateswara Rao Khareedu and Dashavantha Reddy Vudem

Believing without knowing is disastrous; hence, knowledge is empowerment. Imitation and learning are fundamental to the societal behaviour in organisms as diverse as insects to humans that necessitated the establishment of code of ethics. The behavioral patterns required for harmonized functioning of individuals in human communities paved the way for the establishment of both informal and later formal education systems. Apart from imparting broad professional training to students, ancient Indian education system also equipped them with moral and ethical values while the present day system could achieve the same to some extent only. India, being the largest democracy, which is led by elected representatives, necessitates education for its young population that empowers them with the required discretionary power.

The Article 21-A of the Indian Constitution emphasizes providing free and compulsory quality education to all children in the age group of six to fourteen years as a Fundamental Right. Continued Governmental efforts resulted in an increase in the number of children enrolling in school year after year; according to the Annual Status of Education Report (ASER) 2012, more than 96% of children are currently enrolled in schools.

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Despite the high enrollment, the current Indian education system is not able to impart quality education and competence required for rapidly-changing societal needs. The quality of education in India at all levels is lagging far behind than that is required due to flawed curricula (huge content and poor quality), low teacher to student ratio, lack of enough competent and committed teachers, absenteeism of students/teachers, very long hours of monotonous classroom teaching, scant funding (<3% as opposed to required >6% of GDP) for education, outdated methods of pedagogy and student evaluation besides the lacunae in the governance of education system.

As the quality of public schools/colleges deteriorated, the so-called quality education is available only to those who can afford paying huge amounts of money. The profit-oriented private education sector enforces rote-learning, which is responsible for suppressing creative abilities of young minds. Focus of current methods of education is mostly on theory but not on practical understanding of concepts and their applications in real time. Enforcing parental aspirations in deciding the education path of students against their individual preferences resulted in the underperformance and building of unhealthy competition. Meagre infrastructural facilities and lack of emphasis on sports and extra-curricular activities compromised physical health and social behaviour of students. Further, one-

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size-fits-all approach failed to cater to the requirements of the vast heterogeneous student population. Overall, the learning methods have become laborious thereby depriving students from deriving the pleasure of learning as well as minimizing the realization of their potential abilities. Thus, overhauling at all levels of education (school to university) is very much needed for developing the quality and competent human resource.

The school curriculum as well as the number of teaching hours needs to be downsized to essential basics to accommodate experience-based learning, games/sports and other extracurricular activities. Specifically, to preserve diverse cultures, conservation of all languages is essential; hence, the curriculum should include mother tongue as a compulsory subject. In addition, one more language of choice that contributes to the employability also should be made mandatory in the curriculum. Further, emphasis must be given to improve the fluency of languages and better comprehension of mathematics. To realize the full potential of every student, the pedagogy must focus on individual needs, competence, comprehension and **social as well as family background**. Inclusion of small projects facilitates active participation of students in better learning and enhanced creativity. The projects also orient students to work independently as well as in groups. A drastic change in the student evaluation should be brought in whereby students' comprehensive ability is tested rather than memorized content. Some vocational training and skills that are needed to manage day-to-day household as well as community tasks need to be imparted at the higher-secondary school. It is also important to expose children to a variety of cultures so as to expand their thinking horizon as well as understand the importance of diversity which helps them to respect other cultures. The importance of preserving the nature, participation in social activities and co-operative engagement with others must be made as part of curriculum at all levels of education.

The introduction of a process of earning while learning is highly desirable to inculcate entrepreneurial qualities in the young generation. A gap year between secondary (12^{th} standard) and higher education should be created during which the students must be engaged in various societal activities thus empowering them for their self-sustenance. The Government needs to allocate sufficient funds for this pay-for-work purpose. This process plausibly inculcates self-esteem and dignity of labour in young minds which in turn can bring a positive transformation in the society. Cultivation of dignity of labour in the society and reduction of income disparity between different levels of job hierarchy will be helpful to minimize herd mentality among parents facilitating students to opt for courses of their preference in higher education.

On higher education front, a redesign of curriculum to suit contemporary as well as future societal requirements is needed. The intake of students into specific courses must be proportional to the manpower requirement both in the job market as well as for academic purposes such as teaching/scientific positions.

The engineering and technology fields change rapidly and thus the syllabus must be frequently reviewed and updated to suit the requirements of the industry. Collaboration with public/private industry strengthens the education outcome and improves employability of engineering / technology graduates. A large proportion of students are opting for engineering and designing of live projects addressing societal problems will not only help build competence but also facilitates inculcating social responsibility.

Despite the enrollment of best students for medical education, the quality/ competence of resulting trained doctors doesn't match to the global standards. The quality and skills of doctors trained in the Government run hospitals/teaching institutes can be improved by providing adequate infrastructure such as proper buildings, furniture, and modern equipment for diagnosis/treatment, prescription drugs and other essential supplies. Strengthening of continued education for the teaching faculty in medical colleges is a prerequisite for improving the quality of medical education. More focus on bed-side teaching can help students acquire skills of independent diagnosis and effective implementation of therapeutic strategies. Being a noble profession that serves humanity, the outgoing doctors must be sensitized for ethical practices that benefit the patients.

Given that India is primarily an agrarian society, the higher education in agriculture and veterinary sciences must be strengthened with curricula enriched both with traditional and advanced technologies that meet the farmers' requirements. Further, emphasis must be given on on-farm training, extension courses and outreach activities. Translational research in agricultural and veterinary sciences must be performed giving extensive importance to breeding and other allied fields pertaining to crop protection and management.

World over, Universities played a central role in shaping the present day society by advancing knowledge in various disciplines as well as sensitizing people against undesirable practices. However, presently many Universities in India are granting degrees whose quality is debatable and the outgoing graduates are not equipped enough for the job market. Students with some level of comprehension are opting for engineering/commerce courses while the remaining are being enrolled into sciences and humanities. Outdated curricula and teaching methods of humanities besides excess intake resulted in the demotivation of students and poor learning outcomes. There is now an urgent need to reorient humanities and social sciences curricula by updating with evidence-based approaches as well as to meet the societal requirements.

Meagre funding for science research, lack of encouragement, and compromised competence of the faculty in universities resulted in poor research outcome as well as inadequate training at the post-graduate level. Besides updating the curriculum, building laboratory infrastructure, separate funding provision for research in universities, enhancing competence among

science faculty members, encouraging collaborations with national research institutes/industries, incorporating project work with tangible outcomes in postgraduate programs are required to improve science education in universities.

Since the university education is on concurrent list, both the state and central Governments together need to evolve policies pertaining to higher education. The Governments also must ensure adequate funding besides facilitating academic autonomy that leads to wider diversity in the course content across the country. Evolving appropriate enforcement strategies for accountability of university system plausibly improves learning outcomes. In addition, universities also must make efforts to build corpus funds to ensure implementation of innovative programs as per the changing times. Institutionalization of involvement of distinguished alumni in shaping of academic and administrative reforms may contribute to quality education.

Robust Ph.D. programs alone can yield quality research output besides cultivating scientific acumen among young aspirants. The poor outcome of Ph.D. programs in universities may be attributed to the non-availability of sophisticated equipment, limited access to available facilities, lack of interest in developing interdisciplinary collaborations, inadequate funding for consumables, flawed design of research problems and disinterest of teachers in continuous monitoring of research programs besides the lack of motivation in enrolled students. As the jobs are becoming more and more international, the university students must also be trained in communication as well as required soft skills so that they perform well in a future global work place. Further, a finishing school culture has to be established to train graduating students with necessary skills required for a successful career. Thus, an ideal education system needs to be evolved by policy makers and academicians according to societal needs with a major goal of empowering citizens to get employment. The education system thus needs to be made dynamic as per the time and circumstances of the societal needs. The teachers, students and parents must be sensitized to inculcate that the learning is for living during initial years of education followed by the living for learning thereafter.

The Reggio Emilia approach: Education is a right, education is a responsibility

Francesca Severini

Education is a right of all, of all children, and as such is a responsibility of the community. Education is an opportunity for the growth and emancipation of the individual and the collective; it is a resource for gaining knowledge and for learning to live together; it is a meeting place where freedom, democracy, and solidarity are practiced and where the value of peace is promoted. Within the plurality of cultural, ideological, political, and religious conceptions, education lives by listening, dialogue and participation; it is based on mutual respect, valuing the diversity of identitites, competencies, and knowledge held by each individual and is therefore qualified as secular and open to exchange and cooperation.

On December 31st 2015 the inhabitants in the Municipality of Reggio Emilia (Italy) are over 171,000 and children residents between 0-5 years represent about the 5.4% of the population. In Reggio Emilia 6,353 children (the 68.4% of the children resident) attend either an infant-toddler centre or a preschool, thanks to a wide network of educational services, so that nobody is excluded. In the school year 2015-2016, public integrated system has over 80 educational childhood services: 33 directly managed by the Municipality, 14 managed by cooperatives with an agreement, 21 managed by FISM (Catholic inspired schools) and 14 managed by the State.

The history of Reggio Emilia's municipal infant-toddler centre and preschool education is long, courageous and at the same time delicate.

The Municipality of Reggio Emilia began setting up its network of educational services in 1963 with the opening of the first preschools (for children from ages 3 to 6), followed in 1970 by the first infant-toddler centres (for children from ages 3 months to 3 years).

The municipal infant-toddler centres and preschools of Reggio Emilia have their origins in popular initiatives carried out just after the end of the Second World War, when a number of community-run schools were built literally "brick by brick." The municipal early childhood institutions were therefore generated by an act of social solidarity and democratic co-participation that involved parents and citizens in the building and management of the schools.

In 1967-68 the Municipality began accepting requests from all these schools that sprang up after the war to come under municipal management. A network of educational services was thus formed and came under the pedagogical guidance of

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Loris Malaguzzi: he gave direction to and inspired the entire experience until his death in 1994.

This network of early childhood educational services has always been characterized by the modernity of its theories and its deep-seated commitment to research and experimentation, supported by ongoing professional staff development.

But how can we better understand the basis of the Reggio Emilia Approach?

This educational project is focused on the centrality of the hundred languages belonging to every child and every human being, and this is well expressed in the following inspiring poem by Loris Malaguzzi:

No way. The hundred* is *there.
The child
is made of one hundred.
The child has
a hundred languages
a hundred hands
a hundred thoughts
a hundred ways of thinking
of playing, of speaking.
A hundred always a hundred
ways of listening
of marveling of loving
a hundred joys
for singing and understanding
a hundred worlds
to discover
a hundred worlds
to invent
a hundred worlds
to dream.
The child has
a hundred languages
(and a hundred hundredhundred more)
but they steal ninety-nine.
The school and the culture
separate the head from the body.
They tell the child:
to think without hands
to do without head
to listen and not to speak
to understand without joy
to love and to marvel
only at Easter and Christmas.
They tell the child:
to discover the world already there
and of the hundred
they steal ninety-nine.
They tell the child:
that work and play
reality and fantasy
science and imagination
sky and earth
reason and dream
are things
that do not belong together.
And thus they tell the child
that the hundred isnot there.
The child says:
No way. The hundred is *there.*
Loris Malaguzzi
(translated by LellaGandini)

Other distinguishing features of the Reggio Emilia early childhood services are an approach to work which is profoundly collegial and relational, the importance given to the environment, which is seen as an educational interlocutor, the presence of the atelier, a sort of creativity workshop where children can express themselves through music, working with clay, painting, and so on, and the intense, vital

participation of families and community members in the running of the schools.

These services put into practice daily the cultural project developed by Loris Malaguzzi and his many colleagues who, starting from "the hundred languages" philosophy, stressed importance of giving primary attention to the children and not to the subjects taught; transversal culture instead of knowledge divided into separate areas; projects and not programs; the process and not simply the final project; observation and documentation of individual and group processes; exchange and discussion as some of the effective strategies of teachers' in-school professional self-development.

All these aspects identify and sustain a comprehensive educational project for children from birth to 6 years of age, which is based on the image of a child who has enormous potential and who is the *subject of rights*. The aim of this project is to promote children's education through the development of all their *languages*: expressive, communicative, symbolic, cognitive, ethical, metaphorical, logical, imaginative, and relational.

These are the strengths that have made the Reggio Emilia early childhood experience an important point of reference and a subject of interest, study, and discussion among teachers, educators, researchers and administrators, as well as political and cultural representatives in Italy and throughout the world. This multiplicity of encounters continues to provide nourishment for the local experience, which has always developed with a strong reliance on dialogue, the comparison of ideas, and interactive exchange with other experiences.

The first foreign interest in the Reggio experience was shown by delegations of visitors from Cuba, Bulgaria, Spain, Japan, Switzerland, and France. An intensive exchange with Swedish educators and researchers began in 1979, leading to the showing of an exhibit entitled "If the eye jumps over the wall" at the Modern Museet of Stockholm in 1981. This exhibit, inaugurated in Reggio Emilia the year before, bore witness to the work of the city's infant-toddler centres and preschools.

From here, the exhibit became widely successful, and was subsequently updated to arrive at a new version, called "The Hundred Languages of Children." This exhibit has been traveling the world, taking to all continents its message of hope for early childhood, its potentials, and its rights.

Thanks to the exhibit, exchanges with foreign countries began to intensify as year after year, more and more people from around the world came into contact with the educational experience of Reggio Emilia, thereby increasing its international renown. In fact, in 1991, Reggio Emilia's reputation for early childhood education literally exploded onto the world stage when a panel of international experts, on behalf of the American news magazine *Newsweek*, identified the Diana Municipal Preschool of Reggio Emilia as the most avant-garde early childhood institution in the world.

The Reggio Emilia Approach system is composed by Preschools and Infant-toddler Centers - Istituzione of the Municipality of Reggio Emilia, by Reggio Children and the Reggio Children – Loris Malaguzzi Centre Foundation.

The Istituzione is a specific and instrumental body of the Municipality with teaching, pedagogical and administrative autonomy, its own financial budget and its own board of directors nominated by the mayor. The Istituzione is responsible for the direct management of municipal infant-toddler centres and preschools and for relations with affiliated schools, schools belonging to FISM, and state preschools.

In response to many requests for exchange and professional development from around the world, in 1994 the Municipality of Reggio Emilia founded Reggio Children, International Centre for the Defense and Promotion of the Rights and Potential of All Children, from an idea by Loris Malaguzzi and with support from a group of citizens and administrators. Reggio Children, working in close collaboration with Reggio's municipal infant-toddler centres and preschools aims to diffuse a strong idea of childhood, its rights, potentials and resources. Reggio Children's activities are carried out in a number of areas: training and professional development, consultancy and collaboration, exhibits (including a new important exhibit called "The wonder of learning"), and publishing. Over the years consulting and exchange with many countries has been developed: today the Reggio Emilia Approach is in dialogue with more than 140 countries.

In 2011 the not-for-profit Reggio Children - Loris Malaguzzi Centre Foundation was officially established. The Foundation aims to promote quality education in Reggio Emilia and the world through the key concepts of research, internationality, solidarity and educational quality.

In a context of continuous research of innovative tools for managing the present with an eye to the future, the Loris Malaguzzi International Centre is a meeting place where professional development and research intersect for people in Reggio Emilia, Italy and the world who wish to innovate education and culture. This too was a project founded on an idea by Loris Malaguzzi. The ex-Locatelli cheese warehouses were purchased by the Municipality of Reggio Emilia in 1998 and, after a large project for renovation, in 2006 the Centre was opened. The Loris Malaguzzi International Centre houses Atelier, the Marco Gerra exhibition hall, the Documentation and Educational Research Centre, the Annamaria and Marco Gerra Auditorium, the spaces dedicated to food at Pause – Atelier of Tastes (cafeteria, restaurant, bookfoodshop).

It is a place that keeps the central focus on children and their potentials, that aims to offer opportunities for creativity to children, youth, and families, and new opportunities to the international educational community and to all those who embrace and pursue learning and innovation.

As professor Howard Gardner (Harvard University), friend and colleague of the

Reggio Emilia educators since a long time, said:

"…for me I think the [Loris Malaguzzi International] Centre is about educational possibilities: whether you are very young or in the prime of your life, whether you are a teaching candidate or a visiting professor, or a physicist who studies light, this should broaden your sense of educational possibilities".

Our daily commitment is to broaden educational possibilities, in the name of children's rights.

www.reggiochildren.it

Culture shock and Sudbury Valley

Daniel Greenberg and Scott Gray

When people visit Sudbury Valley School for the first time, they sometimes think that they have come during recess. Children are playing and happily enjoying life. If they stay a while, the visitors start wondering when recess is over. Eventually they find that recess never ends. When people first encounter Sudbury Valley they undergo a kind of culture shock. They bring their expectations of what a school ought to be, but immediately come face-to-face with something very different. They don't quite know how to understand what they are seeing.

This happens all the time in cross-cultural encounters. It's what took place for hundreds of years when Westerners encountered indigenous peoples around the world. From the Western standpoint, native peoples weren't doing any of the things associated by the Westerners with *culture*, so it became common to label such peoples as *savage*. When one culture calls another culture savage, what this really means is that they do not recognize any of the usual clues or images that indicate culture to them. One of the lessons we've learned over the last fifty or so years is to be a little more cautious in our labeling, and that when we encounter such a dramatic clash of expectations, we should pause before we call something that we're not familiar with *savage*.

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We have learned to try to understand the newly encountered society, and see what the other culture is about. What we would like to explain here, from that perspective, is what's behind the culture shock that makes people wonder whether Sudbury Valley is a school.

What is the Sudbury Valley culture? What are the expectations that the school set out to meet?

Most people agree that schools are supposed to develop the intellectual potential and moral character of children and, at the same time, to prepare them to perpetuate the culture and to function as citizens in the community. There are two functions that any educational system plays in any culture -- a personal function and a social function. These two have to work in harmony in order to make a viable school.

Most new institutions are begun by asking, "What is it that we want to achieve?" That's where Sudbury Valley started as well, by asking, "What kind of people are needed in the late 20th century to make this country function?" In order to answer this, we have to evaluate carefully what is going on in our society.

When we first opened, in the sixties, people were just waking up to the fact that the United States was entering the post-industrial era. That was a new phrase back then; today it's commonplace. A new social

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and economic environment was appearing in the United States, that went beyond the factory, beyond the industrial revolution, and looked toward a different kind of economic system. The key to the emerging economic reality, is that we are moving towards a world in which *repetitive routine work will no longer be done by human beings*.

Such transformations don't happen overnight. We have always felt that our society is moving inexorably toward a future in which people will have to be imaginative, to find new ways to lead productive lives. This requires every person to be creative, to be responsible, to have initiative, and to be self-starting. All these phrases are widely used in educational circles today, because by now everybody has realized it. Every school talks about producing people who will have these attributes.

A second requirement in the free world is that people be able to function as free citizens. At one time, people would ask "What do you mean, you have to learn how to be free? What's the big deal?" Nowadays, it's a lot easier to explain what we mean, because in recent decades tyranny has been challenged all around the world, and many peoples have become free. There are literally hundreds of millions of people out there who do not have a clue how to function as free citizens where they are responsible for their own lives, responsible to manage their relationships in their communities and families, share in decisions, make compromises, and make political judgments day in, day out. This is no easy task.

All in all, any school has a very challenging, two-pronged task: to produce creative, self-starting, imaginative, responsible people, and also to produce people who know how to be free and know how to function in a democracy.

We started from scratch. We didn't assume anything. We said, "Given these requirements, where do we go from here? Let's consider ideal situations and then see how much we can put into practice."

The first thing we asked was, "What's the raw material we're working with?" We are working with *children.* If we had a glob of clay and wanted to make a pot out of it, we'd have a lot of work ahead of us. We'd have to throw it on the wheel, get it centered properly, and be sure that it doesn't collapse or it's not too wet or not too dry, or that it not crack in the kiln. These are big concerns because clay that comes out of the earth doesn't have a natural tendency to form *pots.*

The raw material that we have when we work with children is, by contrast, much easier. It's easier, because *children are designed to become all the things we want.* That's their inheritance. Children are born with the capacity to interact with their environment and process it, challenge it, work on it, and understand it in innovative ways. This is their human nature. You don't have to take a one-year-old and say, "Look around you," or grab a two-year-old by the scruff of the neck and say, "Go explore the environment," or a three-year-old and say,

"Move around a little, don't lie on your back all day." You can't stop them!

The raw material is perfect. Our main task as adults is to *get out of the way,* to provide an environment where we don't interfere, where we minimize and remove any barriers that prevent children from doing what they naturally want to do. To the extent that we succeed, they'll be alert, they'll explore, they'll be active, they'll be healthy. They'll be solving problems all day; problems that they set for themselves and attack with a passion. Leave children alone and what's the first thing you notice? Their intensity. Their involvement. Their focus.

Where does the social part fit in, that capacity to live in a free society? The only way to accustom children to freedom, responsibility, and democracy is to practice it. There's no escaping that conclusion. We certainly aren't going to teach them by *telling them* the virtues of these values. To take people who have been pushed around for twelve years in the authoritarian environment of traditional school, and sit them down for fifty minutes of talking about freedom, what freedom is about, what their rights are, and that they are part of a democracy, is laughable. The only way to bring up free citizens is to make them free citizens from day one. And there's no reason not to.

There's no reason for a school not to be an operating democracy. There's no reason for four-year-olds not to have the same voluntary access to decision-making as fourteen-year-olds or thirty-four-year-olds.

When we opened the school, we were told that there's no way to give four-year-olds a vote. People predicted that within a year we'd be closed. "They're kids. They'll buy candy with all the budget. They'll do something crazy. You can't give kids responsibility. They're not capable of thinking about the future."

For fifty years Sudbury Valley has been run by the School Meeting, in which every child regardless of age has the same vote as every adult. Sudbury Valley started out in 1968 with a per-pupil cost equal to that of the public schools and today is operating at a fraction of the per-pupil cost of the public schools. The adults in the community are elected and contracted by the School Meeting. The school has never relied on government money, grants, or fund raising. So much for kids who spend all the money on candy! There isn't a person who graduates from Sudbury Valley School who doesn't understand what it means to be a responsible member of the community. And there isn't an adult at Sudbury Valley who is uncomfortable with the fact that they share their power equally with the children.

Is Sudbury Valley really a school? Of course it's a school! It's a school that makes sense for today. The only problem is, it doesn't feel like a school. We're back to the culture shock. Sudbury Valley doesn't have all the road signs that people are used to in schools.

So let's bridge the culture gap. People come to Sudbury Valley and see "perpetual recess," and it gives them a little twinge of worry. But remember this: the schools that

we all grew up in, with their classes, their curricula, their examinations and achievement tests and placement tests, their grade levels and exams. *These schools are relative newcomers to the scene!* These schools are less than one-hundred-and-seventy years old in Massachusetts, where Sudbury Valley is located, and much younger elsewhere in the world. They were started by people who thought about education and said, "This is the kind of school we need to build an industrial society." And what happened? People in the 19th century used to walk into those "newfangled schools" and experience culture shock! They'd say, "This is a school? My kids could be spending their time *productively* out in the fields on the farm. They could be apprenticing as tradesmen, or as craftsmen, or doing all sorts of useful things. You mean to tell us that taking kids and sitting them at desks and having them write on chalkboards, that's a school? You're calling that education?" They felt just as strange then as people today looking at Sudbury Valley. It took many years for people to get used to the industrial-age schools that are accepted now.

University education: Glimpsing a new direction

Ronald Barnett

Introduction: imagining a university

Imagine a new university was being established. Imagine, too, that it was a multi-faculty university that considered it had responsibilities towards society. On its web-site, there would be the inevitable and empty talk of its aspirations towards 'excellence' and 'world-class' (for such terms are lacking in any substance). But what else might there be? What, for instance, might such a university espy as being characteristic of the kind of education it was wanting to pursue? What kinds of graduate might it hope to see emerging from its courses, as they make their way in the world? What kind of language might it employ, and what values might its vocabulary reveal about this new university and how it perceives its place and its contribution to the wider environment?

Of course, there would be the customary mention of 'skills', and it would probably say that it wished to see its students acquiring the skills appropriate for a changing – and even a challenging – world. Certainly, those skills would include those characteristic of a digital economy. Perhaps it would nuance such talk in saying, too, that it looked to its students to be creative, and able to communicate with others and work well as members of teams. In short, it would be looking to play its part in producing entrepreneurial members of society, who can make their way autonomously in a changing and challenging world, ready to face all that may come their way, but to emerge as successful players in the global knowledge economy.

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Short-term, longer term

But is this account of what a university education might look like in any way adequate for the twenty-first century and beyond? Note that 'any beyond'. Quite a number of students coming into higher education this year (2017) will be alive in the twenty-second century. That this simple observation is not being made in the public debate about higher education may say something about the deficiencies in that debate. The debate about higher education, in so far as it does consider the kinds of development expected of students, tends to focus on the near-to-hand, on the short-term. The very ideas of 'student outcomes' and 'student satisfaction' that we are seeing in harder or softer forms tacitly incorporate just such immediate time frames. That higher education might help to develop students so that they can go on being and continually becoming evermore themselves, both in themselves and in relation to the wider world, is much seldom contemplated.

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Certainly, there is something of a gap between the dominant ideas in circulation in the public and political debate on the one hand and actual practice and ideas in circulation among teachers in higher education. Whereas the public debate is heavily constrained – in favour of skills largely for today or the foreseeable future – both practice and ideas being put into practice are very much broader and have a longer time horizon. The booklets listing the outlines of papers among teachers and professional developers in universities are bewildering in their spaciousness and creativity and sheer intellectual energy. Interests abound over inter-culturality, embodied learning, inter-disciplinarity, the co-production of curricula, reflective learning, the student as global-citizen, research-based learning, and so on and so on.

Different agendas, conflicting agendas

And so there is a ferment across the world among educators in higher education that runs quite against the rigidity of the dominant framework to be seen among the think-tanks, the inter-governmental agencies, national planners and even the senior managers of universities. Inevitably, the curriculum is an area of contended visions of the kind of experiences that should be extended to students. There are perhaps four main conceptions:

i) Skills for the global graduate market
ii) Disciplinary knowledge and understanding
iii) The student developing as a person
iv) The student as a global citizen.

In practice, any one curriculum is a mixture of two or more of these conceptions, sometimes guided by large over-arching themes. The idea of 'research-based' learning, for instance, can open spaces for students' own explorations and so combine conceptions (ii) and (iii). The idea (iv) of the student as a global citizen characteristically is combined with (i) skills for the graduate labour market, even though these conceptions pull in opposed directions; the one to a student coming to acquire human capacities to understand and empathise with those in other cultures, the other to acquire entrepreneurial skills of an instrumental kind. Not surprisingly, the most innovative higher education systems are witnessing a welter of curricula innovations, including the use of problem-based learning, embodied learning, the use of social media, the recognition of 'lifewide learning', joint programmes across nations, multidisciplinary work, Socratic dialogue (collectively to develop critical thinking over controversial issues) and the co-construction of curricula.

This curricula experimentation is accompanied by developments in the teacher-student relationship, in which the student is variously granted more autonomy (whether in face-to-face settings or via the use of the digital technologies) OR, paradoxically, in which the student's pedagogical space is reduced as curricula come to follow institutional, national or trans-national regimes oriented towards tight 'learning outcomes' and ever-higher completion rates.

Two large observations may be gleaned from this overview. First, curricula are now complexes – 'asssemblages' is a fashionable term – that exhibit movements not just in a multitude of directions but often in contradictory directions, even within a single programme of studies. Second, and notwithstanding this inchoate and apparently pattern-less picture, there are dominant steers in the direction of interpersonal abilities for the global graduate labour market. Global cognitive capitalism exerts its influence deep in the heart of the student experience.

A new thinking: an ecological curriculum

Might a different kind of curriculum be glimpsed that is sensitive not just to global change but also to an Earth that is troubled and that faces huge social and worldly problems? I suggest that a new kind of thought about curricula is necessary. Let us call it thinking in favour of an ecological curriculum, where the term 'ecological' would amount to a concern not just with the natural world but with the whole Earth. For the past half century or so, the economy has stolen the main attention in the orchestration of higher education. The economy must continue to be significant but concern, too, has surely to be directed to many other fields, including those of knowledge, persons, social institutions, culture, learning and the natural environment itself. We can term each of these seven fields 'ecosystems', for each is of value, is liable to be impaired, may lack diversity and can come to exhibit fragility.

Seen in this way, with higher education oriented towards its total ecological hinterland, the curriculum becomes an educational space for developing capabilities and understandings that enable students themselves to take on ecological dispositions, with concerns for the whole Earth. The framing of such a curriculum cannot be understood as a matter of technique or a matter of fulfilling a universal – or even a national – blueprint. For the ecological possibilities will differ profoundly, as between institutions and programmes of study. More still, such ecological possibilities have to be imaginatively discerned and created, within the very real disciplinary and institutional structures that present themselves.

The imagining, the design and the bringing off of such an ecological curriculum is a never-ending project, therefore. It has continually to be emerging as the new exigencies, challenges and resources appear. The ecological curriculum is a project of everlasting hope, even in the most difficult of circumstances.

Challenges and opportunities for the century ahead in education & educational technology

Clif Kussmaul

To reflect on challenges and opportunities for the century ahead in education and educational technology, first imagine a typical traditional classroom:

A teacher stands at the front of the room, and the students sit in straight rows that face the teacher. The teacher talks and writes out some notes that the students can see and copy down, to study later. The teacher refers to physical objects, posters, or projected images to demonstrate or support some of the concepts. The teacher asks a few questions, and sometimes they are answered, usually by the same few students. Many students do not ask or answer any questions.

The size of the classroom varies, as does the age of the students, and technology evolves, but this basic scenario hasn't changed much in hundreds of years. However, the larger world has changed dramatically.

The changing landscape of work and education

Until a century or so ago, most work involved knowledge and skills that could be learned on the job. Only a relatively few people with privilege, motivation, and/or talent completed secondary school and attended higher education. Most people spent their entire lives at the same work, which was often the same as their parents and grandparents.

In the last century, people's lives have changed dramatically, due in part to the increasing power and expanding use of technology, including computers and networks. In agriculture, manufacturing, and other areas, technology automates work that is repetitive, low-skill, or dangerous, enabling people to focus more on high-skill, high-value work that requires specialized training. This is true across disciplines, including arts, humanities, sciences, and engineering. Technology also makes people more productive in such work. Thus, many more people attend and complete secondary school and higher education, with more diverse abilities, backgrounds, motivations, and perspectives. People live and work longer, and are likely to need new knowledge, skills, and even careers during their lives. At the same time, the world population continues to increase. These changes have presented challenges for educators, educational institutions, and societies across the world.

Table 1 shows data from the UNESCO Institute for Statistics [UIS, 2017].

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The *gross enrolment ratio (GER)* is the ratio of people enrolled in education to the total population at the appropriate age level. From 1970 to 2010, the GER for secondary education increased from 70% to 100% in developed countries, and from 25% to 66% in developing countries. In absolute numbers, this is a 10% increase and a 5-fold increase, respectively. Similarly, the GER for higher education increased from 25% to 75% in developed countries, and from 3% to 22% in developing countries. In absolute numbers, this is a nearly 3-fold increase and a nearly 17-fold increase, respectively. The *gender parity index (GPI)* is the ratio of women to men enrolled in education. In 1970, women were underrepresented, but in 2015, the ratio is nearly even, and in some developed countries women are the strong majority in higher education.

In the next century, these changes will continue. Technologies like automation, robotics, speech recognition, and autonomous vehicles will continue to displace low-skill work in agriculture, manufacturing, and service. Most people will need higher education, so the student population will be even more diverse. Knowledge and skills will evolve continually, and nearly everyone will change jobs and careers multiple times. Thus, for most people, education will be an ongoing priority and activity, not something that ends in their teens or twenties. Thus, educators, institutions, and societies will face increasing challenges.

Educational methods

Unfortunately, educational methods have not kept pace with the changing educational landscape, technology, or advances in educational research [e.g. CDSL, 2000; Zull, 2002]. Many students and teachers assume that "learning" means that they listen to lectures, read books, or perhaps watch videos. However, there is clear evidence that for most people, such approaches are not effective. Effective learning follows the ICAP model (*interact, construct, active, passive*) [Chi, Wylie, 2013]; instead of being *passive*, learners should be *active*, *construct* their own understanding, and *interact* with other people. This is particularly true as educational objectives move up *Bloom's Taxonomy* [Bloom, Engelhart, Furst, Hill, Krathwohl, 1956; Anderson, Krathwohl, Bloom, 2001] from low-level objectives like "remember", "define", and "list" to higher-level objectives like "analyze", "evaluate", and "design". Note that these higher-level objectives more closely match the nature of high-skill, high-value work.

Thus, educators need to shift their approach from a "sage on the stage" who lectures, to a "guide on the side" who helps students to interact and construct understanding. A variety of evidence-based educational methods have been developed and validated [e.g. Eberlein, Kampmeier, Minderhout, et al. 2008] but are not yet widely adopted by educators.

As in other areas, technology in education should automate work that is repetitive or low-skill, and enable and support work that is high-skill and high-value. However:

It is a sad fact of research and development funding in educational technology that the focus is always on a particular medium or method ... The more rational approach, seldom adopted, is to offer vast sums to investigate the best way of teaching a particular topic, and through that to fund the use of computers as an incidental part of the strategy. [Laurillard, 1993]

Future directions

Thus, as we head into the next century, educators and educational institutions should work to:

Define learning objectives that specify what students should be able to do. Too often, a syllabus lists topics to be "covered" or that students should "know" or "understand". Active objectives (at higher levels of Bloom's Taxonomy) will better prepare students for future work.

Develop, implement, assess, and refine learning activities to help students achieve these objectives, and then use detailed analytics to study their effectiveness and how they can be improved. Learning activities can take many forms, including classroom activities, online activities, laboratories, homework assignments, and projects. Educators will need expert knowledge of content, pedagogy, and technology, and how they interact, referred to as *Technological Pedagogical Content Knowledge (TPACK)* [Mishra, Koehler, 2006].

Determine the scale of collaboration and supporting technologies. Should this work be done by an individual educator, an institution, or a broader consortium? In many domains (e.g. airlines, banking, retail, telecommunications) many small providers have given way to a few large providers, which can leverage economies of scale. Software systems are expensive to develop but scale easily, so they should be shared across institutions. Instead of having many educators prepare and deliver similar lectures of varied quality, produce high quality multimedia lectures (documentaries) that students can access on demand. Even low-tech activities require effort, and students should use the best available activities to support their learning. Educators can then devote more time to observe, assist, and coach students as they interact and construct their understanding through individual or team projects.

Conclusions

The demand for education, and its objectives and methods, have changed dramatically in the last century or so, and these changes will continue into the next century. Developing countries have an opportunity to lead these changes, since they have large populations eager for education, and the resources to develop scalable solutions.

To conclude, imagine a very different classroom:

Students are scattered around the room working on a variety of learning activities. Depending on the activity and individual preferences, a student might write on paper, interact with a computer, use lab equipment, watch a video, or even read a

book. Similarly, students might work alone, with a partner, or with a team. When students have questions, they talk to each other or ask the teacher, who might respond with an answer, or with another question to help guide student learning. The teacher circulates around the room to check on student progress, notice potential problems, and identify opportunities to improve the activities. From time to time, the teacher might gather some or all of the students together for a short discussion. A learning management system help the students and teacher keep track of who is doing what, and which students might benefit most from individual attention. In a larger classroom, teaching assistants might help the students and teacher to work more efficiently.

Compare this to the first vision above. Which of these visions reflects research in education and psychology? Which is most like the work environments students will encounter? Which makes the most effective use of limited resources?

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Table 1: Data from UNESCO Institute for Statistics

	Gross Enrolment Ratio (GER) ***absolute numbers (millions)***				**Gender Parity Index (GPI)**			
	secondary		higher		secondary		higher	
	1970	2010	1970	2010	1970	2010	1970	2010
Developed countries	70% *73M*	100% *80M*	25% *17M*	75% *48M*	0.83	1.00	0.66	1.29
Developing countries	25% *81M*	66% *440M*	3% *7M*	22% *118M*	0.62	0.96	0.46	0.97

Empowerment through education

Dame Asha Khemka

Being successful and having an impact are a state of mind; the right attitude and behaviour will make all the difference and this is what we need to teach our children. When education teaches the head and nurtures the soul, I never fail to be amazed by a person's creativity, confidence and aspirations. However, far too often we see education that pays little attention to the soul and it is then that I become disheartened when aspirations fail to be nurtured and creativity developed. Organisations, communities and countries are only as strong as the human capital that resides within it. When that human capital is developed effectively, our investment is repaid a 1000 times over, communities prosper and countries become world leaders.

However when human capital is squandered, it can become a liability. If we do not realise the power and potential of every last individual, we create a lost generation, who, individually cannot reach their potential and collectively become a drain on society. It has the capacity to develop, to sustain and promote the power of education to empower and to transform.

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There is the hunger and the drive, the entrepreneurial spirit and the intellectual capacity for India to become a world leader. Education is the key to this future.

Life without education is life without hope. Education is the silver bullet. Education is the only thing that can change the destiny of a family in just one generation. Education is the mechanism through which young people learn important skills for life and employment. Education should ignite minds, lift souls and transform communities.

Through the work that we do at my college, I see the impact of education that not only educates the head but nurtures the soul. My college brings out the very best in our young people. Too often I see the damage that a lack of self-confidence, a lack of esteem and a lack of hope can do to a person's ability to dream big and more importantly to achieve them. Through exceptional teachers, amazing support and an unwavering belief in young people themselves we can very quickly turn despair into delight and disaffection into pride.

It has been an enormous privilege to serve the education sector for a lifetime. It is with an unrivalled sense of pride that I see our students develop and grow and become successful themselves every single day. Colleges like mine are at the centre of their communities; developing prosperity,

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confidence and pride in what we can achieve if we work together. Despite the amazing things that we have already achieved there is still much, much more to do. There are still far too many of our young people who leave formal education without the basic life and employability skills needed to be successful.

In India, the country of my birth, we are at the start of a skills revolution. Prime Minister Narendra Modi realises that the right kind of education and skills development is the key to India's continued growth and prosperity. He understands that in order to achieve his ambitious development strategy, the country needs to harness the power of every individual's potential.

"Each of us has a natural instinct to rise like a flame of the lamp. Let's nurture the instinct".

Prime Minister Modi understands that we must embrace all kinds of learning and value academic and vocational routes equally in order to succeed. Across the globe and still in rural parts of India, too often, people have to fight for their right to be educated. Malala Yousafzai was one such individual, she, better than anyone captured the power of education:

"*Let us remember: one book, one pen, one child and one teacher can change the world.*

Education will create our future leaders, our future role models and indeed the very future of our country. I know that within my college, within colleges in India and across the world are not just one but hundreds of young people with the potential to be amazing. It is our job to bring that potential out, to nurture it and to allow that potential to soar.

Pursuing rankings in the age of massification: For most—forget about it

Philip G. Altbach and Ellen Hazelkorn

We have one simple argument: universities around the world, many more than will ever publicly admit it, are currently obsessed with gaining status in one or more national or global rankings of universities. They should quit now.

Although some may succeed in becoming ranked or may improve their numerical scores marginally, it is almost never worth either the resources required, or the substantial changes in mission or academic programs necessary. Indeed, most "gains" are due to methodological changes, introduced by the various rankings to remain in the media and public headlines, and thus commercially lucrative.

Our advice is particularly pertinent for midrange national, regional, and specialist universities and colleges, and their stakeholders and governments.

Today, these institutions constitute the overwhelming majority of Higher Education Institutions (HEIs) worldwide, due to a combination of demographic demand for participation in higher education, and societal and economic requirements for a more highly educated citizenship. Indeed, projections suggest the number of students enrolled in higher education is forecast to rise from 99.4 million in 2000 to 414.2 million in 2030, an increase of 316 percent. Accommodating these additional students will require more than four major universities (30,000 students) to open every week for the next fifteen years.

These HEIs are the real backbone of society and their locales. They serve as anchor institutions, the mainstay for social and economic growth and development. They will develop some research focus, but are unlikely to become globally prominent.

However, our advice extends even to those universities that adopt the mantle of "flagship"—those at the top of the hierarchy in their country or state. This is because rankings pervert one of the main purposes of higher education, which is to ensure that students and graduates acquire the knowledge and skills needed for a successful, satisfying, and active life throughout one's increasingly longer life span.

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Insights from M. Yudkevich, P. Altbach, and L. Rumbley, eds. The Global Rankings Game (Routledge 2016) and E. Hazelkorn, ed. Global Rankings and the Geopolitics of Higher Education (Routledge 2016) inform this article.

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What global rankings measure—and don't measure

It is by now well-known that the three main global rankings: Academic Rankings of World Universities (ARWU, the Shanghai Rankings), *Times Higher Education* (*THE*) rankings, and QS, mainly assess two things: research productivity and (except for ARWU) reputation among peers, employers, and students. *THE* devotes 90 percent and QS 70 percent to measuring research, while, respectively, they assign 33 percent and 50 percent to reputation. *THE* uses a subjective reputational survey to measure teaching quality, but it is unclear how anyone can rate teaching ability without being in the classroom. Internationalization incentivizes quantity over quality, and often reflects a country's geographic position. Switzerland is one good example.

U-Multirank, developed by the European Union, uses a broader set of indicators but has struggled to gain wide acceptance, while others, such as the Leiden Rankings, are more narrowly focused in scope and coverage.

There are a growing number of national and specialist versions, ranging from those done by such publications as *US News and World Report* in the United States, *Macleans*in Canada, *Der Spiegel* in Germany, the *Asahi Shimbun* in Japan, to Global MBA Rankings from the *Financial Times* and the Green Metric World University Ranking from Indonesia. The former have access to a broader dataset, but they all suffer from methodological problems.

Why universities should forget about rankings

There are 18,000 higher education institutions (HEI) worldwide, according to the *World Higher Education Database* (http://www.whed.net/home.php).
However, only a small minority will ever appear in the rankings, no matter how much they try and how many resources are devoted to the task. Indeed, the top 100 universities represent only 0.5 percent HEIs or 0.4 percent students worldwide. No doubt being ranked is itself an accomplishment, but maintaining position and even climbing in the rankings is not easy. There are rising expectations, and slippage is a constant problem—bringing inevitable negative publicity.

This is because competition is fierce, and those in the upper reaches of the rankings have considerable resources, financial and human, to devote to the effort. Furthermore, rankings favor universities with strength in the sciences, engineering, and medicine. Newer and smaller universities, especially in developing economies, and institutions without these specializations, have limited opportunities. At the same time, universities already at the top of the rankings continue to improve. Thus, without massive financial and other resources, it is almost impossible for academic institutions to improve their ranking status.

Lessons from rankings

Rankings have had an outsized impact on higher education and policy. International evidence from the last decade and more

show how they influence decision-making, academic behavior, and resource allocation; research priorities and disciplinary practices, including publication in English-language and internationally ranked journals; recruitment and promotional criteria; and organizational structures and institutional mergers. Today, many universities have a rankings strategy and institutional research units that benchmark rankings performance.

Because of the overemphasis on research, international experience highlights emergent tensions between a university's mission and values, and efforts to enter and/or climb in the rankings. Teaching and undergraduate students, as well as the arts, humanities and social sciences, often take a backseat when decisions are made or resources are allocated. Some universities report preferential attention and benefit being given to research "stars" over longer-employed or domestic faculty. Other examples show how universities have attempted to refocus student entry criteria and become more selective and exclusive to better meet outcome indicators such as completion rates, graduate employment or salary levels, alumni donations, etc. However, in making such changes, universities can significantly alter their mission and purpose. Other examples highlight the huge financial costs associated with attempting to make statistically insignificant changes in their ranked order—leading to huge debt.

Focus on mission, not rankings

Our combined recent experiences highlight the fact that rankings have become a major factor influencing all higher education. Yale recently announced it can no longer ignore them—while a university in the midst of a war zone, concerned about its position in the rankings, recently approached one of the authors. This experience is not unique. At a time when universities seek to promote and protect academic autonomy from all kinds of interference, it is remarkable that some universities willingly allow their decisions to become vulnerable to an agenda set by others.

Prestige and reputation have become dominant drivers rather than pursuance of quality and student achievement, intensifying social stratification and reputational differentiation. There is a big assumption that the choice of indicators and associated weightings are meaningful measures, but there is no international research evidence that this is true.

The problem is particularly acute—and concerning—for the overwhelming majority of middle- and lower-ranked universities and colleges that have got caught up in the rankings maelstrom. To these universities, and their governments, we say: concentrate on what matters—helping the majority of students earn credentials for sustainable living and employment, rather than ensuring that your institution matches criteria established by different rankings. Even if much attention and resources are so expended, the results will not be favorable.

Higher education in its social context

John Brennan

I recall a few years ago hearing a vice-chancellor of a large British university tell his audience at a conference that "nearly all our students are studying part-time, though most of them are taking full-time courses". In other words, the student experience of higher education always has a social context, a 'life' outside the university. Partly, it is a context of social, economic and cultural developments occurring in the society, which may be local, regional, national or global. But partly, it is a context of the particular student's own social world, much of which may be private and invisible to the people, other students and staff members, who the student encounters at university. Let me give one example.

I was doing some research on a project looking at the learning experiences of students in different subjects and different universities. This took me to a relatively remote university in a fairly industrial British town where I interviewed several undergraduate students taking social science courses. One of the students was a youngish woman, probably in her late 20s, who continuously during the interview would give me answers to my questions but follow them with laughter. Inevitably, after six of seven outbursts of laughter, I asked the student what was funny.

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She replied "Oh, it's just that I couldn't have said what I'd just said to you if I was back home on the council estate". The student was a married woman, her husband was a plumber, and they rented an apartment on the other side of town in a very working-class community. Effectively, she was living two lives with two identities which she switched on and off according to where she was and who she was talking to.

Another memory from a different research project is of interviewing a senior academic at a quite prestigious UK research university about the university's efforts to widen participation and extend opportunities for young people in socially disadvantaged areas to get access to a good university and, potentially, transform their lives. He had a good story to tell about the university's efforts to engage with schools in the poorer parts of town, to provide information to them about the university and opportunities to visit the university campus, to experience some of the facilities at the university and, overall, to get a sense of the great things that could be available to them at this prestigious university. And then, the comment I always remember, "But it is so frustrating! Most of them apply to go to (the town's other university)!" This was a lower status, former polytechnic institution which had a very different social mix of students. But it was the university where students from the lower social class backgrounds felt

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more comfortable. Were they wrong to do so?

One more recollection. One of my most privileged experiences some years ago was to participate in a public debate at one of the UK's 'top' universities. There were several members of the British parliament present, leading scholars, well-known media figures, business leaders as well as academic staff and students from the university. After the debate, there were drinks and snacks available and opportunities for people to socialise with each other well into the night. I remember talking to one of the university's final year students. Since he was in the final year of his course, I asked him about his plans for the future and what he would be doing in the year following the completion of his degree. His reply went something like this: "Oh, I'm not sure. Can't really decide. Either become a politician or enter the judiciary. Parliament or the courts. Just can't decide." This was a social world far far away from the world of the plumber's wife on the council estate I quoted above.

Everything in higher education has a social context. It shapes the way in which we experience the things that are going on around us. It determines what we enjoy and what we hate, what we want for the future and what we want to avoid. And my social context is not your social context. Not entirely, anyway. And as a result, there is always the danger that we will not understand each other.

Of course, everything has a social context. Higher education is not special in this way. But there is one way in which it can be rather distinctive. For many people, it can be an opportunity to change social context and, in so doing, to change themselves. In this way, higher education can be transformative. At the same time, however, we have to recognise that participation in higher education is biased towards the socially advantaged, and that participation at the most prestigious universities is biased towards the extremely socially advantaged. To this extent, higher education is socially reproductive, a means by which social advantage is maintained by the already socially advantaged. Thus, higher education can be both socially transformative and socially reproductive, a place both for the plumber's wife and the future judge/politician. The unfortunate thing is that, in our increasingly stratified higher education systems, the judge/politician is very unlikely ever to meet the plumber's wife!

Social inequalities lie at the heart of all societies, although they take different forms and have different strengths in different places. They are the social contexts for universities, and for everything else. Universities both reflect but can also change the societies of which they are a part. Political and economic forces often bring a socially reproductive emphasis to the university's social role. In divided societies, is it realistic for universities to 'take sides'? And if they do, whose 'side' are they likely to be on? And in the century ahead, might some universities decide to 'change sides'?

A positive role that Osmania University can play in meeting the current and future energy and environmental needs of Telangana and India

B. R. Reddy

At present, about 90% of India's energy consumption is based on fossil fuels that include crude oil, natural gas and coal. In 2010, India imported 80% (160 million tons) of consumed crude oil. The contributions from alternate energy sources, although on the increase, are woefully insignificant. Recent data on per capita energy consumption which is taken as a direct indicator for social progress and standard of living indicates that Indian consumption is about 1/5 and 1/10 that of China and United States, respectively. A parallel indicator for social progress is Innovation Index data which give values of 23 to most African countries, 30 to India, 48 to China, 60 to USA and a maximum of 70 to Switzerland. Considering the aspirations of all Indians to be included in the elite list of superpowers or countries with the highest standards of living, it is anticipated that Indian per capita energy consumption will increase at least five to ten times during the current century, most of which will be imported even after taking into account the anticipated increase in domestic oil and gas production. Uncontrolled and reckless increase in energy consumption without proper measures to limit environmental damage can have disastrous implications for the environment and for the standard of living.

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For example, a 2016 list published by WHO listed 13 Indian cities in the top 30 most polluted cities in the world. Air and water pollution and the consequent compromises in the quality of living affect the rich and poor, and the educated and non-educated alike.

Indian universities have been focusing on training students in traditional areas with very little emphasis on relevance to the local and national needs. The education system is inflexible, with little relationship to regional and national supply-and-demand issues. The universities worldwide, especially in countries with higher standards of living, have moved in the direction of becoming economically self-sustaining by focusing on training students to meet the needed workforce skills, and by developing advanced technologies which can be turned into commercial ventures. Such technology developments can be employed to generate income to the university in the form of patent-licensed technologies, or contributing to the local economy in the form of new industries. The state of Telangana and Osmania University stand to benefit by following this model for an academic institution. The University can make a concerted effort to identify areas for technology development based on the available resources, and the needs of Telangana, in particular, and, India, in general. Energy and Environment related

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technology developments offer, perhaps, the best opportunity for Osmania University to become an integral part of the process for realizing 'Bangaru Telangana' and "Incredible India' during the current century. The specific areas listed below for future focus will require establishment of a Center of Excellence for Energy and Environmental Development. This center shall employ scientists/faculty who are selected globally based on their expertise, scientific contributions, and relevance to regional and national interests, and not on any quota basis. The center should have interdisciplinary faculty in the areas of chemistry, chemical, electrical and mechanical engineering, plant genetics, material science, polymer and manufacturing technologies working together for common goals.

Telangana is not likely to be a fossil fuel producing state to any significant extent in the near future unlike some other areas of the country. Osmania University can focus on developing alternate energy technologies in the state. Considering the fact that many areas of Telangana are arid, plant-based biofuel technology development offers an attractive area for development. Hydrocarbon/fuel producing plants that grow in arid regions, for example, Jatropha and Camelina varieties, can be genetically modified to increase the fuel content. Another area which is already being encouraged by the Indian government is solar energy. Currently, this technology is silicon dependent. The efficiency of this system is not very high at its best, and is not yet cost competitive when compared to fossil fuels. Osmania University can focus on developing new technologies that address improvements to polymer-based photovoltaic cell development for capturing solar energy. This area will see a rapid progress, and it is best for Osmania University to be at the forefront of this technology. Another technology that is based on solar energy utilization is development of hydrogen-fuel cells as new consumer batteries for electricity that utilize water as the feed stock. Reduction in dependence on fossil fuels helps the environment, helps local and national economy, provides jobs for intellectuals trained by the university and secures international recognition for academic excellence.

Environmental research can focus on reduction in the use of fossil fuel based petrochemical products such as plastics by the development of biodegradable plastics. Such materials are already in different stages of development globally. The biodegradable products can be plant based, such as starch based plastics; manufactured from plant based feedstocks such as lactic acid, or utilize bio-mass. This research will require plastics fabrication/processing technology to test the new products for their suitability to be converted into consumer products. Another area for environmental research is development of low-cost catalytic converter development that is not based on rare metals, such as palladium and rhodium, for reduction of nitrogen oxide emissions from automobiles.

The primary objective for the suggested areas for technology development by Osmania University includes the educational component of a typical

university while contributing to regional, national and global welfare, raising the standard of living, providing employment opportunities and becoming self-sustaining with reduced dependence on government support. Another objective is to not only develop 'me-too' technologies that are actively pursued globally, but to develop new technologies for the first time and become the pioneer by focusing on the immediate needs of the state and the country. To achieve these goals in this century, a commitment by the university and the government to set up, with an initial funding, an autonomous center and tasking it with the acquisition of expertise from wherever available globally with no restrictions on the selection process, with the provision that it become financially self- sufficient in a limited period would be desirable.

Biotechnological options for coming years in the Indian context

Ramareddy V Guntaka

I express my deep appreciation to Osmania University on its 100th anniversary. I am not exaggerating if I say that it is one of the premier Universities in India, producing many graduates in various disciplines in arts, sciences and engineering. I sincerely hope that it will continue to do an outstanding job in producing high quality graduates in various disciplines, who can serve the country in the next decades to come.

No country would prosper without science and technology. Those countries, which recognized this importance and invested heavily, are doing exceptionally well. Medical applications of scientific discoveries increased the life expectancy of people by combating infectious diseases and reducing the morbidity and mortality due to chronic diseases in the last century. Similarly, technological advances of engineering applications witnessed a phenomenal growth in instrumentation that aided improved diagnostics and surgeries. In spite of these developments and achievements, India is still behind in health care, agriculture and animal husbandry.

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Still, more than a million children die of diarrheal diseases, compared to 20,000 deaths in our neighboring China. Deaths due to flu and pneumonia also are 3 times more than in China. It is a challenging task for India to combat these preventable diseases. Diseases caused by viruses and transmitted by mosquitos such as Dengue virus, are still a major concern in India. These can be solved by improving hygienic and sanitary conditions, developing infrastructure in hospitals to provide supportive care and by developing proper vaccines.

Although, India witnessed the green revolution in agriculture, it is still lacking in many areas and the challenge is to improve the yields of crops. In advanced countries and in China as well, genetically modified crops are paving their way for future where as in India, we are still debating about the benefits of these proven crops. If we think about progress in animal husbandry, it is remarkable to note that India is second in the world in total milk production, just behind USA, yet the yield of milk per cow is 6 to 8 times less than that in the USA, Canada and many other European countries. If we achieve the levels produced per cow like in USA, for the same number of cows India will be in the first place in the world. These are only a few examples to illustrate the point that progress in the application of science and technology can result in a dramatic improvement in human health.

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India challenged the world in space technology and we are all proud to see the launching of 104 satellites into space from a single rocket, a feat unparalleled in the world. It is also pleasing to note that our achievements in nuclear industry (power and nuclear blasts) make us proud in the world. This was possible because of teamwork, concerted effort by many engineers and scientists, and most importantly, absence of interference from politicians and bureaucracy. If we can display the same spirit and teamwork in other disciplines in medicine, agriculture and animal sciences, we can show phenomenal growth in the next decades to come.

Now is the time to reap the benefits of biotechnology. It is very difficult for institutes in India to spend a lot of money and effort on basic research and to compete with advanced countries, where they budget huge sums of money. Instead, they should utilize the vast body of available basic knowledge developed in advanced countries and translate it into potential applications. In intelligence, Indians are very competitive but they lack teamwork. This is a challenge that we have to overcome in the future, if India were to succeed with new applications. A large number of new therapeutic drugs, proteins and monoclonal antibodies are being developed in advanced countries, which are prohibitively expensive, and unless India prepares to discover and apply these healthcare products, it will be lagging behind many countries, especially those with high populations. To remedy the situation, we can utilize the ultramodern technology developed and apply to our own needs.

Through biotechnology we can make available many costly therapeutics and vaccines. In mid to late nineties, we successfully produced a recombinant hepatitis B vaccine in India. At that time, the cost of the imported vaccine was almost 1200 rupees per dose, which today costs less than 100 rupees, a remarkable reduction in price and an affordable vaccine. Another major biotech product is insulin and we should be proud to say that an Indian biotech company is making this product in India and supply through international marketing into BRIC countries. If Indian scientists put a concerted effort, they can excel in producing many such products. In generics, they established a niche in the world market; these are being exported all over the world.

We should also focus on a vaccine for hepatitis C virus, a silent killer, which already infected more than 20 million people in India, and is rapidly spreading largely through blood contact. In the last two to three decades we have witnessed a large number of emerging deadly viruses such as AIDs, Swine Flu, SARS virus, Ebola, and Zika. There is a chance that new viruses continue to evolve and pose a threat to the country. Unless India prepares well, sets up diagnostic laboratories to detect all kinds of viruses and drug-resistant bacteria very early, and cope up immediately with appropriate treatments, we might face a risk of losing lives of millions of Indians.

Drugs came into market very recently but cost more than 30 to 40 lakh rupees per course of treatment per patient. We should try to discover similar drugs whose cost is affordable to Indian patients. Unfortunately, Indian pharma companies devote very little money and resources for research and development. In advanced countries, many giant companies allocate more than 10 to 12% of their budget for drug development and therefore, are always in the forefront in bringing new drugs into the market. Indian Companies and Government should learn from these experiences and prioritize their goals to combat deadly infectious and chronic diseases. The chronic diseases – coronary heart, lung diseases and stroke – are killing more than 3 million people in India alone. Unless the Government takes a new direction and invest properly in health care, it will be lagging behind. They should focus on applied science, in human and animal health and in agriculture and support goal-oriented projects that solve India's problems.

Indian entrepreneur from science: My experience

M. Shesheer Kumar

After completing my masters in Biotechnology followed by a short exposure to a Bioinformatics company, I joined R&D unit of M/s. Shantha Biotech Ltd. Couple of years of working at Shantha, I decided to pursue my Ph. D. Fascinated by the research work being carried out in diverse areas such as isolation of genes, development of genetically modified organisms and recombinant proteins at the Centre for Plant Plant Molecular Biology (CPMB), Department of Genetics, Osmania university, I joined Prof. Vudem Dashvantha Reddy`s laboratory as full time research scholar and secured my Ph. D. degree jointly under his supervision and Prof. R V Guntaka, University of Missouri, Columbia, as co-guide. My Ph. D. work on Hepatitis C virus resulted in the development of recombinant proteins with great potential for diagnostics, which inspired me in becoming an entrepreneur. The well established connections of CPMB with industry and my working experience in biotech Industry, prior to Ph D, was helpful in choosing the difficult option of becoming an entrepreneur in India, that too in a biotech sector. We (Rachana, my wife and myself) started RAS Lifesciences like most of the middle class aspirants, to do something in our country.

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We sold our house and invested entire money in setting up a unit providing molecular diagnostic services with contract research unit in the year 2008. We being from non-business family had no clue of opex/Capex/PnL etc. Life began right from coming early to office, closing the door, cleaning our premises and then planning for rest of the day.

To cut long story short, by 2011 we got DSIR recognition, DST LOCKHEED innovation award, couple of DBT projects, ICMR project, got manufacturing licenses for about 32 products and finally approval from TDB for a soft loan. I needn't specify how difficult it was to get all these through. Since things were going well I did not quite felt the hardships. With an objective of representing one Indian biotech product in the world market, we could explore possible collaborations. After due diligence for 9 long months, a French Microbiology giant M/s. BioMerieux in 2012 could become a major partner in RAS Life Sciences.

RAS Lifesciences focused on developing, manufacturing and commercialization of molecular diagnostic kits. RAS is the first company to receive licenses for manufacturing and commercialization of 32 molecular diagnostic kits which are used for detection/quantification of infectious agent, cancers and genetic diseases. Currently focus is on 6 parameters which include real time PCR based quantification kits for HBV, HCV and HIV and qualitative

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kits for dengue, chikungunya and LAMP based TB kits. These assays constitute about 80% of infections in Indian population.

In India, diagnosing infections, specifically of TB, is by observation and experience of the clinician. This practice is followed primarily to avoid huge expenses incurred on a diagnostic test. Lack of a sensitive test, affordable price, availability of testing systems in resource limiting settings and lack of trained manpower are major reasons for not prescribing a diagnostic test. Treatment of infections with inconclusive diagnosis is paving way for an infectious agent to emerge as much stronger multi drug resistant strain. Hence, treatment not only becomes ineffective but adds to the expense to patient.

Availability of cost effective diagnostic kits is the need of the hour. But there are several challenges encountered to develop an industry, in general in life sciences and specifically in diagnostics or medical devices.

Diagnostics has been a low priority career for many life sciences postgraduates and PhDs. Hence, availability of trained manpower is the biggest challenge an entrepreneur faces today in India. Lack of manufacturing ecosystem in the area of diagnostics, all the more makes it difficult for a manufacturer.

Various initiatives from Government of India like creation of awareness on importance of diagnostics, promotion of facilities to develop skilled labour, entrepreneurial development programs and promotion of various incentive based programs to promote start-up companies will help build careers in life sciences in India.

Industry-academia association is a great initiative from universities like Osmania that will be very helpful to build a world class ecosystem. These initiatives not only help to seed many startups but also lure many students to take up education in basic life science programs at undergraduate level.

Towards improving Indian science

Gautam R. Desiraju

Indian science is at crossroads and while the various attempts that have been made over the last 70 years have yielded some positive results, it is widely felt that we could have achieved much more given the innate talents, enthusiasm and patriotism in this country. Accountability is a must, and if accountability is not fixed, there is a danger that we will simply drift along neither being particularly elated nor disappointed with what is happening in Indian science. This is not the attitude that should be displayed by a large, aspiring and progressive country like India, which many abroad see as an emerging international power. The world expects a lot from us in terms of developing our science education and research, and this is not going to happen if we simply do more of the same thing. I list a few initiatives which I feel need to be taken up on an emergency footing if science education and research in India is to see an improvement in terms of quality and quantity.

Universities are at the core of science education and research, and the small investigator who is given modest but realistic funding is its bedrock. A thorough revamping, modernisation and reform of the state university system is imperative. The UGC in its present form has become an antiquated monster and needs to be transformed into something that is more proactive, friendly and facilitating.

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In the same way that the erstwhile Planning Commission was morphed into NITI Aayog, the UGC needs to be completely restructured and overhauled. This giant and ineffective post office in New Delhi is now ridden with sloth and corruption and can do no good.

The system of caste reservations needs serious reconsideration. While, the existing policies have definitely made a difference in the uplift of groups that have been traditionally discriminated against, this has come at the expense of cutting edge quality. Higher level research is elitist and discriminatory. Caste reservations are egalitarian and inclusive. There is an inherent dichotomy here and successive governments have failed to come to grips with this contradiction. Many of the problems that have assailed the state universities are directly or indirectly connected with the caste based reservation system, or should one say, the absence of their clear and fair implementation. If one pretends that this problem does not exist, one is living in a fool's paradise and one may never see better days.

Corruption, largely instigated by politicians and, aided and abetted by all too willing university officials and scientists-turned-bureaucrats, has weakened our education system to the point where there seems to be no hope for younger people who aspire for a science career in India. In the same way that demonetisation is seen as a

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surgical strike against the cancer of black money in the country, there needs to be another surgical strike against physical and academic corruption in the university system. This needs to be addressed on a war footing by the central and state governments.

The Indian Institutes of Technology (IITs) have, by and large, not lived up to the lofty expectations set for them by our founding fathers. In their earlier years, they merely served as sources of cheap labour for advanced nations—the so-called brain drain. Today, we claim that they have a world class branding but no less a person than the President of India has said recently that IIT graduates have become highly paid detergent sellers. We live in a society where crazy coaching schools subject young students to all kind of physical and mental torture so that they clear this wonderful exam called IIT JEE for admission into these institutes. This qualification is supposed to guarantee them eternal success and riches. Those who do not clear IIT JEE are doomed to a life of desperation. No less culpable is the private sector which pays all kinds of inflated salaries, but only to IIT graduates. These stupid attitudes and priorities have cost us all very dearly and we are now paying the bitter price. The IITs are not doing what they were supposed to do—train new generations of highly qualified entrepreneurs who lift the commercial and economic activity of the country through start-up and spin-off companies. Instead, IIT graduates are happy to take up management degrees and then go for salaried employment. The internal management of the IITs need more autonomy, and less interference from the central government, but in turn they need to do more soul searching about their very method of student selection. The IITs have been reduced to B.Tech. teaching institutions and this is not what they were supposed to be.

Turning now to well-recognised central institutions like IISc, TIFR, NISER, Central Universities, IISER, NIT and so on, these are all at a sub-critical number for a country of our size, and the required critical mass is simply not there. It is quite unfair to place the entire burden of carrying forward science education and research in this vast country on these central institutions. It is also a misnomer to say that they are highly funded. Compared to the funding levels in China, even the IISc gets practically nothing. The smallness of these organizations, however, lays the door open for academic nepotism, control by cliques and the relative impossibility for a large number of well-trained scientists to ever hope of getting employment in these places, unless one is well-connected. Recently, the government has compulsorily retired some IPS and IAS officers on grounds of non-performance and corruption. It would do well to consider such possibilities for academic faculty in central institutions, evaluating them say 15 years after they have joined service and then continuing this process of evaluation every five years.

In any case, it is not the quantum of funding that finally determines if scientific research will take off in our country. We have a serious attitude problem and our willingness to condone laziness, corruption

and incompetence has led to an undermining of the very value system that is so important in scientific research. Honesty is the first casualty and this is disastrous in the scientific enterprise, where honesty is prized above all. Those who are affected by the system are the stake holders and they should be the ones who manage the system. Universities need to be self-governed and we do not need elderly people from outside to occupy positions in the academic and executive councils of the universities. We rely so often on the "advice" of aged geriatrocrats who have sat in too many important committees and have decided too many important things for too many years. These aged people should not be allowed to determine important appointments and big research funding. They have all had their chance and they have all largely failed. It is time that they stepped aside gracefully and allowed younger people with more physical energy and more new, perhaps untested, ideas to step into the arena. In most advanced countries the people who wield administrative, academic and executive power in the scientific enterprise are in the age group of 50 to 60. This seems like fiction in today's India!

I come now to government laboratories which are doing scientific research, most notably CSIR, ICMR and ICAR. As far as science is concerned, the CSIR system is the most relevant. CSIR labs are government labs: their first and foremost duty is to carry out the scientific policy of the government in a manner that is directly targeted towards the betterment of the lives of the Indian people. The infrastructure and the monetary input in many of these laboratories has been quite excellent over the years but they have failed sadly in terms of acting as an effective bridge between the academic and the industrial worlds. The CSIR scientist is not a university professor. At the same time he is not an industrial scientist either. He or she is given the security of government employment so that new out-of-the-box ideas can be attempted. CSIR should be able to convince industry that using newer and better science can help industry to make more money. A few good breakthroughs have come from CSIR but unless they can do this in a general and regular way, they would have failed in their main mission. CSIR is an extra stop that was deliberately introduced by our founding fathers in the academia → industry knowledge transfer process. It is a good idea in a poor country. CSIR must meet this challenge and live up to the country's expectations.

Many of the things I have said here may not find favour in a culture that is used to a baffling variety of options, soothing consensus, soft core corruption and laziness. However, there is a significant proportion of the younger generation of our society who badly want to see a more positive scenario where the very great enabling attributes of science may be harnessed towards overall national progress. The anger that is mounting in our younger generation is now palpable. Those in power and authority can only neglect these sentiments at their peril.

Creating job opportunities for the coming years

N. D. Reddy

Introduction

Technology has long been a leading driver of growth and opportunities. The creators of the personal computer (PC) and internet, and later the smart phone, brought in a change that revolutionized the way people work, communicate, engage, and live. Trends like globalization and liberalization have been drivers of job opportunities in the 1990s and early 2000s and information technology (IT) and internet will be the drivers of growth over the coming decades. Almost every aspect of business and personal lives is being impacted by IT, and as it becomes more affordable and accessible, this trend will only grow. This, combined with entreprensurship, will create the most job opportunities in the coming years.

The rise and rise of IT and internet

From the time of their invention in the mid-1970s, PCs have seen tremendous growth in usage and today number more than 2 billion. It is estimated that there will be more than 5 billion smart phones in usage by 2020, with a penetration rate of more than 65 percent. The number of internet users has rose by about 1000% in the last fifteen years.

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However, there is still scope for growth as many emerging markets still don't have access to IT or the internet. With governments getting into the act and encouraging digital literacy, it is easy to see that the trend is going only in one direction.

What the proliferation of IT and internet have done effectively is to redefine boundaries, both on an individual and enterprise level. Individual today have voice that can reach the highest annals of power through social media. Businesses can start up and scale up faster with the use of automation and the right tools and practices. Efforts and opportunities are exponentially amplified with technology, and those who take advantage of these opportunities will be the job creators of the future.

The individual as the job creator

In the future, the individual will be the job creator. The digital world has opened up so many opportunities and lowered the barriers to entry so much that today, an individual with a PC can start up shop and offer products and services. Instead of waiting for someone else to open shop and offer jobs, modern entrepreneurs can take their future into their own hands and create enterprises that offer value to stakeholders and help improve the economy.

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Let's consider a couple of examples. First, business productivity software. Earlier, there were on-premise deployments of business software. This required huge investments, both on the vendor and customer side, which was an effective entry barrier. Unless you invest in infrastructure and resources, you could not develop a product that you could sell, and unless you were willing to invest in technology, you could not have an automated and efficient business process.

Then came along the internet, which revolutionized how products could be built and offered. Vendors could now build products with much fewer resources and much less infrastructure investment and huge upfront investments were no longer required from the customer to use the product. Individuals could now architect and build innovative products and small businesses could afford business software. This is the Software as a Service (SaaS) market today, which brought in revenues of $48.8 billion in 2016 and is slated to hit revenues of more than $100 billion in 2019.

Another huge market opportunity that internet has created is online or digital marketing. Digital marketing can be a cheaper and more effective way to reach the target audience and many organizations are taking to it more and more. Even brick and mortar enterprises are rushing to have an online presence and grab the attention of more than 3.5 billion people online today. By some estimates, digital marketing spend in the US alone will be about $120 billion within the next five years. Just the SEO industry, which is dependent on a search engine, is reported to be worth about $65 billion in 2016 and is poised to grow significantly in the coming years.

This throws up tremendous potential for jobs in the future. Digital marketing also has very few barriers to entry. Anyone with access to the right tools can create online presences and launch marketing campaigns. This is another way how an individual can create job opportunities using IT and the internet in the future.

The above are but few examples of the huge potential of technology and individuals to create jobs in the future. From e-commerce to professional services to a variety of other domains, technology helps individuals become self-sustaining and be the drivers of job growth.

Internet and IT have been the drivers of jobs for the past few decades, and this trend is set to accelerate over the next decade. Technology has revolutionized how prospects are found and services are offered, and has removed entry barriers for both customers and vendors. With access to the right technology and tools, every individual has the potential to become self-sustaining and create jobs and value. To conclude, technology and individual enterprise will be key drivers of job opportunities in the coming years.

Reflections for a global career: Learning throughout the journey

Cris Wilbur

As Osmania University marks 100 years of educating people, it is a fitting occasion to reflect on learning and its implications on one's career journey.

When university students contemplate life after graduation, they often envision finding work that, ideally, embraces their passion while enabling greater financial independence. For some, the dream job is already clear. For many others, there are numerous uncertainties, multiple scenarios to weigh and a mix of emotions. No matter whether the first job is chosen for pragmatic or idealistic reasons, it is a major decision; yet, there are typically limited opportunities to gain real insights into a profession during academic studies, so it can be difficult to visualize the day-to-day experience and how it connects to one's interests. Moreover, it is crucial when thinking about a career that one imagines beyond the first job, right from the start, in order to develop a longer-term idea of how a successful and satisfying professional life could materialize, without getting fixated on just one pathway. Taking all of this into account and considering pursuit of employment with a company versus an entrepreneurial endeavor, I will share some personal insights on a global career. In my university years in the United States, I studied computer engineering and accounting.

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So, not surprisingly, I had not envisioned becoming globally responsible for Human Resources for nearly 95,000 people, for a world-leading healthcare company, headquartered in Switzerland. Yet, today, this is exactly where I (happily) am. I grew up in Los Angeles, California, a city that many refer to as one of the most diverse "melting pots" of the United States. I was exposed to many different cultures and ways of thinking because of the vast number of immigrant families moving to this part of the world, including my own, that came from the Philippines. The diversity of people fascinated me, yet also perplexed and challenged my thinking because so many perspectives could be derived from a common situation. How and why does this happen? I was curious to understand why, curious to unravel what was underlying a person's thinking, curious to find the logic, while managing my own biases. At the time, I would not have called this a global mind-set, but in retrospect, I would say this is exactly the genesis of that concept – *to think about a situation or topic from the lens of many versus simply my own.*

People generally couple a global mind-set with the experience of living abroad. There is definitely a benefit in making an international move, but this does not need to be the only possibility or starting point. Businesses are operating from a more international landscape today than ever before. People are participating in global projects and initiatives without ever leaving home and interacting with team

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members dispersed across the world through a variety of video options. Each conscious step to understand another person's thinking and the dynamics of how things get done in different places is a building block to a global mind-set. If one does have the opportunity to experience living in another country, then these opportunities can be amplified by staying attentive to the cues, especially the subtle ones. Today, I engage with people from more than 140 countries and I can still leverage my early learning to listen from a starting point different than my own, to avoid making faulty assumptions, and to make strong connections.

Another reality of learning is that failure is part of the equation. No matter how much one tries, business life is not perfect, and can impact you at each stage of your career. Dealing with setbacks in new projects or assignments in a constructive way is difficult, but through that struggle, one can gain extremely valuable insights. Prior to Roche, I worked in various industries that have developed products such as ruggedized power supplies or high-intensity lighting for stage and studio applications. In every company, finding the best solutions required in one form or another testing hypothesis and running experiments. Success rarely occurred on the first attempt. When I consider the healthcare industry in general, and pharmaceuticals, biotech, and medical devices, in particular, risk-taking is part of the business model, and the stakes are high. For Roche, in our quest to discover and develop breakthrough medicines and diagnostics solutions, failures and setbacks are normal and to be expected. It is critical that they are openly and transparently shared in order to ensure quality and safety are preserved, and to explore new solutions. In essence, the faster we learn, the faster we can further innovate. Our commitment to science, our purpose – *"Doing now what patients need next"*– and our culture based on "*integrity, courage, and passion"* ignite ideation, innovation and motivation to deliver life-saving outcomes. This focus fosters an environment where failure is accepted as part of the learning equation. In my career, I certainly have encountered difficult situations, made complex decisions, struggled with choices and the implications, and made mistakes. Reflecting upon and learning from each of these experiences has strengthened my capabilities and helped to shape my values, and what I stand for as a person and as a leader. So, do not hesitate to seize opportunities to learn and broaden your horizons early and often in pursuit of personal and professional growth. Gain exposure to other countries and deeper insights into different cultures to nurture a global mind-set and expand your perspectives. For someone at the beginning of a career, this may be the best point in time to make an international move because complexity of life grows with time. Learn to get comfortable with being uncomfortable. Hone your ability to quickly recognize and push through artificial boundaries, to distinguish facts from assumptions, and to embrace the learnings that can be found in failure and try again. Learning is truly ever-present if you remain astute and self-reflective, and with that journey, a meaningful career anywhere in the world is possible.

Can wealth concentration be stopped?

Muhammad Yunus*

Victory of the people

Outcome of Cop 21 got me thrilled and inspired. After 40 years of battle between believers and non-believers, finally believers won. They persuaded everyone that the world is in real danger, and we must act collectively. Paris got all the nations, big and small, together to sign on a legally binding agreement to protect the planet from impending climate disaster. Everyday I feel like thanking all the activists who have gone through an uphill task to convince political leaders, businesses, and ordinary people, year after year, to show the writing on the wall. Many took it as their life-long campaign to bring the nations to their senses. Citizens who were on the sidelines gradually became activists. They voted for political candidates who supported climate action. Political parties started getting elected to power because they are green.

I see Paris as the victory of the people led by the committed activists who never gave up campaigning for their cause. Even during the Paris conference, over 7,85,000 people marched at 2,300 events in 175 countries united in one voice calling for a 100% clean energy future to save everything they love.

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Normally we expect governments to mobilize public opinion behind their brave actions. In the case of global warming, it was the reverse. It is the citizens of the world who mobilized their governments.

Paris inspires me to believe that this kind of citizen's movement can make the world ready to overcome another impending disaster which has been looming on the horizon. This has been a hot subject in politics for ages. Many powerful movements, many ambitious initiatives have been taken over centuries to address this problem. Much blood has been shed over this issue. But it not only does not go away, it gets more threatening than ever. This is the problem of ever-exploding gap in private wealth. It keeps on growing locally, nationally, and globally. As the economy grows, concentration of private wealth gets worse. Faster the rate of growth, faster is the rate of concentration of wealth. This is dangerous because it destroys peace and harmony, it threatens human rights and democracy. It pushes the world towards social explosions, each worse than the previous ones. It triggers armed conflicts among nations.

Oxfam updates on wealth concentration

Oxfam has been giving us horrifying updates on wealth concentration each year. This year Oxfam tells us that the 62 richest people own more wealth than owned by the bottom half of the world

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population. In 2015 they reported that the 80 richest people, and in 2014, according to them 85 richest people, owned more wealth than owned by the bottom half of world population. In 2010, six years back, it was 388 richest people who had the pleasure of owning similar wealth. They also told us that the wealth of 80 richest people doubled in five years, between 2009 and 2014.

Oxfam has a terrifying projection for 2016. During the current year, they projected, the richest 1% of the world will own more wealth than owned by the bottom 99% of the world's population. That means total wealth of 99% of the population of the world will barely be equal to the wealth of the top 1% of the world. And it will get worse each year

This information is so unbelievable that it takes time to absorb. We feel like asking many more questions. How many of world's richest people will own more wealth than owned by the bottom half of the world population, say, in 2025? It is obvious that if the number can drop from 388 persons to 62 persons in six years we are just one small step away from one lucky person owning more wealth than owned by bottom half of the world population!

US presidential candidate Bernie Sanders kept reminding in his campaign speeches that in the USA, the top one-tenth of one percent owns almost as much wealth as the bottom 90 percent.

What about Bangladesh? Is it 62 or more, or less, of the richest owning more wealth than owned by the bottom half of the country's population? Does it interest anyone to find the number? How long will it take to reach a point where only one person will own more wealth than owned by bottom half of the people of Bangladesh? Obviously he will be the 'King'. His wishes will be the law of the land. Does it sound too far-fetched?

Concentration of wealth also means concentration of power -- political and social, privileges, and opportunities. The reverse is also true. If you don't have any wealth, you have no power, no privileges, and no opportunities.

We can raise another question. Who will get how much of the additional wealth to be generated in the next two years? Will top one percent get more than half of the additional wealth, making them own much more than fifty percent of the total wealth reducing the share of the bottom fifty percent of the people? Bottom fifty percent will continue to be on the losing side as long as the present capitalist system remains in force. Under this system concentration of wealth will remain an ongoing non-stop process.

That's the point I am drawing your attention to. The richest people are not necessarily bad people, as popularly imagined. They are not busy engineering the non-stop expansion of their wealth by 'stealing' from the bottom people. It is the system which does it for them. Wealth is like a magnet. The bigger the magnet the greater is its pulling force. It draws smaller magnets towards it. That's how the economic system is built. People with no

magnet find it difficult to attract anything to them. If they somehow own some tiny magnets, retaining them becomes difficult for them. Bigger ones pull them to themselves. Unidirectional forces of concentration of wealth keep changing the shape of wealth-pyramid making its base thinner and its peak narrower and higher, ultimately looking like a thinning column rising out of a thin but large base.

These are horrifying realities which are taking shape minute by minute, while we are busy with our daily chores. For example the temperature of our planet quietly reached 1 degree Celsius, above the temperature during the industrial revolution, only a few months back, without drawing much attention. If we don't take heed of such major milestones our planet will keep getting warmer and warmer, and at one point we will reach the point of no return. Had it not been for the dedicated scientists and activists, who worked day and night over years, to galvanize a citizen's network and mobilize the governments forging a collective decision on global warming.

Wealth-concentration is as dangerous as environmental threat. One is a physical threat against the existence of the planet; another is a threat against humanity, against the right of the people to live with dignity and peace pursuing higher ideals.

If the collective efforts of citizens led by committed group of scientists and activists from all sections of society could make us aware of climate danger, I believe by following the same roadmap we can galvanize forces to protect humanity from the danger of its destruction through ever-intensifying wealth-concentration. Citizens have to create little islands of wealth harmony through their efforts. They have to inspire the world, particularly the youth, that this can be done and must be done. We have to remind ourselves that we are in an era where impossibles become possible faster and faster. This is one impossible that we'll have to make possible very fast irrespective of all the hurdles in reaching it.

Let me share some of my thoughts on how we can make it happen.

People at the centre

Can wealth explosion be stopped?

My firm answer is, yes, it can be done. Human beings can do anything they want. There must be a strong desire behind it. Old ways of doing it through government and charities alone cannot do it. People will have to take it up as their personal priority. People will have to take the lead in doing it themselves and then put strong pressure on government to move in the direction of creating right kind of policy packages to facilitate this.

Since the appearance of modern capitalism around 250 years back, the concept of free market has been well established. It has been believed that an invisible hand ensures competition in the economy and thus, it contributes to the equilibrium in the markets. It is also believed that society is benefited automatically if individuals pursue their own benefits without paying any attention to social benefits. Now the

question is: Does the invisible hand ensure benefits equally for everybody in the society? Obviously the invisible hand is dedicatedly biased to the richest. That's why enormous wealth concentration continues.

How can we reverse wealth concentration?

My faith in the possibility of transforming a wealth-pyramid gradually into a new shape, wealth-diamond -- very few at the top, and very few at the bottom, bulk of the people in the middle, simply sky-rocketed after the victory of the people in Paris. Now I feel confident that wealth explosion can be arrested.

First of all, it is not an unalterable fate that mankind was born with. Since it is our own creation, we can solve it through our own efforts, same as global warming. It is our blocked mind which prevents us from seeing the problem that is pushing us towards this explosion. Our efforts should be directed to unblock our minds. We must challenge the existing paradigms which led the world to this problem. The usual political agenda to reduce the problem focuses on income-gap, not on wealth-gap. It is done through a programme of income redistribution -- taking from the top (through progressive taxes) and giving it to the bottom (through various transfer payments).

Obviously only governments can undertake income redistribution programmes. Some governments carry out this programme with toughness, some do it in a relaxed pace. Unfortunately in a democratic environment, a government cannot achieve any significant success in a redistribution programme. People at the top from whom the governments are supposed to collect heavy taxes are politically very powerful. They use their disproportionate influence on the governments to restrain them from taking any meaningful step against their interest.

I don't think addressing income inequality is a real answer. We will have to address the cause, not the manifestation of it. We must address the wealth gap which is the cause of the income gap. If we keep the wealth base unchanged any reduction in income gap will be ineffective. On top of that, governments' cash transfer programmes are usually charity programmes. Charity programmes are excellent as temporary relief, they cannot give permanent solution to the problem. Rather they hide the problem. Democratic governments committed to the rule of law find it extremely difficult to embark on wealth redistribution. Land distribution seems to be the only successful wealth distribution programme undertaken by some democratic governments.

While governments should continue with their redistribution programmes, I am proposing to bring the citizen's power to transform the wealth-pyramid into a wealth-diamond. Central point in my proposal is to redesign the economic framework by moving from personal interest driven economics to both personal and collective interest driven economics.

I want to tell you why I think redesigning of economic framework is the essential task

in achieving an egalitarian society.

My personal journey

As I look back, I see how circumstances pushed me into doing things which I knew nothing about. Famine of 1974 pushed me into growing an irrigated third crop in the village of Jobra. This introduced me to the money lending operation in the village. I wanted to help the victims of money lenders. In 1976 I offered to lend them from my pocket to protect them from money lenders. My money was running out as I gave loans to more and more people. I went to the bank, Janata Bank, located in the Chittagong university campus inviting them to offer loans to the poor. They refused. Finally I persuaded them by offering myself to become the guarantor. I called the project Grameen Bank Project. Then came the Krishi Bank to help me because of the personal interest taken by its Managing Director. They opened a special branch in Jobra with me as its de facto head, operating with staff that I recruited for the branch, all of whom were my students. I called it experimental Grameen branch. Later Bangladesh Bank wanted to expand it to Tangail because of strong support from some board members of Bangladesh Bank. In 1983 we became a formal bank.

Everything they do, we do the opposite

What we created was not just another bank. It turned out to be an anti-thesis of a conventional bank. Everything a conventional bank did we started doing the opposite in Grameen Bank. Conventional banks love to operate where businesses and rich people locate their offices. As a result, they work in the cities. Grameen Bank (GB) works in the villages.

Even after 40 years, GB does not have any branch in any city or municipal area. Conventional banks are owned by rich people, GB is owned by poor women. Poor women sit in its board. Conventional banks serve mostly men, GB focuses on women. Conventional banks believe that poor are not creditworthy. GB established for the first time in history that the poor people, more so poor women, are creditworthy in any formal banking sense. Grameen America has shown that even in the USA poor women can demonstrate amazing ability to handle bank credit to transform their lives. Grameen America has 18 branches in 9 cities in the USA with 62,000 borrowers, all of whom are women. It has given out a cumulative amount of $ 380 million with an average start up loan of $ 1,000 and repayment rate of 99.9%.

Conventional banks operate on the basis of collateral, GB is collateral free. Therefore, it is lawyer-free. We have developed a banking system based on trust. In GB, borrowers don't come to the bank, the bank goes to borrowers wherever they live. GB created pension fund to make sure that borrowers can take care of themselves during their old age. GB offers health insurance, loans to beggars, student loans for the children of GB families, loans for sanitary latrine and tube wells. GB partially covers the funeral cost of the borrowers, loans are written off when a borrower dies. In GB, total interest on loan cannot exceed total principal no matter how long it takes to repay.

By July, 2016 cumulative disbursement of loans of the bank came to Tk.1,323,353.74 Million (USD$ 19,471.05 Million) and total loan outstanding stood at Tk.109,389.02 Million (USD$ 1,395.27 Million). The balance in the savings account of borrowers stood at Tk.117,415.77 Million (USD$ 1,497.65 Million). This means borrowers now have more money in their saving accounts than their total loans outstanding. One can say, in reality, they are the lenders to the bank, rather than borrowers of the bank.

In recent years, the World Bank, IMF, UN, and many bilateral donors are promoting inclusive finance. It is mostly manifested in encouraging conventional banks to take steps to provide limited financial services to the poor. If anybody aims at inclusiveness in banking with any seriousness, definitely it can't be achieved through conventional financial institutions. These financial institutions are built on principles and mode of operation which promote financial exclusion. Their DNA will not allow them to work for inclusion. If we wish to reach the poor, we need to build separate institutions with completely different architecture. Rich people's banks are not designed to serve the poor. They may take some token actions through NGOs, under pressure from above, but that won't constitute even a fraction of one percent of their business. The unbanked of the world need real banking, not some "let-us-look-good" actions.

Through my work with microcredit, I questioned the very basics of the banking system. I kept pointing out that real human beings are much bigger than the human beings assumed in the theory on which banking system is designed. Story of Grameen Bank is a living proof of that. Grameen Bank's microcredit idea flourished globally because NGOs took it up. But NGOs are not the answer to fill the vacuum left by existing financial institutions. I have been arguing that one easy way would be to give banking licenses, with some restrictions, to the microcredit NGOs, to operate as banks and take deposits, so that they can become self-reliant institutions. I am very happy to see that after many years of bringing it up, now Reserve Bank of India is issuing licenses to microcredit NGOs in India to become microcredit banks. This is the beginning of the right steps towards inclusive financing. But there is still a long way to go. There is an empty space for providing varieties of essential financial services to the unbanked, exclusively designed for them, not just offering them nano-versions of what is being done by the conventional institutions for their regular clients.

I have been arguing for years that credit should be recognized as a human right, so that it can be addressed seriously, and be given the importance it deserves. We can establish this human right only by creating complete financial system for the poor.

Critics of GB always pointed out that the loans it gives is actually wasted because the poor don't know how to use the money. It only adds to their debt burden. The reality turned out to be far from that. Instead of accumulating debt burden they accumulated large savings, now bigger than their outstanding loans. GB helped

them to prove themselves to be excellent savers, proud owners of investment capital, and owners of a financially robust nation-wide bank. I have been arguing that all human beings are born with unlimited creative power. If the society gives them the chance to unleash this power it will surprise everyone.

Critics argue the opposite. They warned us not to waste our money by giving it to the poor people, rather to give it to people who can employ them in large numbers. I did not see it their way. I wanted to turn the poorest women into entrepreneurs by bringing out their suppressed talent of entrepreneurship. The critics seem to believe that entrepreneurship belongs only to small class of special people, the rest are born to work for them.

If we leave the financial institutions unchanged, they will only keep on adding fuel to the wealth concentration. To slow down concentration of private wealth two things need to be done. Existing financial institutions have to be redesigned to make sure they cannot remain to be the facilitating vehicle for wealth concentration. Secondly, we need to build an entirely new set of financial institutions to deliver all financial services to the poor. It is extremely important to provide financial services to the poor so that they can move up on their own. These exclusive institutions should be designed as social business rather than allowing them to become instruments of personal profit making for the rich, which in turn would strengthen the wealth accumulation process for them.

If one wants to find out why the wealthy becomes wealthier, all one has to do is to look closely at the financial institutions. They are the engines which drive wealth concentration. If we wish to see change in the wealth-pyramid in favour of the poor, a new financial system is a must. Existing system has not only created the wealth-pyramid, it is making it worse at a faster and faster rate.

Social business

Working with the poor led me to know many other problems of the poor. I tried to address some of them. I always tried to solve each problem by creating a new business. Over time it became a habit with me. Every time I confront a problem, I created a business to solve it. Soon I created many companies, and company-like independent projects, such as, housing for the poor, sanitary toilets for the poor, health care, renewable energy, nutrition, water, nursing college, eye care hospital, auto mechanic training school, and many more.

They gradually started displaying some common features. They are created as sustainable businesses, but no one is allowed to take any personal profit out of it. Investor gets back the investment money, nothing more. Company's profit is ploughed back into the company for improvement and expansion. I called this new type of business as “social business”, defined as a non-dividend company to solve human problems.

I was amazed how easy it was to solve human problems if we designed it as a

business with the sole mission of solving a problem, and with no intention to benefit personally from the business. We are always told that business-engine was designed for only one use, making personal money. I used the same engine for a completely different purpose, that is, to solve human problems. I found it extremely powerful in getting the job done. Suddenly all the creative power could be marshaled behind this engine for one specific purpose -- solving human problems. I wondered why the world left the problem-solving to the governments and charities alone? I found my own answer. It was because business world was given a very clear mandate by the economic theory. Their only mandate was to make money, leaving the people's problem to be addressed by governments and charities. A businessman is supposed to be driven by self-Interest. To him, business is business.

Human beings are not money making robots. They are multi-dimensional beings with both selfishness and selflessness. When I create a social business I am allowing the selflessness to be expressed through business. Old interpretation says that selflessness cannot be a part of the business world, it is to be expressed in the world of charity. My point is if human being has selflessness in his DNA, why it should not be allowed in the business world. Business world should be an unbiased playground for both selfishness and selflessness. Economics text book should introduce two types of businesses to the students, self-interest driven business and selflessness-driven business. Let the young people decide whether they would like a cocktail of both businesses mixing them in various proportions, or enjoy each one separately.

In the world of selfishness driven business, many express their selfishness in its extreme form, they become limitlessly greedy. They become addicted to money. In the process mankind has been brought to the verge of losing its human identity. A human being is a person of love, empathy, compassion, and fellow feeling. If we create a conceptual framework that allows us, indeed encourages us, to express our deep rooted human values in our economic life we can transform the wealth-pyramid into a wealth-diamond. These values can be expressed through social business to take us there.

Social business may be seen from two perspectives. From charity side, we can look at it as sustainable charity. From business side, we can see it as a selfless business. Great thing about social business is that it is done by choice, no compulsion is involved. One can go in and out of social business as one likes. This makes people feel free. They can decide what they want.

I am glad social business is drawing attention from all sections of people from all around the world. Universities are opening social business centers, multinational companies coming forward to set up social businesses, young people are getting attracted to the idea. More and more people are convinced that as human beings we are capable of solving all our problems. Combined power of youth, technology, and social business will make it happen.

Technology

Technology is expanding exponentially. What is impossible today becomes possible tomorrow. Dramatic changes take place in technology in such quick succession that it does not surprise us anymore. Young people are the beneficiaries of the full power of this incredible technology. They absorb the new technology much faster than the older generation. It is only the power of their imagination which limits the exploitation of each new technology. The bolder their imagination the greater are their accomplishments. If they start imagining a world where wealth disparity shall not exist, I can guarantee you that it will not exist. The combined power of the youth, technology, and social business can become an irresistible force.

Education has to play the key role

Education has to play the key role to bring the wealth concentration problem to the consciousness of people. Reorientation of education system is vital. Despite its ambitious goals, education system has basically become a training ground for preparing young people to be job-ready. It is assumed that every young person has to be able to find a job. Job is such an overriding issue that all other purposes for education had to take a back seat. Education is supposed to help a young person to discover himself and to find meaning of his life. The motto was to "Know Thyself." Now most of the time he is kept busy to "Know Thy Boss."

I find it extremely demeaning to imagine such a fate for human beings. I see human beings as beings much larger than spending life time trying to fit themselves into the wishes of their bosses. I see human beings as go-getters, creator of new horizons, and problem solvers.

We are not job seekers, we are job creators

Human beings are packed with unlimited creative capacities. They have to discover their potential during their life time. Task of education is to introduce them to their potential as a human being, so that they become aware of their power, they start imagining the use of their power. The least education should do is to prepare them as entrepreneurs- as job creators, not as job seekers. There is a world of difference between the two. By training young people as jobseekers we create unemployment because there is no job for everybody. If we had prepared them as job creators, there would be no unemployment.

Can everybody be an entrepreneur -- a question that is frequently asked. Entrepreneurship is natural to human beings. That's how we began life on this planet. Millions of microcredit borrowers all around the world are entrepreneurs. If illiterate rural women can become entrepreneurs, why should we question the entrepreneurial ability of the educated young? All they need is a supportive financial system.

We have created social business funds, as the supportive financial institution. We are asking young people to come up with business ideas. When they come we invest in their businesses. We become their

partner, like an angel investor with one exception, we don't take any profit from them because we are social business. Once they are successful they buy back our shares without giving us any profit. They pay a share transfer fee, a fixed fee to help us cover our management and advisory services.

Now thousands of young people, boys and girls, are running their businesses with partnership with us. We encourage young people to believe and practice that "we are not job seekers, we are job creators".

I am very happy to see that Indian Prime Minister Mr. Narendra Modi has been repeating again and again in his speeches to the young people of India that "we are not job seekers, we are job creators". He has established a refinancing bank, called Mudra Bank, to support the actual implementation of the programme. I hope he succeeds in building up a support system to make it real.

Once we get our education system transformed to produce creative entrepreneurs, the global picture of wealth gap will start changing. If we leave the talented young people with the destiny of making other people rich, wealth-concentration will continue to soar. We cannot let our young people become mercenaries for wealth concentration.

To counter the concentration of wealth we need a two-way flow of wealth, instead of a one way flow. Present flow takes wealth upwards to the wealthy. We need a flow which will bring wealth from the wealthy to the wealth-less. I see social business as this new force. Whether it will be as strong as the existing upward moving force will depend on how strongly people rally around it.

Resources for social business

As I go about promoting social business concept, I feel happy to receive warm response from all countries. Now social businesses are growing up in many countries. While discussing social business a question always comes up: where can we find the investment funds to enable social businesses to spread around the world?

Charity

Existing investment funds are available only to personal profit making enterprises. The more personal profit you can promise or deliver the more investments you get. These investors have no reason to pay attention to social business. Where should social business look for investment funds? Of course, it has to come from the selfless part of human beings. Selflessness has the best expression in the charity world. Anything that happens in charity world gives us a measure of selflessness that is already expressed. It is a matter of time to see how to convert some charity money into social business investment money. After all charity and social business has the same root. Both focus on helping people.

Charity has been with us since time immemorial. It has been recognized as an integral part of human beings. All religions put great emphasis on it. Islam puts it up as one of its five fundamental pillars, and requires that every Muslim to give away

2.5% of wealth and income every year. Imagine how much of potential this sum is. If we add up the amount actually paid out every year that will be a huge sum too. Total amount of charity given out by US public charities (organizations based on raising money from general public and others) each year is over $1.6 trillion dollars. They have combined assets of over $3 trillion dollars. These two I mention as examples. There is an enormous variety of charities with huge amounts all around the world.

Personal giving

In addition we can go over the innumerable stories of personal giving. Mark Zuckerberg is a recent one. He announced on the occasion of the birth of his daughter that he would donate 99% of the shares of Facebook to charities over course of time. The present value of this is $45 billion. He started out by giving away one billion dollars a year. I find it a very interesting case of selflessness. It was done on the occasion of the birth of his first child. Usual story would be that father handing over the inheritance to his new-born ahead of time as a gesture of love. Mark did the opposite. He deprived the child from inheritance by giving away his wealth for creating a better world for her. Usually one gives away wealth at the end of one's life. Mark made a remarkable decision; he gave away nearly all his wealth at the beginning of his life. He is only 31. Since the beginning of Facebook Mark takes a salary of only one dollar as the CEO of Facebook. He already signed up "The Giving Pledge" when he was 27. Zuckerberg, Bill Gates, and Warren Buffett signed a promise in 2010, they called "The Giving Pledge ", in which they promised to donate to charity at least half of their wealth over the course of time, and invited others among the wealthy to donate 50% or more of their wealth to charity. The Giving Pledge started out with 40 multi-billionaires. Now there are 141 multi-billionaire signatories.

I highlight the case of Mark because he is young. He is at the age when one is expected to be ambitious about money, and remain busy with “building the future". He has been doing the opposite. Mark may represent a new trend among the young generation. They are different. They are more committed to the creation of a better world than just making their fortune. The old generation may be holding them up by passing on their old structures to them.

As the idea of social business becomes popular, a part of charity money, wherever the law or religious requirements will allow, will start flowing into social business. And that flow will continue to grow. As decisions are taken, a question will arise, should I give it to charity or rather give it to a social business fund. Individuals, charities, foundations, companies will see social business as a sustainable charity, where the same money can be used endless times.

Selflessness in the business world

But what about business money? Will the business door remain ever closed to social business? I don't think so. Already there are many examples of selflessness in the

existing business world. There were many even in the past. Unfortunately they were never made part of the business school curriculum. I give two outstanding examples from the past, which are still going strong.

Bosch

Bosch is a 130 year old German multinational engineering and electronics company, with an annual revenue of $ 50 billion. It is a familiar name throughout the world. Not many people know that it is owned by Bosch Foundation. Founder of the company created a foundation to own the company. Only 8% of the shares were given to the family. It is still that way. Foundation manages the company and use the profit for charitable activities. If we are looking for an example how business and selflessness can be combined Bosch is a good example. This is what I call type 2 social business, a company owned by a trust or a foundation to solve human problems.

Tata trust

Another example is again a household word in many parts of the world, particularly in South Asia. This is Tata. Founder of Tata did the same thing 128 years ago. Two-third of the shares of Tata group of companies, worth $118 billion, is owned by Tata Trust.

There are endless examples, big or small, old and new, all around the world. These are examples of defiance of the capitalist rules, but done in a smart way so that they could not be excommunicated from business world. They led the initiative to create a new business world. These examples could have been followed boldly and massively. But orthodox theory of business did not recognize them.

Corporates and social business

Besides individuals, corporates can also invest in social business. Usually corporates create foundations for their companies. They can easily direct the foundations to invest in social businesses. Foundations can invest in regular companies, and make money to invest in social businesses, like in Bosch and Tata examples. In addition, corporates can create social businesses as their subsidiaries, can have joint ventures with other social businesses. Already we have many excellent examples of joint venture social businesses created by Danone, Veolia, Uniqlo, Intel Corporation, McCain, Euglena, and others.

Corporates can do something else. They can invite their shareholders to sign a "giving pledge". Shareholders will be asked to give their consent to allow a percentage of their dividends to be deducted to go into a social business fund as their equity. In case of necessity these shares in the fund can be sold to another social business investor at the face value. That way, their money is not gone forever. Corporates can use their annual CSR contribution to go into a social business trust.

I have been trying to draw attention of investment funds to a similar programme. They manage huge funds. Total worldwide assets invested in mutual funds alone amounts $30 trillion. There are many types

of investment funds. All put together it amounts to an ocean of money.

My proposal to them is to give each individual investor a choice whether he/she would like to set aside, say, 2.5% (or more, or less) of his assets to create a sort of recoverable endowment fund. Annual Income from this recoverable endowment fund then can be invested in social businesses. All that an investor has done is to sacrifice the income of 2.5% of his assets to achieve some social objectives, without sacrificing his assets. If the companies agree and the investors agree this recoverable endowment fund can potentially be enormous.

I have been suggesting to top policy-makers of giant pension funds to apply the same policy to create recoverable endowment funds. Globally, pension funds have a combined total assets of $ 84 trillion. All they need to do is to take the initiative to write to their investors about the plan and seek their consent by signing up. I did not get positive response yet. They explained that nobody will respond positively to this idea because all that the investors want is the growth of their funds, they are not interested in giving. I politely pointed out that they may be surprised by the responses, they may be completely contrary to their expectation. I tell them if you don't ask you'll never know what surprise is waiting for you. I have concrete experience of seeing a Fortune 500 company asking a similar question to all its shareholders and getting a totally unexpected positive from 98% of shareholders. Of course, not in every occasion we may be as lucky as that. All shareholders or investors may not sign up after the first call. If some of them sign up that will be the beginning of a great story. It will snowball if the result produced by social businesses is convincing.

It is all about taking initiative. It may begin with one pension fund in one city. No matter how small the response, it opens up a door which may get wider over time. But a beginning has to be made. We have no reason to hide behind our age-old conviction that investors are interested in nothing but making money. They see nothing else, and hear nothing else. We must remain aware that the world and people are changing. They have started to behave differently. Their behavioral pattern will continue to undergo changes.

Money generated from the recoverable endowment fund borne out of pension funds can be invested in taking care of all old people, from the richest to the poorest, with differentiated prices. It will create social businesses to provide health insurance, health facilities like hospitals, clinics, nursing services, income opportunities, hospice care, old peoples home, housing, sports, travel etc.

Social business day

Whenever people look for ways to bring down the wealth-gap they will find social business as a very powerful tool to make it happen. Social business will slow down the process of accumulation at the top while people at the bottom will build up their asset base and retain whatever they earn.

We can play our role too. All of us can

examine the concept to see if it makes sense. Each one of us can come up with social business ideas. Idea is the most precious thing in social business. Each one of us can decide to invest in social business directly or through others who are involved in it. We can earmark 5% of our annual income and put it in a separate account, sort of personal social business fund, to invest in social businesses. To give a simple idea, anyone can transform 5, 10, 25 or more unemployed youth into entrepreneurs. We can show you how we are doing it. You may like it.

We hold a big event, a Social Business Day each year. This year it will be held on July 28-29. In addition to sessions devoted to exchanging experiences in social businesses throughout the world, we will hold Country Forums to let the delegates from each country exclusively country-wise sessions to discuss plans for social businesses in their own countries. They will bring business leaders, political leaders, academics, foundation leaders, to participate in these country forums.

You may like to think about what you can do in slowing down wealth concentration. You can play a role in reducing wealth gap with some simple steps. Think about creating your own "giving pledge" or create a collective giving pledge with your friends and your business partners. You may decide to make a "will" now, to leave most of your wealth or at-least half of your wealth during your life time, to a social business fund of your own, or to a trust dedicated to solving human problems through social businesses. You may think about leaving all your companies in the hands of a trust. That way your wealth will perpetuate and grow as Bosch's and Tata's grew, and contribute fundamentally in changing the country, as well as the world.

I remind everyone that making money is happiness, but making other people happy is super happiness. Don't miss the super happiness. It is better to act now, than later, so that you can see things happening and enjoy the super happiness resulting from it, rather than waiting for things to happen when you are no longer around. Invite your children to run social business funded by your trust or social business funds. You will be surprised to see how much they are enjoying doing that. Instead of just being successful second generation entrepreneurs they may become global celebrities by creating and successfully replicating social businesses globally. They will enjoy being leaders of the new global generation.

Anybody with above a certain level of wealth may make a will to give away his or her wealth to social business trusts or funds. Their children may remain involved in these trusts or funds, so that they don't feel they are left out of the control of their parent’s wealth. You'll be amazed how you and your family can impact the whole world.

If you wish to take any one of these initiatives, we at Yunus Centre would be happy to offer our services to make it happen. Don’t hesitate to contact us. In addition, to experiment with social business you can create a joint venture with your friends, or your international business partners, and see how it feels. It

could be as small as you want. Size is no issue. The purpose is the issue. Bangladesh has been a pioneer in bringing down poverty by half. World has applauded it. We can be the leader in reversing the process of wealth inequality too. Instead of allowing inequality to increase each year, faster than previous year, we can make it decline each year, as the economy grows. Then we can call for a global Paris conference (may be Dhaka conference) to bring all the nations of the world to tell the story how we made it happen, who did what in the process. The conference will end by inviting the UN to convene a conference to let every nation declare a deadline when it will stop the increase in wealth gap and reverse the process. It would be similar to the global commitment to stop the increase in global temperature and hold it under 1.5 degrees Celsius.

Conclusion

Wealth-concentration is a global threat. It has already entered the danger zone this year with 99% of wealth going to 1% of people. Not only it is getting worse globally, it is getting worse within nations, and between nations. Wealth gap between nations is always a threat to peace. Historically some nations had accumulated more wealth than others. Some nations took unfair advantages over other nations in accumulating their wealth. There are old scores to settle and there are new scores taking shape. This leads to confrontations, conflict, and wars. If a nation feels threatened they hike up their military budget, which is shockingly huge already. Present annual global military expenditure stands at over $1.7 trillion. US alone accounts for 39% of this total. If the wealth-concentration within and among nations become acute, social, political and economic compulsions for armed conflicts will become imminent.

The time is ripe for us to recognize the gravity of the situation on wealth-concentration, and take actions against it. As we learn from the process of arriving at an international consensus on global warming, we can also initiate a similar process to build a global consensus on bringing the speed of wealth concentration to zero in phase one, and making it negative in phase two. Both global warming and wealth concentration arise from the same root -- a flawed economic framework based on human greed.

We can undo both by reinventing ourselves in the economic world as caring and sharing human beings. We may aim at creating a world of three zeros: zero poverty, zero unemployment, and zero net carbon emission. A world of diamond-shaped wealth distribution. A world of equality, harmony, peace and happiness. It can happen only if we citizens get into the action.

Globalisation: Challenges and opportunities

Y. V. Reddy

Globalisation may be defined as the process by which greater connectivity is achieved in regard to ideas, goods, services, finance, and people, across the borders of nation states. The restrictions on movement of people is a phenomenon of early 20th century while globalisation as a concept came into prominence in later part of the 20th century. 21st century so far has seen explosion of global finance, then a crisis, followed by uneven recovery and more recently a dampening of the process of globalization, especially in growth of trade and capital flows.

There are several areas of global economy and national policies that would be subjected to rebalancing as a result of the global financial crisis. Such a rebalancing will have to be based on three factors, viz., the lessons of experience from the events leading to the crisis; the after affects of policies undertaken to manage the crisis; and, the evolving socio-political and economic factors in different parts of the world, including in particular demographic profiles. Rebalancing has to include capital, trade, employment, monetary system, financial architecture, and above all, global power balances.

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First, it was assumed that globalization of finance will result in the capital flowing from advanced economies to developing economies, thus helping the developing economies to accelerate their growth potential. However, the global capital has moved uphill, *viz.*, from poor countries to advanced economies, on a net basis. This phenomenon may persist and even intensify in the future.

Second, the global trade continues to be a source of hope for growth for many developing countries. However, the enthusiasm for globalised trade is getting moderated in advanced economies due to the crisis and high levels of unemployment. The extent of current unemployment in advanced economies may be partly cyclical and significantly structural. The technical solution to solve this problem is improving the productive capacity of the labour force in advanced economies to match their current standards of living, but their age profiles make it difficult to improve skills among them. The economic activity in developing countries and in the global economy are likely to increase significantly, and hence trade among developing countries is likely to grow faster than trade between advanced and developing economies. Some of the developing economies may shift their demand to consumption from investment, while in some others, investment may gain priority. The labour costs are likely to increase in some of the developing economies. Overall, replacement of advanced

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economies as the locomotives of growth in global economy by the emerging market economies may be inevitable, but may occur over a longer term than widely believed.

Third, the employment trends in global economy have been particularly disturbing after the global financial crisis. The globalization of capital has enabled capital to move to areas where labour is least expensive. This also brought about unionization of global capital along with deunionisation of labour at the national level. The bargaining power of labour has been considerably eroded both by technological progress and breakdown of its union power (capital is mobile across countries, but labour is not), though this phenomenon is more prevalent in advanced economies than developing economies. The interplay of employment, demography, migration, and globalization may be more challenging for public policy in future. In addressing these issues, inequalities and social cohesion within each country may dominate the discourses.

Fourth, the international monetary system is described as non system because the dominant global reserve currency, *viz*., U.S. Dollar is not subjected to market discipline, and is not bound by any globally agreed set of rules. The weaknesses have been recognised, but no feasible new system is on the horizon. Replacement of one national currency with another will not solve the fundamental problems of such a non-system. Replacement of one currency with multiple currencies may diversify the risks, but the externalities will push the system towards dominance of one currency. SDR is essentially an accounting unit and not a currency. A global currency is not feasible without a global monetary authority endowed with powers to expand money supply, contract money supply and act as a lender of last resort, when essential. In fact, the problems arising out of current monetary non-system may be more complex in future than those before the crisis because of the threat to U.S. Dollar position over the medium to long terms, without a viable alternative.

The limitations of the present global financial architecture comprising IMF, World Bank, WTO, and possibly G20, are well-known. Improvements in their resources as well as governance have been made, but by all accounts they are marginal. There are signs of diminishing returns from G20, though there is promise of greater role in future. These considerations give rise to a strong possibility of lack of substantial improvement in global monetary and financial systems, and possibility of greater uncertainties and tensions in the global monetary system and financial architecture.

Fifth, there are efforts to improve the financial regulation in the global economy, and in particular designing minimum standards of regulation in different countries. Regulation of cross-border activities and financial conglomerates, has gained attention, particularly after the recent developments. There is considerable skepticism about effective regulatory regimes in the major international financial centres simply

because they can continue to be global financial centres mainly through soft regulation. Further, globalization of finance without globalization of fiscal management may pose problem as illustrated by the experience in Euro Zone. Experience has shown that financial sector problem spillover into fiscal, and fiscal problem can impact financial sector in a variety of ways.

Finally, there is an increasing recognition that global power balances would shift from West to the East, and in particular, to Asia. There is considerable consensus that incremental economic activity in the global economy and incremental trade will shift considerably to the developing economies, in particular, Asia. It is not very clear whether financial intermediation will undergo a corresponding shift. More important, in terms of institutional capital and human capital, the advanced economies are way ahead of the developing economies. The shift of global power balances is also influenced by the social and cultural factors.

India will inevitably be an important part of the shift in power balances.

Out of the bubble: Heritage professionals in times of increasing polarization

Hester Dibbits

In our globalizing world, identity politics seems to be gaining momentum. How can heritage professionals respond? Is it their job to select tangible or intangible heritage items and use them to create attractive and collective narratives, with the aim of establishing a strong sense of group identity? Should they support initiatives towards the establishment of fixed heritage repertoires, linked to a fixed set of standards and values, hoping that all citizens can identify with those, behave in accordance with them, convey them, and, in doing so, feeling part of a collective, a community?

Embarking on identity politics may make some heritage professionals feel uncomfortable, since it inevitably implies exclusion. Collectives can bring about solidarity and a sense of pride; they can empower, offer the possibility to claim rights on behalf of the group, but at the same time they are rigid: collective identities do not always match personal identities, solidarity remains confined to one group, and the leaders of the collectives become the "representatives" of the group (McCarry and Jasper 2015, 3).

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In his book *Liquid Times* (2007), sociologist Zygmunt Bauman describes "the paradox of an increasingly local politics in a world increasingly shaped and reshaped by global processes". He notes that "the more [people] 'stick to themselves', the more 'defenceless against the global whirlwind' they tend to become, and so also less capable of deciding, let alone asserting, the local, ostensibly their own, meanings and identities – to the great joy of global operators, who have no reason to fear the defenceless" (Bauman 2012, 113). Bauman is referring here to the "local identity politics" deployed to stay on top of the global whirlwind, but one can argue that *national* identity politics springs from a similar need. The outcome is a getting together of like minds.

According to sociologist Richard Sennett, the desire to resemble each other is people's way of avoiding the necessity to get to know each other. But, Sennett says, there is hope. As it happens, people have the talent to observe, to listen, and to imagine other people's points of view. We sort of neglected this talent, but the problem can be fixed: with the right guidance, it can be developed (Sennett 2013). One may wonder if appealing to a past as a form of identity politics is the solution. By using an appeal to the past to establish the essence of the collective in the present, one creates the notion that there would be something like a people, a

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tribe, with descendants sharing a past through inheritance. This notion may appeal to those who (wish to) consider themselves descendants, but what if we want to get rid of the idea of such a tribe? We need a different approach; one that enforces the breaking of bubbles.

To enforce the breaking of bubbles, one could argue for an active quest for alternative voices (to be confronted with each other in conversation) and the visualization of these different voices. This comes down to addressing the different views, interests and emotions existing and arising around a heritage item. Heritage is a hallmark attributed in an interplay of forces involving a diversity of interests and emotions. Heritage is not a given. It comes about whenever it is advanced, rooting in a desire for collectivity and continuity. People turn things into heritage by labelling them as monuments, housing them in museums or putting them on inventories – looking to the future with reference to the past. The selection process does not take place without a struggle, and the result is in no way neutral. If only the like-minded are gathered around a heritage item, it is impossible to gain insight in any latent conflicts. Given the fact that heritage professionals are among the participating parties, they cannot operate without a profound understanding of the dynamic character of the above mentioned interplay of forces concerning interests and emotions, and the context-bound nature (time, place, group) of the result.

But heritage professionals can do more than that. They can help other people to develop such an understanding. How?

The Amsterdam based organisation Imagine IC* and the Reinwardt Academy (Amsterdam University of the Arts) started researching the notion of “emotion networks” – the fickle, emotional constellations surrounding heritage items. We made steps towards the development of a tool that shows how people – by getting out of their “bubble”, and exchanging thoughts about heritage items in varied company – can change their positions, and, who knows, even get nearer to each other. In the present phase, we aim for visualization, imagination, mirroring, displaying the multitude of voices and the shifts that might occur in people's positions (Dibbits and Willemsen 2014; Rana, Dibbits and Willemsen under revision). In addition, we investigate how the multi-voice and multi-time approaches could be combined, making museal collections and archives accessible in a multi-voice way, in retroaction.

One of our main aims is to help developing heritage skills, which we consider to be part of a form of critical heritage education with lessons about heritage formation, including people's roles and responsibilities. Is this a complicated process? Not necessarily so. Inviting people to think about heritage making as a process, almost any heritage item can function as a case, as long as one takes a the multi-voice approach. Projects can be limited in size: it keeps things workable. It offers the possibility to gradually move towards a cooperation with others who

work from a similar critical perspective. It seems obvious to think of the arts sector here, but other sectors might also provide interesting opportunities for cooperation. By cooperatively investing in critical heritage education, heritage professionals may help to stop polarization and this, in the end, is what we aim for.

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* Imagine IC "pioneers the heritage of contemporary living together". It is based in Amsterdam Southeast, a 1960s metropolitan extension. Upon the Surinamese independence in 1975, considerable numbers of people of Surinamese background came to inhabit the area. Until today, it has daily received new people from all over the world. In the house that Imagine IC shares with the local branch of the Amsterdam public library, young people from the neighbourhood and the city challenge concepts of who "we" are.

Why is Marx the most influential thinker of all times?

Göran Therborn

A recent issue (no. 5 2017) of the leading German liberal weekly *Die Zeit* devoted upper half of its large front page to asking " Was Marx right after all?" The answer was somewhat half-hearted, as liberalism often is, At least in some respects, referring primarily to the galloping inequality and the sundering of the current capitalist world.. Germany's most powerful liberal economist, decöared, "Marx' s crisis theory is highly relevant today".

The global influence of Karl Marx is one of the most remarkable facts of intellectual history. No other non-religious thinker can rival it remotely. Among human beings, only the founders of the world religions have had more impact. Mass political parties and movements have formed out of his ideas, revolutions have been made under his inspiration, state governments on all continents have invoked him. Marxist or Marxian social thought and social science have developed in places of research and higher learning all over the world. Like all classics Marx has had cycles of boom and recession, and of strongly variable readings and interpretations, but he remains the intellectual pivot of the modern world, in the South as well as in the North. How can Marx's unique position of influence and inspiration be understood and explained?

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The Marx phenomenon has to be grasped as a concatenation of several factors.

First of all, Marx was the most profound critical analyst of the economic system which has come to dominate the whole world, capitalism. Its spatial expansion and acceleration have given name to our current epoch, globalization. Only a minority of current Marxists would claim that Marx was completely right in his analysis of capitalism. Most will hold that, for instance, the labour theory of value, which Marx fetched from Ricardo, is untenable. What made Marx's analyses of capitalism so influential is not that they were all true, but their historical approach and remarkable foresight, their dialectical perspective, their comprehensiveness, analytical edge, and, in crucial parts, accessible language.

Marx wrote at the beginning of the capitalist revolution, on the threshold of its international breakthrough. Marx studied in detail the most advanced form of capitalism in mid-nineteenth century, the British, and he predicted its coming conquest of the world. The fundamental basis of Marxian economics was a historical approach to an epochal social transformation just started.

At the same time as he was predicting capitalism's conquest of the world, he alerted his readers to its contradictions, its recurrent crises, and its generation of its

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own resistance, the working class and class struggle.

Both these central predictions turned out true, validated by historical development. Industrial capitalism triumphed and spread. The working class grew and resisted. It formed trade unions and labour parties, which, to varying degrees succeeded in civilizing capitalism. No social theorist or analyst of modern times has made predictions of comparable scope, boldness, and accuracy.

The range of Marx's analyses of capitalism meant that different readers at different times could find arguments of particular interest to them. Among liberal readers, around 2000 the New York Times ideologue Tom Friedmann and others became fascinated with the *Communist Manifesto* for its prescient portrait of capitalist globalization 150 years later, and today's serious liberal economists are reading Marx for the relevance of his crisis theory. On the intellectual left, faced with the onslaught of postmodernism in the late l970s-l980s, an American Marxist, Marshall Berman, picked up courage from his discovery that Marx was a modernist. Nobody had thought of that before, although in fact it was there for all to see. In the first eight pages of the *Communist Manifesto* Marx talks about "modern" twelve times, modern industry, modern bourgeois society, modern working class, modern state power etc. And in his preface to the first edition of *Capital* he said that his "ultimate purpose" was to "disclose the economic law of motion of modern society".

But his most important readers were the ones who were most exconcerned with what he had to say about capitalist exploitation, capitalist misery, and the possibilities to resist, and to overcome them. Marx lived and wrote in the dawn of the modern class of wage-workers, at the outset of the first big strikes, the first trade unions, the first political mass organization of workers – the British Chartists -, and the very beginning of workers taking part in urban revolutions – for whom the *Communist Manifesto* was written. Marx was a leading figure in the first workers' International, of 1864.

Marx' dialectical critique of capitalism provided the incipient, growing working class movement with an enormous self-confidence and resilience. In spite of their still limited numbers and despite the well-entrenched power of pre-capitalism as well as of capitalism, working class militants saw themselves as carriers of a better future. Without elaborating any prescriptions Marx also gave that future a name and a visible horizon to strive towards, socialism and communism.

Marx grew up in the aftermath of the French Revolution, and his work was focused on Europe, before the late l9th-early 20th century heyday of European capitalist imperialism. It was Lenin and the Russian Revolution which put Marxist analysis at the centre of modern anti-imperialism. Marxism became also the only social science and political theory of anti-colonialism. Marx got millions of new readers and admirers in Asia, Latin America, and Africa, and Marxism came to inspire eventually victorious class-based

nationalist parties and movements, in China, Vietnam, Indonesia, India, and other countries.

In the last quarter of the 20th century, the word turned. De-industrialization and financialization in the centres of capitalism dealt a heavy blow to the working class and the labour movement. The attempts at socialist industrialization, in Russia, China, Vietnam etc. reached their limits and imploded or were abandoned. Socialism disappeared from the horizon.

However, we have already seen that Marx has not become obsolete. New interests in and angles on his work are recurring, in many places. There are two main reasons.

First, we are still living under capitalism, with its contradictions, class cleavages, class conflicts, and its crises. In Marx's work and in a Marxian approach there is a rich, enormously important research agenda, about the implications of the new post-industrial dynamics of capitalism and its crises, about the resistance potential of the new, huge East Asian industrial working class, about the stability or instability of global capitalism in its intertwining with new social landscapes, of new class configurations, of the resurgence of religious, ethnic and other pre-capitalist cleavages, under the darkening cloud of climate change.

The other reason is the moral and intellectual example of Karl Marx, as a proponent of emancipatory reason, as a critical intellectual committed to the struggles and the liberation of all the downtrodden and oppressed.

The punitive regulation of poverty in the neoliberal age

Loïc Wacquant

How and why has the prison returned to the institutional forefront of the advanced societies, when four decades ago analysts of the penal scene were convinced it was on the decline, if not on the path toward extinction? In my book Punishing the Poor, I make three arguments to resolve this historical conundrum. First, the expansion and glorification of the police, the courts and the penitentiary are a response not to criminal insecurity but to the social insecurity caused by the casualization of wage labor and the disruption of ethnoracial hierarchy. Second, we need to reconnect social and penal policies and treat them as two variants of poverty policy to grasp the new punitive politics of marginality. Third, the simultaneous and converging deployment of restrictive "workfare" and expansive "prisonfare" partake of the forging of the neoliberal state.

Ramping up the penal state in response to social insecurity

My first thesis is that the ramping up of the penal wing of the state is a response to social insecurity, and not a reaction to crime trends. In the three decades after the peaking of the Civil Rights movement, the United States went from being a leader in progressive justice to apostle of "zero tolerance" policing, architect of "Three Strikes and You're Out," and world champion in incarceration. Why? The conventional answer is that this stupendous expansion of punishment was driven by the rise in crime. Mais voilà, victimization first stagnated and then decreased during this entire period. Consider this simple statistic: the US held 21 prisoners for every 10,000 "index crimes" in 1975; thirty years later, it locked up 125 prisoners for every 10,000 crimes. This means that the country has become six times more punitive, holding crime constant.

To explain this punitive turn in penal policy in the United States, we need to break out of the crime-and-punishment box and pay attention to the extra-penological functions of penal institutions. Then we discover that, in the wake of the race riots of the 1960s, the police, courts and prison have been deployed to contain the urban dislocations wrought by economic deregulation and the implosion of the ghetto as an ethnoracial container, and to impose the discipline of insecure employment at the bottom of the polarizing class structure. As a result, the resurging prison has come to serve three missions that have little to do with crime control: to bend the fractions of the postindustrial working class to precarious wage-work; to warehouse their most disruptive or superfluous elements; and to patrol the boundaries of the deserving

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citizenry while reasserting the authority of the state in the restricted domain it now assigns itself.

If you cross the Atlantic, you will note that Western Europe sports comparatively modest rates of confinement, ranging from one-sixth to one-tenth that of the United States. But this must not hide two crucial facts. First, penalization takes many different forms and is not reducible to incarceration. Second, incarceration rates have shown steady and sturdy growth across Western Europe since the early 1980s: they have grown by more than one-half in France, Italy, and Belgium; nearly doubled in England and Wales, Sweden, Portugal, and Greece; and quadruple in Spain and the Netherlands, long held up as model of humane penality. In reality, a drift towards the penalization of urban marginality has swept through Western Europe with a lag of two decades, albeit on a smaller scale (commensurate with the makeup of the state and social space in these societies).

This drift presents three distinctive features. First, the new penal laws embraced by European governments typically "bark" louder than they "bite" because the texture of social and economic citizenship is more robust, human rights standards thwart excessive criminalization, and judicial professionals have been able to resist penal extension from within the state apparatus. But hyping "insecurity" and promoting crime-fighting in and around districts of dereliction to the rank of government priority, ahead of fighting unemployment in these same areas, has definitely shifted government priorities in favor of penal posturing and action.

Second, European societies endowed with a strong statist tradition are using the front end of the penal chain, the police, rather than the back end, the prison, to curb social disorders and despair in low-income districts. One example: in France, the inmate population has risen by one-third over the past decade, but during that same period the number of persons arrested and held overnight for a "garde à vue" in a police lockup nearly tripled to approach the extravagant figure of one million. Third, instead of a brutal swing from the social to the penal management of poverty as in the United States, continental countries have intensified both, expanding welfare protection and police intervention simultaneously in a contradictory thrust that has both stimulated and limited the extension of the punitive mesh.

These three features define a "Western European road" to the penalization of poverty which is not that of the United States. Yet, from a longer macro political perspective, the dominant trend is similar: a punitive revamping of public policy that weds the "invisible hand" of the market to the "iron fist" of the penal state.

Relinking social and penal policy

My second thesis is that we must relink shifts in penal and social policy, instead of isolating them from one another. The downsizing of public aid, complement by the shift from the right to welfare to obligation of workfare (that is, forced participation in subpar employment as a

condition of support), and the upsizing of the prison are the two sides of the same coin. Together, workfare and prisonfare effect the double regulation of poverty in the age of deepening economic inequality and diffusing social insecurity.

My contention here is that welfare and criminal justice are two modalities of public policy towards the poor, and so they must imperatively be analyzed –and reformed—together. Supervisory workfare and the neutralizing prison "serve" the same population drawn from the same marginalized sectors of the unskilled working class. They are guided by the same philosophy of moral behaviorism and employ the same techniques of control, including stigma, surveillance, punitive restrictions, and graduated sanctions to "correct" the conduct of their clients. In some states in the United States, TANF (welfare) recipients stand in line together with parolees to undergo their monthly drug tests to maintain eligibility for support. In others, parolees who fall into homelessness because they cannot find a job are returned to prison for failure to maintain a stable residence.

Nowadays, you cannot track penal policy without reckoning with social policy, and vice-versa. You cannot understand trends in offending without factoring in the sea changes in welfare provision, public housing, foster care, and related state programs, including the oversight of irregular migration that set the life options of the populations most susceptible to street crime (as both perpetrators and victims).

Crafting the neoliberal state

My third thesis is that the meshing of workfare and prisonfare partakes of the making of the neoliberal state. Economists have propounded a conception of neoliberalism that equates it with the rule of the "free market" and the coming of "small government" and, by and large, other social scientists have adopted that conception. Problem is that it captures the ideology of neoliberalism, not its reality. The comparative sociology of actually existing neoliberalism reveals that it involves everywhere the building of a erection of a Centaur-state, liberal at the top and paternalistic at the bottom. Then neoliberal Leviathan practices laissez faire et laissez passer toward corporations and the upper class, at the level of the causes of inequality. But it is fiercely interventionist and authoritarian when it comes to dealing with the destructive consequences of economic deregulation for those at the lower end of the class and status spectrum. This is because the imposition of market discipline is not a smooth, self-propelling process, it meets with recalcitrance and triggers resistance; it translates into diffusing social instability and turbulence among the lower class; and it practically undermines the authority of the state. So it requires institutional contraptions that will anchor and support it, among them an enlarged and energetic penal institution.

Conclusion

The linked stinginess of the welfare wing and munificence of the penal wing under the guidance of moralism are profoundly

injurious to democratic ideals. As their sights converge on the same marginal populations and districts, deterrent workfare and the neutralizing prisonfare foster vastly different profiles and experiences of citizenship across the class and ethnic spectrum. They contravene the fundamental principle of equality of treatment by the state and routinely abridge the individual freedoms of the dispossessed. Moreover, they undermine the consent of the governed through the aggressive deployment of involuntary programs stipulating personal responsibilities just as the state is withdrawing the institutional supports necessary to shoulder these and shirking its own social and economic charges. In short, the penalization of poverty splinters citizenship along class lines, saps civic trust at the bottom, and sows the degradation of republican tenets. The establishment of the new government of social insecurity wedding restrictive workfare and expansive prisonfare discloses, in fine, that neoliberalism is constitutively corrosive of democracy. Yet, it is the result of policy choices, not a preordained necessity. Other historical paths out of the turmoil of the 1960s and the stagflation of the 1970s were open, and remain open. But to locate them we must first elucidate the overall architecture of the institutional maze which contains them, and the deep causes of the shift to the punitive management of poverty. It is my hope that the debates and discussions on this Open Democracy forum will be yet another step in that direction.

1. Punishing the Poor: The Neoliberal Government of Social Insecurity (Duke University Press, 2009)

2. These rate ranges from the 70s per 100,000 residents across Scandinavia to just over 150 per 100,000 for England, Scotland and Spain.

3. This “route” differentiates further into distinct national paths in accordance with each country’s state structure and conception of citizenship.

4. For further developments, see LoïcWacquant, “Crafting the Neoliberal State: Workfare, Prisonfare and Social Insecurity,” Sociological Forum 25.2, Summer 2010, pp. 197-220.

LoïcWacquant is a professor of Sociology at the University of California, Berkeley. His work, widely acclaimed and translated, includes the trilogy, *Urban Outcasts: A Comparative Sociology of Advanced Marginality* (2008); *Punishing the Poor: The Neoliberal Government of Social Insecurity* (2009); and, *Deadly Symbiosis: Race and the Rise of the Penal State* (2011). See loicwacquant.net for more.

Former manual scavengers 'untouchables': How innovative learning and skill-building transformed their lives

Bindeshwar Pathak

Reaching out to the most marginalised

Historically dehumanised as untouchables, Dalits constitute 16 per cent of India's population and suffer from terrible socio-economic discriminations. A section of them, and mostly women, do scavenging, which means they crawl into the dry or bucket latrines, collect the human excreta with their bare hands, and carry it as head-load in a container to dispose it off. The women scavengers represent a large number of people in the world who variously suffer from most severe forms of caste, class and gender discriminations. Employing scavengers to clean excreta is now punishable under the law, yet this work continues in many semi-urban areas.

Sulabh International Social Service Organisation was established in 1970 to build a movement for liberating manual scavengers and eradicating open defecation through a safe and affordable toilet technology. We invented such a technology and over the years constructed a large number of household and public toilets all over India.

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But, our real success lies in helping abolish scavenging and bringing scavengers in to the social mainstream. We have run several campaigns to end scavenging in different parts of India, and here is an account of Sulabh's campaign for providing vocational education and self-employment to the scavenging dalit women of the towns of Alwar and Tonk in the state of Rajasthan.

Innovative education and training for gainful employment

Till our intervention, these women cleaned and disposed human excreta with their bare hands from houses lacking flushing toilets to eke out their living. Our challenge was to devise appropriate modules for their basic education and skill-building that were essential for ensuring their alternative employment without which they could not be freed from poverty, hunger and poor health.

Sulabh established a centre in Alwar in April 2003 with this aim. Against severe odds and scepticism of the local people, this centre was started with the active support of socially conscious scavenging women. We encouraged these women to give up scavenging and learn vocational skills that would help them get better employment. We convinced them and their family members on the importance of health and hygiene, as they lived in filthy surroundings and manually cleaned human

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excreta, alongside giving them functional literacy and numeracy. We took their feedback into account and created a training module to develop their skills in food processing, cutting and tailoring, carpet making, embroidery, beauty care, bag making, etc.

Considering their poor condition, we gave the trainees a monthly stipend. Such courses are normally designed for six months or one year, but we made it a two-year course, as they had been doing nothing except scavenging, for generations. When the first batch of women joined the training centre, 97 per cent of them were illiterate. During the training all were taught to read and write and operate their bank accounts. After training, 115 women have learnt to successfully market the goods they produce. Now these women have organised themselves into self-help groups and are availing credit facilities from banks to buy raw material before making and selling their products in the market, and thus earn a steady income.

The people who once considered them as 'untouchable' are now buying their food products. Their dal, papad and vermicelli are in great demand in local markets. The women trained in beauty-care now are providing service at the homes, the doors of which were earlier closed to such 'untouchables'. Thus, our initiatives have produced encouraging social impact. Untouchability has become a thing of the past in Alwar.

Among the liberated scavengers from Alwar, Usha Chaumar who rose to become the President of Sulabh International and Guddi Athwal, who attended the World Water Forum in 2012 at Marseille, France, and the World Toilet Summit (2012) in Durban.

Alongside these developments, all dry buckets or pit-latrines (which need to be cleaned manually) have been converted into hygienic Sulabh toilets, thus making Alwar a scavenging-free town from 2008 onwards, the Alwar experiment has been successfully replicated in the neighbouring town of Tonk.

Lessons we learned

There is deep urge among the hitherto uneducated and under employed women to get educated and gain a rewarding employment. If the suffering women are given effective means and tools, they are more than willing to break their shackles. An integrated holistic approach is required to solve their problems because the socio-economic and gender inequality do not exist in isolation, but in close proximity with each other. The question of education and employability of women and men in India or elsewhere is essentially the question of their liberation from various forms of structural subjugation which are cultural, social, economical, educational, psychological, and thus all pervasive. Therefore, a larger social movement for equality must accompany any campaign for health, education and empowerment of the suffering people.

Mountaintop removal in appalachia: Environmental degradation and the pollution of the waters of the USA by the fossil fuel industries

Maria Gunnoe

Water, air and land unite life across all boundaries. I have fought for decades to protect the air, water, and land of where I live in the southern Appalachian Mountains from the impacts of coal. Since I first saw mountaintop removal coal mining (MTR) as a child near my community of Bob White, West Virginia, I have feared what it would one day bring. Today in West Virginia alone, well over a million pounds of explosives, the equivalent of over a thousand tomahawk missiles, per day are used to blow the tops off the mountains to get to the coal that powers many parts of the world. More than 500 mountains in the region have been flattened by this mining technique, and over 2,000 miles of streams have been buried or polluted. The people of our communities (our culture) are dependent on the mountains, the clean water and productive land to survive. Throughout my struggle to protect my water, land and air I have met hundreds of thousands of people globally that share the same concern for the future of a healthy, livable environment.

I have witnessed clean water resources throughout the US being polluted and people being made unhealthy by the pollution of the fossil fuel industries.

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The government agencies turn a blind eye and protect industry profit while people suffer from the health impacts of environmental degradation and the pollution of life-giving water resources throughout our country. I fear again what this may bring to my grandson's future. There is no security, health, peace or hope where water is poisoned and the land and air surrounding communities is destroyed forever. Ultimately, the children pay the price for the consumption of these resources, and they unknowingly pay it with their future clean water, air, land and the ability to live healthy lives.

In 2014, a coal-cleaning chemical spilled into the Elk River from where the municipal water was drawn to supply the water treatment plant that piped water to 300,000 people across nine counties. Suddenly 300,000 people were just like me, without healthy water. Even worse, the chemical had never been studied for its impact on human health. Our people are the first "live experiment" of this chemical on humans. Everyone across nine counties in West Virginia spent weeks struggling to have any healthy water at all. Most of the groundwater resources have been polluted by the coal industry throughout this nine-county area, so that was not an option for good water either. In Flint, Michigan, the people are now going on for three years with no good water. In Standing Rock, North Dakota, my Native Brothers and

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Sisters struggle to protect all that makes up their lives and culture. They are up against a government and industry that value nothing but money.

The Ohio River, drinking water for millions, is one of the USA's 10 most polluted streams. The headwaters of the Ohio River begin where I live. The small tributary streams have nearly all been permitted to become pollution spillways by our state and federal government agencies. The coal, chemical and gas industries use our streams and our underground aquifers as their dumping grounds for their toxic waste with no regard for the need of the people for clean healthy water. The government is permitting these waters to be polluted and even increasing the allowable amount of pollution, all while making it easier to blow up even more mountains and impact more people's health. There have been nearly 30 peer-reviewed scientific reports that show that MTR is causing fatal health problems, many associated with the airborne dust from blasting, and these have been mostly ignored by the politicians and coal companies.

These agencies also allow the coal companies to operate massive sludge dams holding back millions of gallons of coal waste above our communities. These do fail. In 1972 one in Buffalo Creek, West Virginia, failed. It released 132 million gallons of liquid coal waste. The Buffalo Creek dam failure devastated 17 communities. In the end 125 people were killed including entire families. One of these families was part of my family. 4000 people were left homeless. This event was dismissed as an "act of God" by both the coal industry and the politicians of our state. People continue to suffer today from post-traumatic stress disorder caused by the Buffalo Creek disaster 45 years ago. The government and coal operators care so little about what they had done that they continued to build hundreds of massive sludge dams over our communities throughout Appalachia since the failure at Buffalo Creek. Then in 2000, in Martin County, Kentucky, over 300 million gallons of coal sludge broke through the bottom of a sludge dam built over abandoned mines. Thankfully there was no loss of life in this failure. Living here, you know it's only a matter of time before the next one fails. There are 14 sludge dams that could fail at any time in only a 25 mile stretch of the Pond Fork River.

People often wonder why I don't just leave where the mountains are exploding and water and air have been poisoned. I have to ask if they realize what is upstream from their water resource. Now most places are impacted by fossil fuel extraction. It's just not as obvious as it is when mountains are being blown up and streams are being buried in rubble. In the USA there is no safe place left to run. People nationally have no choice but to take a stand and fight to stop the degradation of our living environment.

The Appalachian people's work has been used as an example globally to encourage people of all nationalities and ethnicities to fight for the protection of the resources that support life. Protecting this not only protects the very culture we live here in our mountains, it protects all cultures and all future generations of people. We do

unite as a planet. No matter what our global politicians say about us as people I believe we all want good for one another. The protection of global water, air and land resources is the obligation and responsibility of the people who depend on that no matter where it is. It is your children's life. Protect it.

Without a clean, renewable energy plan that doesn't kill the land, the air and the people globally, there will be no healthy future generations. We have the technology and the ability to supply our needs with clean, renewable energy, but leaders around the world are in the grip of fossil fuel industries. Living the impacts of coal for the past 48 years has honestly been hell on this earth but it has taught me many things. One of those many things is that our global environment and our global societies are being impacted by ongoing bad decisions by people in power and people of great wealth. Another is that our global energy plan is deeply connected to the destruction of a living environment and the corruption in global politics. One more thing that I have learned is that by protecting your own community you are in turn protecting other communities and future generations. We are a world apart, but we share many things. Every one of every walk of life deserves clean energy, clean water, clean air and healthy, productive land to flourish on. Only then we will be great and only then will our next generations live in peace and health.

Some myths about language

Duggirala Vasanta[1], Aditi Mukherjee[2] and Dipti Mishra-Sharma[3]

'Language' was traditionally viewed only as a purely symbolic representational system used by human beings via auditory-vocal channel. A consensus seems to be emerging across language-related fields that language is not a static entity fixed in the mind of a 'native speaker' in a 'homogenous speech community'. At a time when world over bi/multilingualism is becoming a norm rather than an exception, it is important to question certain received notions about language.

In a multilingual society like ours, people may have several native languages with the order of acquisition not being an indicator of their linguistic ability in any given language. This is because different codes are appropriate for performing different functions in everyday life. In South Asian communities, people are open to negotiating diverse languages in their everyday life…they do not depend on pre-constructed grammars, in fact they do not even depend fully on verbal medium. Instead, they rely on language ecology – the objects in the communication setting, the context, the body, and even gestures. The non-autonomous nature of language is also supported by recent advances in language technology. Machine translation for example has opened-up the possibility of helping individuals to interact with one another without having to learn to speak / write different languages. In this short paper, we address some commonly held myths about language, and offer explanations that we hope will help demystify

Myth 1: Sanskrit is the 'mother' of all Indian languages.

This is a very common misconception. The population of India today consists of diverse groups of people who belong to different stocks and speak languages from different language families. A language family is a group of related languages that developed from a common historic ancestor. There are four major language families in India: Indo-Aryan, Dravidian, Austro-Asiatic and Tibeto-Burman. An earlier version of Sanskrit came to India with the advent of the Aryan migration. The language these ancestors spoke is termed as Indo-Aryan which was the mother of modern Indian languages like

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Assamese, Bengali, Gujarati, Marathi, Hindi etc. The Aryans were not the first inhabitants of the country. People of the Dravidian stock were already present – their language is the mother of modern Indian languages like Kannada, Tamil, Telugu, Malayalam etc. There were also groups of people (known to us today as 'adivasis', literally meaning the 'original inhabitants') who spoke Austro-Asiatic languages like Munda, Khasi etc. In the North-East of India there are groups of people that speak languages like Bodo, Ao, Angami, Meitei etc. that belong to the Tibeto-Burman family.

These groups of people have co-existed for hundreds of years resulting in widespread multilingualism, necessitated by the need for communication across groups. The prolonged contact among the diverse groups had given rise to not only social intermingling (including inter-marriages) but extensive cultural and linguistic borrowing/blending. It is true that over a long period of time many Sanskrit words have been borrowed by languages of non-Indo-Aryan families for various socio-cultural factors (giving rise to the myth that Sanskrit is the mother of 'all' Indian languages). But it is equally true that Sanskrit has also borrowed words from Dravidian and Austro-Asiatic languages. The mutual borrowings among the languages of different families have not been restricted to words alone. There has also been structural convergence to such a large extent that the today's India, notwithstanding its linguistic diversity can be identified as one 'linguistic area' with a host of shared structural features that distinguish it from other languages of the world.

Myth 2: Borrowing from other languages or language-mixing 'spoils' the purity of a language

One of the consequences of language contact and multilingualism is mutual 'borrowing'. In the history of the world there has been no language that has not taken words from other languages it has come in contact with. In that sense the notion of linguistic 'purity' is vacuous. In fact, instead of spoiling its purity, borrowing from other sources enriches a language. English is a fine example of enrichment by borrowing. It has extensively borrowed from European languages like Latin and French in different scientific and cultural domains. It has borrowed many words from Indian languages -- 'sepoy', 'pundit', 'juggernaut' being only a few examples. Even a common word like 'banana' is borrowed from Spanish! The fact that the Oxford English dictionary is revised periodically even today to accommodate new words taken from other languages, indicates that 'borrowing' is accepted as a source of enrichment rather than 'contamination'.

Myth 3: 'Dialects' are inferior to 'languages'

It is another common misconception that a 'dialect' is linguistically inferior to a 'language' – it has no grammar, lacks sophistication, cannot be written or has no literature etc. The fact is that the distinction between language and dialect is not grounded on any linguistic reality. All

varieties of a language – whether designated as the 'standard' language or 'dialects' – are, linguistically speaking, equally grammatical, and have the potential to be used for all the purposes for which a language is used. The difference between language and dialect is a political distinction based on the power relations obtaining in a speech community. Of all the speech varieties existing in a community, the variety that is used by the group which wields power (whether political or cultural) generally gets recognized by the rest of the community as the standard 'language' and it is propagated through institutional means like education, textbooks, dictionaries, mass media etc. The other varieties get relegated to the status of dialects. It is precisely because of the power relations that dialects lack prestige and are perceived as 'inferior' to language. The myth of the superiority of language over dialect is perpetuated in many ways. For instance, in movies or literature, it is the socially subordinate groups (like a gardener, domestic help or a driver) are seen to use dialects whereas the social 'superiors' use language. It has been aptly said that 'A language is a dialect with an army and navy'.

Myth 4: 'Script' is an essential part of language

It is not true. Spoken languages have existed for centuries even before the humankind evolved different writing systems to visually codify them into various 'scripts'. Even today there are perfectly legitimate languages that have no script of their own. The fact that languages like Tulu, Khasi, Bhojpuri do not have their unique scripts, does not make them lesser languages. Many European languages share the Roman script. Does it prevent them from being considered as distinct languages? Conversely, some languages are written in many scripts. Konkani, an Indo-Aryan language is written in Kannada, Devanagari and Roman scripts by its speakers depending upon which part of the country they are settled in.

Myth 5: Exposing preschool children to multiple languages / scripts will hinder their cognitive growth

This is not at all true. Multilingual environments provide opportunities for extensive code mixing and code switching which has been shown to contribute to cognitive reserve even in later life. Children who learn and use many spoken languages OR even one spoken language along with a sign language are shown to develop good intention-reading skills (appreciating others' point of view) and enhanced metalinguistic awareness (reflect on language using language as we do in translation). Since the goal of using many languages is to fulfill inter-personal communication needs, we must not use monolingual norms (by adopting tests developed elsewhere) to measure language abilities of multilingual individuals in India.

Myth 6: The alphabetic writing system of English is inherently superior compared to Indian scripts

Not true. This is a myth created by dominant Anglo-American and European

theorizing on reading, writing, and literacy instruction. The scripts of most Indian languages are derived from Brahmi script which appeared during the reign of Ashoka (273-232 BCE). Unlike English alphabet which permits separation of consonants and vowels in a linear fashion, Brahmi-derived Indic scripts make use of akshara or an orthographic syllable as the minimal unit of reading. Most aksharas have consonant signs with an inherent vowel. These consonant signs are not phonemes as in the English alphabet. There is some degree of non-linearity in the way aksharas represent spoken syllables, especially in the case of complex closed syllables with double consonants or consonant clusters. Indic scripts, unlike English require awareness of both syllables and phonemes. However, most of us learn to write in one or two Indic scripts as well as English alphabet. How developmental dyslexia (reading difficulties in children) manifests, and which pedagogic approaches work best in our context are important questions that await further empirical research.

Myth 7: Sign languages are not real languages / there is just one universal sign language

Both these statements are untrue. Sign languages, like spoken languages have evolved naturally by people interacting with each other. Gestures used at home (technical term is, home-sign) eventually give rise to full-fledged sign languages like American Sign Language (ASL), Australian Sign Language (AUSLAN) and British Sign Language (BSL). One has to learn each sign language separately although it is English that is spoken in all these countries. Sign-dictionaries and on-line courses are available for hearing by the people interested to learn these sign languages or for getting jobs as sign interpreters. All of them have rules for well-formed sentences; users exhibit slips-of-the-hand just as the way spoken language users experience slips-of-the-tongue. Brain damage affects sign language in the same manner as it affects spoken language. The Indian Sign Language is still in the process of getting codified. It was only during the year 2016 that the Ministry of Social Justice, Govt. of India announced their intention to start Indian Sign Language Research and Training Center.

Myth 8: Men and women differ in their linguistic / spatial abilities because their brains are wired differently

This is not true. A recent study published in the Proceedings of the National Academy of Sciences, USA, debunked this myth. After examining the brains of over 1400 people between the ages of 13-85 years for differences in grey matter, white matter and other neural connections, researchers found that there was a great deal of overlap between males and females. Popular beliefs that girls possess better linguistic abilities whereas, boys exhibit good spatial abilities (map reading/ solving puzzles involving graphics) are a result of deeply held gender stereotypes perpetuated by differential socialization practices and unequal opportunities for participation in different domains of everyday life.

Myth 9: Machine Translation (MT) will replace human translators

A major misconception about MT is that it will take away the jobs of human translators. However, the truth is otherwise. The quality of translation that most MT systems can produce currently has not reached a level where it can replace human translators. Translation itself, even by humans, is a challenging task. The process of 'understanding' a linguistic utterance involves, not just the linguistic knowledge of the given language, but also cultural context and the world knowledge. Language is highly ambiguous and often the immediate linguistic context cannot resolve it. For example, a simple sentence such as 'The angry man shot the dog with a bushy tail' would pose severe problem for the machine to translate it correctly. Given its grammatical structure, this sentence can have both the interpretations – (a) the man shot with a bushy tail' or (b) 'the dog had a bushy tail'. It is only through our world knowledge that 'shooting is not possible with a bushy tail and the dogs have tails which could be bushy' that we resolve this ambiguity. The technology right now is far from being able to handle cultural and world knowledge required to produce quality translation. Hence, so long as the machines cannot handle the contextual information beyond a sentence, cultural knowledge, world knowledge etc., the human translators will always have a role. In fact, MT technology is most useful for the human translators, i.e. it will remain as an aid to the human translators rather than replace them.

Myth 10: Machine Translation output quality is so bad that it is useless

Free machine translation systems are available online. Anyone can use these systems to translate a piece of text from any domain. Often these translations are bad, hilarious or simply incomprehensible. This leads people to believe that the MT can only translate some of the very basic simple sentences and is effectively useless for any practical purpose. However, if the domain is limited in terms of vocabulary and certain grammatical constructions (for example, weather bulletin, recipes), then the MT system can provide quite good translation fully automatically. There are several MT systems in day-to-day use around the world. Examples include METEO (at the Canadian Meteorological Center in Dorval, Montreal from 1981 to 2001), SYSTRAN etc.

Mother tongues and other tongues in India: Speaking about languages as if they mattered*

Vijay Kumar Tadakamalla

On 5 November 1995, a man named Bogon died in Cameroon and with him died a language called Kasabe spoken in the Mambila region of Cameroon. Bogon was the last speaker of the language. A couple of years earlier, the West Caucasian language Ubykh was reported to have 'died' on 8 October 1992, when the last speaker, Tevfik Esenç passed away. Closer home, on 26 Jan 2010, a woman named Boa Senior died in the Andaman Islands of India at the age of about 85. With her died a language called Bo and a world view and the wisdom of nearly 70,000 years embedded in that language. After the death of her parents, some 30 to 40 years earlier, Boa had become the lone speaker of the tribal language and she reportedly kept it alive, often by speaking to the sparrows.

Such deaths, however, seem to have become familiar phenomena and they hardly cause much concern. Linguists estimate that roughly half of the world's 6,000 and odd languages will vanish within next 100 years. Wars, colonialism, and globalization extend the dominance of the world's leading languages over other, less powerful languages.

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As David Crystal writes, "Many things can kill a language, from natural disasters to cultural assimilation and genocide". But if the survival of the mightiest is the new, socially accepted norm, why should we worry about languages becoming endangered or extinct? After all, everything that has life is also inherently susceptible to death. As Crystal points out, "There is nothing unusual about a single language dying. Communities have come and gone throughout history, taking their languages with them. But, judged by the standards of the past, what is happening today is extraordinary. It is language extinction on a massive scale".

The answer to why linguistic diversity matters, is simple. The argument in favour of biodiversity—that the greater the variety of plant and animal species, the more enriched our lives are—also holds good for a rich diversity of languages. Linguistics such as John Lipski and ecologists like William Sutherland have drawn our attention to the relationship between our linguistic and natural environments. Lipski notes that "Those who live around many cultures and languages tend to be more tolerant than those who don't", and adds that preserving linguistic diversity might be a factor in creating a more peaceful planet (qtd. in Duchene). Relating species diversity to language diversity, Sutherland came to the stunning conclusion that, "areas with high

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language diversity also have high bird and mammal diversity" (277).

Language shapes our world, our response to it, and to each other. Our language articulates, yet determines, our notions of time, space, self, and our relationship with others, with society, and with God. As Oliver Wendell Holmes observed "Every language is a temple, in which the soul of those who speak it is enshrined". Our views about other people are also often coloured by our views about the language they speak.

Every language, as we know, is a complete ecosystem. It is the collective consciousness of a community and *is* the 'worldview' of that community. For instance, the Inuit language of the Eskimos supposedly has more than twenty words for different kinds of snow but has no word for romantic or individualized love because their world revolves around community bonding which has no place for individual attachments. Similarly, in Sanskrit, one does not announce his/her name as 'My name is…' but only as 'People call me …', or as 'I am known as …'. In several African languages, I understand, there is no equivalent to something as simple as 'This is a table'. Instead, one simply says 'It looks like a table'. Preservation of a language involves, therefore, respecting the worldview of that speech community. Social Darwinism of the survival of the fittest does not apply to languages as a language does not merely reflect social or cultural reality but shapes it. So when a language dies out, an entire ecology which it embodied dies out.

The striking parallels between ecology and language were brought out by the British ecologist William Sutherland. Writing in *Nature*, he noted, "There are global threats to biodiversity with current extinction rates well above background levels. Although less well publicized, numerous human languages have also become extinct, and others are threatened with extinction" (276). Applying the standards of species classification to the 6809 living tongues in the world, he demonstrated that there are more extinct languages than species and more languages on the brink of vanishing. According to his findings, 7.1 percent of languages are in critical danger of extinction, compared with 4.1 percent of mammals and 1.9 percent of birds. Relating species diversity to language diversity Sutherland concluded, "Areas with high language diversity also have high bird and mammal diversity" (277).

So, the career of a language is intrinsically linked to the people who speak it, the land they live on, and the worldview which governs their life. It is in this sense, that language preservation is different from, say, preservation of monuments.

How many living languages does India have? How many have been lost? Is there anything we can do to save them from dying? And why should it matter? When the Indian Constitution was adopted in 1950, 14 languages were listed in the VIII Schedule of the Constitution. Subsequently, several languages were added to the list and as of now there are 22 scheduled languages. However, Sahitya Akademi, the National Academy of Letters, recognizes 24 languages, including English.

(Contrary to popular belief, neither the Constitution of India, nor any Indian law prescribes any 'national language' for the country. Hindi is listed as the 'official language' of the Union and English as the 'subsidiary official language').

At the time of independence in 1947, there were officially 565 princely states in India. In 1956, a major reorganization of states and their territories was carried out, and 14 states and five Union Territories were created along linguistic boundaries. Now, there are 29 states and seven union territories. What this really means is that although the geographic boundaries of Indian states are supposed to be coterminous with linguistic borders, there are more states than languages with official status. What is also true is that among the 22 official languages, there are languages without states.

The Census Report of 1961 listed a total of 1652 mother tongues in India. After taking into account the many variants of the same language that had figured in the list, the number was later reduced to 1100. However, ten years later, the 1971 census listed only 108 languages, thus 'disappearing' (to use Joseph Heller's phrase from *Catch 22*) nearly 1000 languages. This was done because the government had taken a decision not to disclose languages that are spoken by less than 10,000 people. All such languages were simply categorized as "others". We do not know the logic behind this decision, but one of the reasons could be the breakout of the war in Bangladesh, in which language was the most emotive and contentious issue. But on the other hand, the Census decision was not an abrupt or a sudden decision and nor was it influenced entirely by current political concerns. The decision was in a way the culmination of the intellectual history that was in the making over of the last two centuries. The process was indeed initiated during the colonial times, when only about 2 percent of India's languages were committed to print. A script does not make a language. To define it so is a self-destructive myth that India had imported as part of colonial modernity. The poet AK Ramanujan used to say that everybody in India knows *The Mahabharata* because nobody reads it.

The decision of the Census authorities not to disclose the statistics for languages spoken by less than 10,000 persons turned those languages into 'non-citizens' of the republic of languages that India has been all through its history. Most of the languages thus 'othered' by the 1971 Census are in fact languages that are on the state borders and are the voices of nomadic people, tribals and other poor people that routinely get suppressed. To think about how to reclaim this lost heritage of linguistic diversity, a Language Confluence was hosted in 2010 by the Bhasha Research and Publication Centre, Vadodara (Baroda), in the western state of Gujarat. The venue of the Confluence was titled "Ground Zero" (a term associated with the nuclear attack) to draw attention to the fact that "India, and the world, is becoming the graveyard of languages" (qtd. in Pathak). Representatives of 320 languages participated in the Confluence and a collective decision was taken to launch a nation-wide survey of languages "rooted in people's perception of

language". And thus was born the "People's Linguistic Survey of India" (PLSI).

The first ever survey of Indian languages was done by Sir George Abraham Grierson, an Irish language scholar and civil servant who conducted the Linguistic Survey of India (1894–1928), by obtaining information on 364 languages and dialects. The vast amount of data, of nearly 8,000 pages, was published in 19 volumes. Five of the volumes, on non-Indo-European languages, were prepared by the Norwegian linguist Sten Konow, and the remainder mostly by Grierson. Grierson used local language teachers or government officials as informants, rather than laypersons for collecting the linguistic data.

In the period after independence, two other surveys were initiated by the Government of India. The first, initiated in 1984, is still going on and at the end of 2010 only less than 40% was completed. The survey was instituted mainly to trace the linguistic changes that had occurred since the Grierson's survey. A second, ambitious 10-year project with a budget of 2.8 billion was announced in 2007-08, which was to have two parts: a New Linguistic Survey of India and a Survey of Minor and Endangered Languages. However, the project was quietly abandoned in 2010. Thus, Grierson's Linguistic Survey of India conducted nearly 100 years ago remains to date the only survey of Indian languages.

Since the People's Linguistic Survey of India (PLSI) is a survey "rooted in people's perception of language", it has consciously decided to stay away from the question that historical linguistics follows obsessively, namely the question of the origin and the family of a given language. The PLSI has adopted, instead, an apparently ahistorical method of presenting merely a snap-shot of languages as they are in the early twenty-first century. Apart from the principle of determining language identity in terms of its filial relation with a given language family, (the most ardently followed principle from William Jones to Grierson, and beyond) was the issue of language-dialect distinction. PLSI has decided after considerable thought, discussion, and debate for nearly three decades among language specialists, speech communities, and the PLSI Editorial Collective to avoid branding any of the languages as dialects. If a large number of people who speak a given language think that it is a language and not a dialect, then it better be accepted as a language, even if linguistics may find the claim untenable.

PLSI has been carried out by 3500 people, including language experts, social historians, activists, scholars, and writers in partnership with members of different speech communities. It has collaborated with 85 institutions and universities in the country. Despite the extensive range of the survey that has been carried out, the PLSI, however, does not aim to be an exhaustive survey of each and every language in existence in India, or an attempt at standardizing or fixing the writing or the speech of Indian language communities. PLSI does not consider its survey to be a part, substitute of or sequel to Grierson's work. It is neither a sample survey nor part

of a census survey. It tries to uphold the voice of the people and make it heard, before it is silenced forever.

Talking about the time taken to complete the survey, the Chairperson of PLSI, GN Devy said "While the actual survey took four years, it took 17 years of preparatory work. So the reports are a fruit of 21 years of hard work, that too without any governmental assistance" ("780 languages"). The results of the survey are being published in 50 volumes contained in 72 books which will cover state languages, scheduled languages, sign languages, coastal languages, tribal languages, international languages in India, Indian languages in the diaspora, language policy and the future of Indian languages and so on.

The PLSI has identified 780 languages and 86 scripts in India. It has also revealed that the north-eastern parts of India, generally considered less developed, have one of the highest per capita language densities in the world. Even assuming that the survey may have missed another 100 languages, it still means that in the 50 years since the 1961 Census, India has lost nearly 250 languages. Most of the lost languages are those that belonged to nomadic communities scattered across the country. If they were alive, these languages would have been spoken by 3-4 percent of India's population *i.e.*, nearly five crore (or 50 million) people. Some of the reasons identified for the disappearance of the languages are lack of recognition, displacement of communities, absence of livelihood options for the speakers, and the stigma attached to what are considered 'under-developed' mother tongues. The absence of a policy on language conservation completes the picture.

PLSI is probably the world's largest language survey, and it has revealed India's still substantially rich linguistic diversity. Yet, the PLSI team does not feel overly jubilant about their findings. For, as Devy said, "it was like going for rehabilitation work after an earthquake. It should have been done 50 years ago" (qtd. in Pathak).

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Blogging about work, workers, and workplaces

David C. Yamada

Universities are enduring entities. They create, gather, and share knowledge and insight. They evaluate and interpret the past, and they contemplate and shape the future. They present qualities of continuity and even permanence that make them unique among institutions.

It follows that a distinguished university's centennial celebration is a fitting opportunity to reflect upon past academic work. Indeed, Osmania University's kind invitation to contribute an essay in honor of this milestone has inspired me to look back upon and share many years of research, commentary, and advocacy on creating psychologically healthy workplaces. I will do so primarily by accessing my writings at Minding the Workplace[1] , a blog that I have maintained since 2008.

My main discipline is law. Starting in the late 1990s, I forged an association with Drs. Gary and Ruth Namie of the Workplace Bullying Institute and began researching and writing about the legal and public policy implications of workplace bullying, mobbing, and abuse[2].

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This led to authorship of anti-bullying legislation – since dubbed the Healthy Workplace Bill – that has served as the main template for law reform efforts in the United States. My legal scholarship and related work also would become a portal to broader explorations of how we can create healthier workplaces and affirm human dignity on the job, informed especially by various branches of psychology.

I created Minding the Workplace as a platform for engaging in that cross-disciplinary commentary, with a focus on topics such as workplace bullying, worker dignity and wellbeing, and employment and labor law. While hardly a match for social media behemoths such as The Huffington Post, it has grown into a respectable niche blog, attracting over 900,000 page views, some 1,450 individual subscribers, and a readership that is roughly two-thirds American and one-third international. I have posted faithfully to it, with over 1,500 articles published so far.

The "Eightfold path"

The core perspectives that inform the heart of my blog writings are captured in a 2009 piece, in which I describe an "Eightfold Path" to a psychologically healthy workplace[3]. The article poses eight questions that help to "determine whether or not a workplace is psychologically

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healthy, productive, and socially responsible toward its own workers":

1. Is there a sense of zest, "buzz," and opportunity in the workplace?

2. Do employees feel they are valued and treated with respect and dignity?

3. Is the organizational culture friendly, inclusive, and supportive?

4. Is organizational decision making fair, transparent, and evenhanded?

5. Are diversities of all types welcomed and accepted?

6. Does the organization face tough questions concerning employee relations?

7. Are allegations of mistreatment of employees handled fairly and honestly, even when the alleged wrongdoers are in positions of power?

8. Are compensation and reward systems fair and transparent?

These questions draw upon "relational-cultural theory, organizational justice, and therapeutic jurisprudence." They relate to multiple employee relations stakeholders, including rank-and-file workers, managers, human resources personnel, labor organizations, mental health providers, and employment lawyers.

Bullying as the dark side of the workplace

I confess that my blog can make for grim reading. Some aspects of creating psychologically healthy workplaces are more positive, such as building organizational cultures that value human dignity and hiring executives and managers who lead with integrity. However, we must also understand the dark side of the workplace and how to respond to it.

For example, in a 2014 article on workplace bullying as a form of "crazy making" interpersonal abuse[4] , I wrote:

"Crazy making" is a term one hears a lot in counseling and psychology. It basically means what it sounds like: Behaviors and actions — often intended — that create stress, confusion, and anxiety, and sometimes make people question their judgment and even sanity.

There are lots of overlaps between workplace bullying and the concept of crazy making, in ways that validate bullying as a form of psychological torture.

I went on to briefly discuss ways in which crazy making behaviors manifest themselves at work, including gaslighting, ostracism, button pushing, bullies posing as victims, and the Orwellian tool of expunging institutional memories of whistleblowers and others who challenge unethical practices.

Such abuse can exact a horrific cost from its targets. In a 2013 piece, I shared the words of a woman who plaintively described what an extended campaign of mobbing has done to her[5] :

In my case, it is a trauma that I cannot escape, as despite my best efforts, defense

mechanisms, and sacrifices, the trauma keeps escalating, despite my job ended almost 3 years ago. However, the stalking, threats, harassment, and so much more, continue in a terrifying smear-campaign, via cyberspace, involving impersonation of my identity, and technical tactics tweaking search engines to keep the lies and fabrications of me as "crazy" and "a threat" discoverable… permanently.

We are too far-gone, exasperated, terrified of retaliation, or even fear physical assault plus the many other risks we now bear from what was maliciously and permanently put online to smear us. We are sick, in pain, and are probably very isolated.

We have often become hopeless, after years of coping and clinging to an inner strength, that is now gone.

Some of us are dead. Others may soon be.

Comprehending bullying and mobbing is one step. Next, we must do something to end it. In a November 2016 post, I acknowledged the emotional impact of our ugly presidential election, while reminding those in the workplace anti-bullying movement that we still have vital work to do[6] :

Under such distracting (and, for some of us, distressing) circumstances, it can be hard to turn our attention back to the tasks at hand, which for many readers of this blog include preventing, stopping, and responding to bullying, mobbing, and abuse in the workplace. But that we must.

As I see it, our basic agenda as we head into 2017 holds steady:

- Engaging in public education about abusive work behaviors;
- Educating and persuading employers and other employee relations stakeholders about the destructive effects of abusive work environments and the importance of effective prevention and response;
- Expanding the pool of mental health providers who are competent and knowledgeable to assist targets of bullying and mobbing at work; and,
- Enacting legal protections such as the Healthy Workplace Bill to provide targets with a legal claim for damages and to incentivize employers to take these behaviors seriously, as well as building a stronger safety net of public and private employee benefits to help those transitioning out of toxic workplaces.

Traveling across disciplines and countries

My work has benefited greatly from connections that transcend disciplines and borders. I am especially grateful for conferences and workshops that allow for genuine dialogue and fellowship. Three recurring events are especially meaningful to me in terms of the opportunities they provide for learning and exchange.

The biennial Work, Stress and Health conference, co-sponsored by the American Psychological Association, National

Institute for Occupational Safety and Health, and Society for Occupational Health Psychology, offers a multidisciplinary array of panels and programs and draws a wide variety of researchers and practitioners. In a 2015 article, I cited Work, Stress and Health as a prime example of a quality conference experience, adding: "Good conferences are community builders. They foster connections in big and small ways, allowing people to become part of a broader academic or professional community and to build ties within specific areas of interest[7]."

Another compelling event is the annual workshop of Human Dignity and Humiliation Studies, a global network of scholars, practitioners, students, artists, and activists committed to the advancement of human dignity and to the end of humiliating practices. Last December I wrote about the group's 2016 workshop, held at Columbia University Teachers College in Manhattan[8] :

Being part of this extended global community is both a privilege and a blessing. Such a community is not, and should not be, our sole point of connection with the world. In fact, at the workshop we recognized the importance of sharing dignity-enhancing practices with those who are initially resistant to them. Nevertheless, at a time when raw exercises of interpersonal aggression and bigotry are too often rewarded by the dominant power structure, the need for people holding a different set of core values to come together in order to refuel and reenergize is significant.

Finally, the biennial International Congress of Law and Mental Health brings together a large global cohort to examine connections between law, public policy, and psychology, often in beautiful, historic European cities. Here's a snippet of what I wrote about the 2015 Congress held in Vienna, Austria[9] :

Among other things, this biennial gathering allows me to reconnect with people and ideas associated with therapeutic jurisprudence (TJ), the pioneering school of legal thought that examines the therapeutic and anti-therapeutic properties of law, legal processes, and legal practice.

It struck me how absolutely cool it is to be at this particular conference in a city where matters of the mind have such deep historical roots. It is both inspiring and instructive to exchange ideas with scholars, practitioners, judges, and students who embrace no less than a transformative commitment to creating laws and legal systems that advance psychological well-being.

Some of this travel, of course, is virtual, often crossing hundreds if not thousands of miles. In fact, Osmania University's invitation to contribute to this collection of commentaries, landing out of the blue in my inbox, prompted me to draw upon a social media source as the vehicle for sharing some of my work. I am honored to take part in this project celebrating a century of instruction, research, and service, and I hope that I have provided a contribution worthy of the occasion.

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Techno-science revolution and justice delivery system

A. Prabhakar[1] and A. Lakshminath[2]

Higher education and ideological complexities

Education is a means by which knowledge is transmitted and skills are developed. Beneath what appears to be a relatively simple statement exists a complex matrix of pedagogic and cultural practices that inform, shape and give effect to what information is chosen and how it is understood, transmitted and received. University education in its widest sense is a whole-person process, where the focus is not so much on the teaching and learning of specific skills or training as it is on the cultivation of personal autonomy, intellectual independence and the development of life-long critical perspectives.

Justice education and techno- science revolution

The advances in recombinant DNA engineering and micro-chip technology have been spectacularly wide ranging and relate to almost every area of human life.

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Advances in cyber-technology gave rise to a whole variety of technologies and underlie the 'promise' and 'perils' now of new forms of emergent nanotechnologies that pose a serious challenge to the Legal Education. The emergence of Information Technology and Biotechnology is a decisive transformation that marks globalisation. The contemporary world stands transformed in several ways by the revolution in microchips and integrated circuitry. It enables patterns of time-space compression, a defining feature of contemporary globalisation. It makes real the hitherto unimaginable advances in genetic sciences and strategic biotechnologies. Advances in recombinant DNA technologies and integrated circuitry depend wholly on revolutionary techniques of artificial intelligence.

This development provides a driving force for the global emergence of trade related market friendly human rights and human capabilities. This leads to movements toward redefinitions of impoverishment. Poverty is no longer identified in terms of material deprivation, but in terms of access to information or to Cyberspace enhanced human capabilities. The new North is Cyber-rich and the new South is Cyber poor, thus marking what is known as digital divide.

The emergence of Information Technologies has facilitated widespread privatization of Governmental functions in welfare administration, health, education,

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finance, business, industry etc. Digitalisation of the world provides time space for increased and voluminous solidarity among the legal fraternity.

These also will give birth to the formation of techno-science based strategic industries that resent and often reject state and international regulation and generate new forms of techno-politics. Together, these constitute a genomic materiality of globalization (little noticed in social theory narratives of globalization) contributing to the formation of the 'New World Order'. Biotechnologies, united in the pursuit of reductionist life sciences-where 'life' is no more than information open to techno-science codification, manipulation and diverse techniques of mutation and reproduction—fall into several domains of law and technology. Agricultural biotechnology, fostered by agribusiness, promises food for all; pharmaceutical biotechnology promises heath for all; industrial biotechnology promises sustainable development for the world and the human genome projects, among other things, now promise new possibilities in therapeutics, health care and benign human cloning. Managing globalization and massive explosion in scientific and technological knowledge and innovations is impossible without an ethical underpinning based on values that are shared globally. The belief that biotechnology provides unprecedented vistas of human progress is not just media hype; its practitioners, in all parts of the world, live by it. The Law Schools must invariably keep in mind the above-mentioned advances in techno-science while formulating curriculum and promoting pedagogic skills and ideology. These developing technologies must be addressed by the Law Educators.

Digital revolution

The prospects are bright both for teaching and research in the application of computers. Interdisciplinary studies in the area of law and computers would provide a meaningful interaction between the legal academics and technologists. Computers can be best used in two ways, to assist the legal profession. One is the information retrieval system which can be developed with the help of law faculty and the computer science department. The second area in which computers can very usefully be employed is artificial intelligence system with which several types of stereotype cases can be decided with the help of computer programmes to arrive at more objective and quicker decisions. The legal fraternity should actively engage in collaborative research with the computer science department. This needs to be pursued vigorously to design meaningful computerized programs as alternative dispute settlement mechanism.

Disruptive legal information technology and emerging Electronic Legal Information (ELI) may arise as the 4th cornerstone in face of the challenges, the other three being (i) Lawyer (ii) dissemination of law and (iii) Judiciary. Electronic Legal Information (ELI) refers to (i) an integrated Electronic Law governing civil procedures and other areas of substantive law, (ii) electronic legal document filings and evidence and (iii) electronic court case status information. ELI is transforming the

existing cornerstones to their virtual existences, which take on new capability to face the challenges of high costs, delay and complexity.

To promote access to civil justice, disruptive legal information technology should be adopted and a positive right to access ELI be established. For unrepresented litigants, the use of ELI will put them in a better position to assess if legal assistance should be sought or it would be better to remain unrepresented. Should they choose to be unrepresented, ELI provides ease of reference to law and integrates law from their perspective. For represented litigants, they will have a greater access to information concerning activity of court proceedings and they will be in a better position to push progress with the availability of case status information and electronic court document filings.

Artificial legal intelligence

The gizmos of the digital age owe a part of their numeric souls to Dennis Ritchie [1941-2011 and John McCarthy [1927-2011], the machine whisperers.

When Mr. McCarthy and Mr. Ritchie first developed an urge to talk to machines, people still regarded the word 'digital' as part of the jargon of anatomy. If they no longer do, that is because of the new vernaculars invented to cajole automatons into doing man's bidding. In 1958 Mr. McCarthy came up with the list-processing language, or LISP. It is the second-oldest high-level programming language still in use today – one whose grammar and vocabulary were more perspicuous and versatile than the machine code early programmers had to use. A little over a decade later Mr. Ritchie created C. C fundamentally changed the way computer programs were written, for the first time it enabled the same programs to work, without too much tweaking, on different machines; before, they had to be tailored to particular models.

Much of modern software is written using one of C's more evolved dialects. These include objective C (which Apple favours), C# (espoused by rival Microsoft) and Java (the choice for a host of internet applications). Mr. Ritchie and his life-long collaborator, Ken Thompson then used C to write UNIX, an operating system whose powerful simplicity endeared it to the operators of the mini-computers which were starting to proliferate in universities and companies in the 1970s. Nowadays its iterations under gird the entire internet and breathe life into most mobile devices, whether based on Google's Android or Apple's iOS.

UNIX spurred the development of mini-and later microcomputers, Mr. McCarthy always argued that the future lay in simple terminals hooked up remotely to a powerful mainframe which would both store and process data: a notion vindicated only recently, as cloud computing has spread.

As for LISP, Mr. McCarthy created it with an altogether different goal in mind - one that was to talk back. Intelligently, LISP was designed to spark this conversation, and with it "artificial intelligence", a term Mr.

McCarthy coined hoping it would attract money for the first conference on the subject at Dartmouth in 1956.

In 1962 he set himself the goal of building a thinking machine in 10 years. He would later admit this was hubristic. Not that technology wasn't up to it. The problem lay elsewhere: in the fact that "we understand human mental processes only slightly better than a fish understands swimming." An intelligent computer, he quipped, would require "1.8 Einstein's and one-tenth of the resources of the Manhattan Project" to construct.

Neither was forthcoming. Mr. McCarthy continued to tinker away at a truly thinking machine at Stanford. He never quite saw his dream realized. Mr. Ritchie had more luck. "It's not the actual programming that's interesting," he once remarked. "It's what you can accomplish with the end results."

The digital revolution offers significant opportunities to those who provide legal assistance and education to low-income people and communities. New technologies enable us to create higher quality work product, conduct better research, work more collaboratively, learn more readily, and – most important – serve clients more effectively. Clients, Advocates and Judges alike can find relevant information on the Internet, programs can use a variety of new management and evaluation tools, and everyone can communicate more easily and revolutionize the Justice Delivery System.

In the past 10 years, our society has experienced a "digital revolution", the implications of which are as stunning as those of the industrial revolution, yet are even more remarkable because these changes are happening in a fraction of the time. Beginning with the affordable personal computer and taking a giant leap forward with the creation of the internet and the web browser, this revolution has changed how we work, play, communicate, learn, and obtain goods and services.

Yet, the pace of change has not been the same in all sectors of society. Technology use by the middle and upper class and by the West is significantly ahead of use by poorer people and people of color, a gap that some observers have termed the digital divide. On a corporate level, this gap looms equally large between the private sector and the nonprofit sector.

These technological advances have *inter alia*:

a) Enabled greatly expanded access to legal information for Judges, Advocates and clients through internet and e-mail technologies;

b) Expanded access for clients by using telephones for screening, obtaining basic client information, referrals, providing brief advice and services, and also by posting information on the Internet;

c) Enabled better court and case management and data collection, along with automated templates for document creation;

d) Improved communication between lawyers and clients through new telephone technologies, cell phones, and video conferencing;

The uses of new technologies by the equal justice community in three functional categories can be discussed as follows:

a) Improving program and office management;

b) Increasing access to assistance and information for advocates; and

c) Improving client education, preventing legal problems, and assisting pro se litigants.

In addition to educating clients and communities about resources, the Internet can also provide people with information about their legal rights and about how to solve legal problems on their own when they are unable or unwilling to obtain an attorney. At the most basic level, pro se brochures and manuals can be posted on websites, which is an efficient distribution and production mechanism.

Moreover, the potential of web technology exceeds simply improving access to what otherwise might be available in print. Computer can help pro se litigants create attractive, properly formatted, and persuasive court forms and pleadings. Computerized templates can use branching logic to take clients through the process of analyzing their case and providing the appropriate information to the court. Video screens can be used to show clients how to navigate through the courthouse, or even how to present their case. Audio files can present information in spoken form for clients who can't read due to illiteracy or disability or language (such as Navajo). These programs can be made available at courthouse kiosks, libraries, or anywhere a client can obtain access to the Internet.

A multifaceted effort, including education, scholarship, resource development, and collaboration, can serve as a powerful catalyst for change, even when the total amount of resources available is relatively small.

Legal reasoning involves case analysis in statutory as well as real world perspectives. The impact of real world perspective on case analysis poses a serious challenge to knowledge engineers for building legal expert systems. A legal expert system intends to provide intelligent support to legal professionals. Legal predictive system is an attempt to predict the most probable outcome of a case according to statutory as well as real world knowledge of the legal domain.

One of the basic principles of justice is that `Justice delayed is justice denied'. It is from this that the Supreme Court of India has carved out the fundamental right to speedier trial from article 21 of the Constitution of India. The present adjudication process requires transformation in view of the high cost of legal services, baffling, complications in existing procedures and frustrating delays in securing justice. Formal adjudication should be more of a last resort than it has been in the past. In recent times, efforts

have been made to develop alternate adjudication models in the form of *Lok Adalats, Nyaya Panchayats* etc. In this context, it is felt that alternate adjudication machinery can be augmented with modern computers to a greater extent of openness and accessibility thus lending credibility to the dependence of both government and people on these modes of alternate adjudication machinery.

Automation in the legal world was first proposed (Mehl 1958, pp. 755-79) at an International Symposium on "Mechanisation of Thought Processes", held at the National Physical Laboratory in Teddington, London. Law machines were classified by him into two types: documentary machines and consultation machines. Documentary machines are meant for legal information retrieval operations such as storing/ retrieving legal provisions and supporting as well as opposing precedents relevant to the given case. A program FLITE (Finding Legal Information Through Electronics), was developed in *1964* as the earliest full text retrieval system for the US Air Force. LEXIS and WESTLAW (Hafner *1987, pp. 35-42)* are some of the recent commercial systems offering interactive retrieval through terminals at the customer's office. Intelligent support cannot be provided for the user while retrieving the precedents owing to the text matching (keyword search) technique followed in these systems. Hafner *(1987, pp. 35-42)* proposed an At-based conceptual retrieval system using individual case frames so that search for relevancy can be made based on a concept of the case rather than text matching of certain keywords. Considerable research work has thus been carried out and significant developments have taken place in the area of documentary machines.

However, no such significant progress can be claimed to have been made in the area of consultation machines which are meant for giving legal advice. The HYPO system developed by Rissland and Ashley (Ashley & Rissland *1988;* Ashley *1991)* during the *1980s* aims at helping an attorney to analyse a new case in the light of relevant precedents and accordingly generate outlines of arguments for both plaintiff and defendant. The JUDGE system, developed in the late *80s* by Bain (Srivastava *1991)* proposed modelling the sentencing ability of judges. This system identifies a binding precedent according to a set of salient features and suggests a commensurate sentence for being awarded in the case on hand. These two systems have been the most widely accepted legal consultation systems to date. But these and similar other consultation systems are oriented towards precedents and are based on a case-based reasoning paradigm.

A precedent can either suggest judgment that is appropriate to cases with similar current fact situation or it can point to an apt case-law to solve a particular technical ambiguity. These two aspects of the precedent are to be dealt with separately since the first aspect provides only the guidelines whereas the second provides the case-law that is binding on lower courts. The first aspect is emphasised in systems like HYPO whereas the second aspect is considered in systems like JURIX (Srivastava *1991)* and Gardner's legal

reasoning system (Gardner *1987).* Gardner's approach suggests that the case be analysed keeping in view statute as well as relevant case-laws. This system aims at giving decisions for `easy' cases, while the `hard' cases, cases which can be argued in either way by a competent lawyer, are left undecided. McCarthy's TAXMAN project (McCarthy *1980)* models deductive legal reasoning based on the statute. The control strategy of legal systems determines the applicability of those systems to various fields of legal domain - HYPO suits trade secret misappropriation. TAXMAN models the taxation of corporate re-organisation. Gardner's system deals with formation of contracts by offer and acceptance. However, for certain other legal fields, legal reasoning involves analysing the case through a real world perspective also. Along with statutory rules, various heuristics imposed by culture, region, conventions and the experience of judges are also to be considered while making the decision. Given the case proceedings/current fact situation, a highly structured legal reasoning system to analyse the case and thereby predict the most probable judgment based on the statute and discretion of the judge, is proposed in this paper. It is hoped that the proposed legal counselling system will be of use to our society in the following ways.

(1) The system, by its ability to predict in advance the most probable outcome in a given case, will enable individual clients to decide about the advisability or otherwise of entering into a legal dispute in a given situation. This in turn will lead to reduced workload on the considerably over-burdened courts.

(2) The system, through its ability to estimate the effect of each individual fact on the judicial decision (by simulating the judgment with altered current fact situations) can aid legal practitioners and criminal investigators in discharging their professional duties more effectively and efficiently.

(3) The system, by providing an integrated view of the case through the highly structured representation of the current fact situation of the case, can be helpful to judges in taking faster decisions thereby mitigating the hardship caused to the litigant public by delayed justice, the bane of the present judicial system.

(4) The system can resolve petty litigations among people who cannot afford the money and the time required in the regular court proceedings, thus providing a computerized alternate adjudication system.

(5) A generalized system can be developed by drawing on the expertise of several meritorious judges, which in turn can be used to check the correctness of a specific judgment, so that the case may be reconsidered, if necessary.

Scholars point out that the essence of modern Research is interdisciplinarity, which is enriched through assimilation of knowledge from diverse sources but degenerates through transplantation or innovation of external models which have little authenticity and relevance to the new

environment. IIMs and IITs are best examples. These have all along been isolated Islands of Excellence. They are socially insensitive. Improvement of quality is brought about through an internal process. External agencies can at best assist the process but cannot substitute internal process.

Conclusion

We have to recognize the kaleidoscopic character quality in higher education and the value of mutually enriching collaborative learning processes, particularly in using new technologies of the New World order in the administration of justice too.

Coping with earthquakes in Himalaya

Harsh Gupta

Earthquakes and resultant tsunamis are one of the worst natural disasters. The Mw 9.2 Sumatra earthquake on 26th December 2004 claimed an estimated 250,000 human lives in south and south-east Asia. At the time of writing this note in April 2017, only 16 years and 4 months of the 21st Century have passed. However, in this short span of time the number of the human lives lost due to earthquakes and resultant tsunamis has far exceeded the total lives lost in the entire 20th Century.

About 160 million years ago, the Indian plate broke off from Antarctica and started moving North North-East (NNE) with velocities of up to 13cm/year and collided with the Eurasian plate some 50 million years ago. The Indian plate continues to move with a velocity of ~ 5 cm/year. Since both plates are continental, the continued collision has given rise to the Himalayan belt of mountains. This continued thrusting results in accumulation of strain and when the accumulated strain exceeds the strength of the rocks, earthquakes occur. That is why Himalaya is seismically the most active intra-continental region in the world. The largest intra-continental earthquake of Mw 8.7 occurred in Assam on August 15, 1950.

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Its aftershocks continued for over three years, ~ 50 of them of magnitude 6 and larger. The other great earthquakes of Mw ~ 8 that occurred in the region in the recent past include the 1897 Shillong earthquake, 1905 Kangra earthquake and the 1934 Bihar-Nepal earthquake. No such earthquake has occurred since 1950. Over the time, enough strains have accumulated to cause several M > 8 earthquakes. Earthquakes cannot be predicted. So the best way to handle the situation is to get prepared. Just for an example, the Japan earthquake of March 11, 2011 with a magnitude Mw 9.0 claimed only ~ 20,000 human lives because of good preparation, while the Haiti earthquake of Mw 7 on January 12, 2010 claimed 300,000 human lives! It is important to understand the relationship between the earthquake magnitude and the energy released. A magnitude 6 earthquake releases energy equivalent to a Hiroshima kind of atom bomb. With the increase of one unit in the magnitude the energy release increases 30 times. So, a M 7 earthquake would release energy of 30 Hiroshima kind of bombs and a M 8 would be equivalent to 900 Hiroshima kind of atom bombs.

The best way to protect against earthquakes is to prepare the public and the civil administration. India has been divided in to four seismic zones numbered V, VI, III and II. Particularly in zones V and VI, where the earthquake intensity is appreciably high, it is important, as a starting point to make all the life line

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buildings, such as hospitals, fire brigades, police stations, schools etc. earthquake resistant. There are techniques such as Rapid Visual Inspection, which can judge whether a building is capable of withstanding the anticipated accelerations during the earthquakes. The buildings could be strengthened through retrofitting. Another important step is to educate the school children on a routine basis about the earthquakes, and how to live with them. In recent years, it has become very useful to create earthquake scenarios and see what would happen if one of the earlier earthquakes repeats today. In India, earthquake scenarios were developed and mega- mock drills were conducted for the repeat of Kangra earthquake of 1905 in February 2013, and for the repeat of the Shillong earthquake of 1897 in March 2014 by the National Disaster Management Authority of India in collaboration with the concerned States. For assessing the damage for the repeat of Kangra earthquake of 1905, a scenario was created with the hypothetical earthquake of Mw 8 with a focal depth of 15 km occurring at Mandi (in the immediate vicinity of the epicenter of the 1905 Kangra earthquake). The earthquake rupture in this scenario had a length of 200 km and a width of 80 km. An intensity map was generated using suitable parameters. This intensity map was used to estimate the number of houses that would suffer partial or total damage today. On this scenario if you place the population density layer, an approximation can be made of the human lives likely to be lost and injured. For the repeat of 1905 Kangra earthquake the exercise was conducted for Punjab, Haryana, Himachal Pradesh and the Union Territory of Chandigarh. If the Kangra earthquake of 1905 repeats today in the middle of the night, the number of human lives lost could reach one million! Initially, this number looked too large. However, when you consider that the Muzaffarabad earthquake of October 8, 2005 of Mw 7.6 near India- Pakistan border in Kashmir claimed ~75,000 human lives, in spite of being much smaller in size and the fact that it occurred in late morning when most of the people were outside their homes, the figure of 1 million seems reasonable. This information was shared with all the state and central government departments, public and schools. At the same time training was imparted to combat these huge losses. Finally, a mega-mock drill was conducted on February 13, 2013 involving all concerned. This provided an opportunity to the public and the government departments to better deal with the earthquakes. A similar exercise was conducted for the 8 northeast states in March 2014 for the repeat of the Shillong earthquake of 1897. Everyone knows that when an earthquake strikes, one should move to a safe place. Most of us would spend half of our time at home and the remaining at place of our work or school. So, it is important to think of a safe place at both these locations in advance. When we first feel the earthquake and we have not thought of a safe place, it would take us time to figure it out.

In this short note, a brief introduction to earthquake hazard in the Himalayan region and how to cope with it is given. It is useful to conduct earthquake drills in earthquake prone areas with a special emphasis on educating school children.

Future of Artificial Intelligence

R. Krishnan[1] and S. Sameen Fatima[2]

First innings of Artificial Intelligence (AI)

AI was born in the 1950's, but till the end of the 20th century, its life was a checker board of nights and days. Proving theorems and winning mind games were initially conceived as intelligent tasks. In 1955 and 1956, the program "Logic theorist" was developed. It had the ability to prove theorems in Whitehead and Russell's book Principia Mathematica, 1960's saw an increase in research projects and funding in problem-solving, language understanding, question answering, speech, vision, knowledge based systems and robotics. 1970's saw a lull in funding and was called "The first Winter of AI". 1980's saw the release of the first commercial expert system. Late 1980 and early 1990 was called the "The Second Winter of AI". In 1997 the "Man Machine War" had begun, a big hue and cry was heard, "Deep Blue beats Kasparov!" The success was due to increasing computational power, greater emphasis on solving specific problems, new ties between AI and other fields and a commitment by researchers to mathematical methods and scientific standards.

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In 1998, Google was founded. The world said good bye to the 20th century, goodbye to huge, gigantic CPUs and welcomed with open arms the major AI technology enablers Internet and the World Wide Web.

Second innings of AI

High Speed Internet and www, in turn enabled dramatic advances in AI in particular in the area of Machine Learning. The advent of 2000 was marked with systems that learn. Work on machine learning shifted from a knowledge-driven approach to a data-driven approach. Data scientists began creating programs for computers to analyze large amounts of data and draw conclusions or "learn" from the results. Support vector machines and recurrent neural networks became popular. Deep learning became feasible and neural networks saw widespread commercial use.

In 2000, interactive robot pets (a.k.a. "smart toys") became commercially available. In 2004, commercial recommender systems (TIVO, amazon.com) were available. In 2005, Stanford vehicle won the DARPA grand challenge driving autonomously in the desert for 211 kms. Meanwhile at CMU, Raj Reddy and Jamie Carbonell in 2006, gave a new "Bill of Rights for the Information Society". Get the right information (search engines), to the right people (categorizing, routing), at the right time (task modeling,

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planning), in the right language (machine translation), with the right level of detail (summarization), in the right medium (text/speech/image/video input and output). In 2007, checkers was solved. In 2010, Google's self driving cars reached their 1000th mile. In 2011, IBM's Watson won "Jeopardy", beating Brad Rutter and Ken Jennings. October 14, 2011, Apple introduced a personal assistant "Siri" on the iPhone 4S. In June 2012, a Google brain cluster trained itself to recognize a cat from millions of images in YouTube videos

Earlier, Internet and existing databases/portals were primarily intended for users literate in English who could synthesize their solutions from multiple sources. The interplay between different heterogeneous knowledge sources to depict intelligent behavior in another important area today with the cloud in place. Today it is possible to send an itinerary through an email to your family member and forget about it. On the day of travel, the recipient of the itinerary, continuously gets updates on their smart phones about the flight taking off, flight landing and flight delays until the flight reaches its destination. This is instant supply chain. Similarly instant administration is possible. Another spectacular app is the "Hawk Eye" launched by Hyderabad Police Department. It seeks to turn common people into citizen police and involve them into checking crimes, curbing unlawful activities and traffic violations. An SOS button is available for accessing help in emergency situations. Continental Divide Robotics has developed a system based on GPS that can locate person or object anywhere in the world and notify the user if it is "out of bounds". This could help a parent monitor a child, or it could be used to monitor the movements of an elderly person at home.

Hard things like theorem proving, game playing, object recognition, recommender systems, tracking through GPS, speech processing and language translation were easy for a computer, while easy things like vision, motion, movement, and perception were still hard for it. As computer scientist Donald Knuth puts it, "AI has by now succeeded in doing essentially everything that requires 'thinking' but has failed to do most of what people and animals do 'without thinking".

AI on home ground

In a country like India, AI has to be viewed from a different perspective. Some of our burning problems are removal of poverty, education to all, employment to the youth, health care, sanitation, women empowerment and benefits to the rural population. An illiterate person needs voice mail rather than email. A farmer needs information on the dynamic pricing of his or her product. A woman weaver wants to know the funding available to set up a loom and the process and profits that can be accrued. And all this in their own mother tongue. India has officially 21 languages and language barriers can significantly slow down the economic growth. To access information without language divide work needs to be taken up in cross language communication, spoken language understanding, dialog modeling,

multimedia synthesis and language generation, multi-lingual indexing and retrieval, language translation, and summarization. Another new technology that has found its way is the Internet of Things (IoT) and Smart Cities. This permits humans to interact with objects just like they interact with people. A student should now be able to talk to books in a library, teachers should be able to talk to smart boards, farmers need to talk to their instruments and command them, a house wife can talk to her stove in the kitchen. For a greater participation in the global economy, India needs to preserve its local languages and promote cross language communication and understanding among objects and individuals. India needs rich language tools to establish its presence in the global economy and to become a world leader in language technologies.

AI as a bouncer

Let's look at today's killer app, the Google search engine, which is used unanimously by most literates. How many hours are spent sieving and filtering through the ranked pages? A child asking for information on heart care for a school project, versus a housewife seeking information on heart care for preparing a healthy meal, versus a researcher seeking latest information on heart care should yield different results. User profiling is still a long way to go. Further, page ranking algorithms should be strengthened with user profiles. If I were to seek an article on "Poverty eradication", which is pro-government, versus which is anti-government, is it easily possible. Is it possible to retrieve a document based on the sentiment it reflects?

The population of the world is aging fast and AI's help in assisting the elderly will be very useful. The Robot which will do many humanoid functions is still a little distance away, but has vast potential. What about a robot nurse which will assist the sick and elderly. With the advent of the internet of things (IoT), would it be possible to embed chips into humans. Suppose someone has lost a limb, can AI activate the limb in consonance with the person's brain so that the limb feels like real? How communication between objects will develop is an interesting thought. Would we like to put limits on the IQ of different devices?

Finally what laws should govern the behaviour of AI Robots. If a driverless car hits a person who is responsible? There is a brilliant story by Isacc Asimov about robots. This was written almost 50 years ago. The robot is told that it should never tell a lie. It is also told that by any of its action it should not harm its owner. The owner commits a murder and the robot has seen it. It is called as a witness. If it tells a lie it is violating its principle. But if it tells the truth the owner will be punished. How should the robot resolve its conflict?

Some of these questions will become relevant. These are but a few reflections. Research in AI has still a long way to go. As we head towards computational resources, which are "for-all-practical-purposes-infinite", we can expect revolutionary advancements in AI.

AI as a googly?

Progress in AI and technology may provide humans with material comfort. Humans can shop, entertain themselves, consult doctors and take treatment, work from home, access information on any topic, take classes through Coursera or NPTEL, find jobs, all in the comfort of their living room. The question is, what will they do with all this comfort? How will it affect the way we live, learn, work and socialize? It is important to understand the psychological and social implications of this new found life and more important to understand our own limitations. Humans tend to forget, tend to become lazy, tend to socialize with machines or through machines, become impatient in this fast paced world. Philosophically speaking, it is often said that the purpose of humankind's creation is to make them strong in knowledge and resolution, so that they may learn more and more, and secure the power to do what they desire. At present, human capability to acquire knowledge can be augmented by thousands of intelligent agents who can search and harness the knowledge contained in terabytes of memory worn on the body and petabytes of memory on the web and the cloud. Thus the future capabilities of an individual will not merely depend upon what he or she knows, but what is knowable by the intelligent agents. Today AI and technology are moving beyond the realm of existence of humans to the realm of elimination of humans, which seems quite scary. Sometimes it is said that the goal of human life is happiness in the sense that during the time one is alive, they should live comfortably and happily, enjoy the blessings of creation and nature, suffer less pain from either natural causes or from fellow creatures. To keep life simple and smart, AI should serve as a means of acquiring knowledge to the extent that you maximize your happiness and minimize pain. The path towards a balanced portfolio of capable, safe, and transparent AI-based systems should be the promise of tomorrow to make this world a better place to live in.

Global navigation satellite system: Evolution, current scenario and future trends

A. D. Sarma

Abstract

The 2014 Nobel Prize in Physiology/ Medicine was given to John O'Keefe, May-Britt Moser and Edvard I Moser for their discoveries of cells that constitute a positioning system in the brain. The Nobel Laureates have discovered a positioning system, an "inner GPS" in the brain that makes it possible to orient ourselves in space, demonstrating a cellular basis for higher cognitive function. The sense of place and the ability to navigate are fundamental to our existence. The sense of place gives a perception of position in the environment. During navigation, it is interlinked with a sense of distance that is based on motion and knowledge of previous positions. This gives a scope for augmenting human brain with GPS technology including the people with memory loss problems. As the world is going to be mostly automated, artificial intelligence and machine learning play a major role in building the next generation humanoids which depends on GPS technology. In this paper, the evolution of satellite based navigation technology is discussed along with important applications, current status and future trends.

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Introduction

History changed on October 4, 1957, when the Soviet Union successfully launched the world's first artificial satellite Sputnik I. Since then satellite based Communication and Navigation fields have advanced leaps and bounds. The first satellite-based navigation system 'Transit' proved the concept of position fixing using satellite signals. Navigation has become part and parcel of everyday life. An advanced and powerful Global Positioning System (GPS) and Global Orbiting Navigational System (GLONASS) became operational in 1990s. As these systems suffer from several errors, they cannot be used for strategic applications and Precision approach of aircraft. To overcome these problems, space based augmentation systems such as Wide Area Augmentation System (WAAS) of USA and GPS aided Geo Augmented Navigation (GAGAN) system of India are developed. Even these systems could not satisfy the Required Navigation Performance (RNP) Parameter specifications necessary for precision approaches of aircraft. Therefore, a new augmentation system known as Local Area Augmentation System (LAAS) of USA is developed. This is expected to satisfy necessary precision approach requirements of an aircraft. The particulars of various navigation systems and the

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technology evolution are summarized in Table 1.

Current status and applications

With the upcoming several satellite constellations from different countries a new term 'Global Navigation Satellite System' (GNSS) is proposed. GNSS refers to the world wide positioning, navigation and time determination capability available from one or more satellite constellations. It is not an exaggeration to say that it is nearly impossible to find an area where GNSS has no application. To name a few aviation, defense, transport sector, medical, and agriculture etc., Personal locator devices using GPS technology can be used to pinpoint the location of lost Alzheimer's patients. For example, Applied Digital Solutions sells a device called the Digital Angel, which is worn as a watch, plus has a separate clip-on pager. Using GPS mapping software and cell phone networks, the Digital Angel alerts caretakers by e-mail (sent to a cell phone, personal computer, Personal Digital assistant (PDA), or text pager) when an Alzheimer's patient has wandered out of a pre-designated area. Even though GNSS based systems have several advantages over conventional navigation systems, there are certain limitations including jamming and spoofing that will prevent GNSS from using in some applications such as indoor position applications.

Due to tremendous advancements in the GNSS technology, several demands, some critical and some not so critical are emerging. Selected few are briefly dealt in this paper. By spoofing the GNSS system, any person can maneuver the user and destroy the very purpose of GNSS. For example, in defense if the missile hits a wrong target, it can make electric power units to be tripped due to loss of synchronization. Aviation needs a multi-constellation GNSS for better performance for increasing number of more demanding applications, more robustness against vulnerabilities and GNSS interoperability. Gradual reliance on multi-constellation GNSS for Communication, Navigation and Surveillance applications for all phases of flight, a key enabler for future ATM. From venues of leisure to buildings in flames, there are many situations where indoor location tracking is useful. GNSS technology does not work inside buildings. Some navigation systems may not be suitable for submarine use. Main challenge is how to achieve position accuracy, portability, and low power consumption at affordable price. The ultimate challenge is to develop reliable and efficient Green Navigation systems to meet these emerging challenges. Recently, it is reported that nearly half of all available mobile applications use location information and this will continue to increase. In the age of Internet of Things (IoT) and Big Data, information technology and geo-positioning are two essential components and are inseparable.

Future trends

NASA (USA) and other space agencies are planning to extensively use GNSS in their future space explorations, scientific discovery, earth monitoring applications and various research activities and also make their spacecrafts more autonomous

with respect to position and time aspects. The users in space orbit can obtain their position and time using on-board means of processing one way navigation signals from GNSS or by using communications channel tracking via the Deep Space Network (DSN), Near Earth Network (NEN) and Space Network (SN) thus making spacecraft operations autonomous. GNSS may also provide accurate time synchronization and attitude determination in lieu of other sensors such as star trackers. With the help of satellite laser ranging to GNSS constellations, systematic errors in the radiometric data can be identified and corrected. This information can be used to improve Earth centered terrestrial Radio frame on which GNSS system depend upon. Many of the services provided by innumerable agencies around the globe are tied to the use of GNSS including time and space reference systems. By 2027, due to multi constellation satellite signals and corrections from the augmentation systems, the GNSS users will be able to fix their position even in indoor and in sub lanes also. According to a recent report, the GNSS services are made available to anyone, anywhere, anytime, any accuracy by 2027. In the scenarios such as indoor environment and dense tree canopy where GNSS signals cannot penetrate, Navigation via Signals of Opportunity can be used to facilitate continuous navigation. NAVSOP uses the same wireless technologies as mobile phones, TVs, radios and the Wi-Fi. These signals will have greater resistance and utilizes wider range of signals. This aspect has been generating huge excitement in both civilian and military circles and it is going to be real game changer when it comes to navigation and promises positive civilian impact. It also finds applications in fire and rescue services. Green navigation is going to be order of the future. Design, development and implementation of energy efficient, low power, low cost and environment-friendly navigation systems is on the top priority. Expectation from the common man is that the location technology should work wherever the ‘smart’ cell phone works. A combination of technologies such as GNSS, cellular triangulation, Wi-Fi data networks and Ultra wideband triangulation will facilitate both outdoor and indoor tracking infrastructure of the future. Location information is going to be as important and essential as time itself. GNSS assisted Location Based Services provide everything you need to capitalize on the growing demand for location-enhanced communications, including emergency call positioning. The evolved positing and localization techniques will be thoroughly exploited in exploring interplanetary atmosphere and other planets. In Cooperative satellite navigation for marine weather forecasting, research is going on to find a way to use ships on the move as a distributed meteorological sensor network capable of retrieving data, via satellite and/or off-line, on sea surface conditions and in combination with accurate EGNOS-augmented GNSS. Other important applications include optimizing driver behavior with enhanced active green driving, GNSS-based odometry for rail safety and management, a GNSS receiver for safe information retrieval, and use of GNSS precision farming in agriculture sector. The on-going activities in GNSS will improve the use of satellite navigation in agriculture.

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Table 1: Satellite Based Navigation Systems evolution and their status.

S. No.	Satellite Navigation	Country (Year of Fully Operational)	Remarks
1	Transit	USA (1978)	Retired in 1996
2	GPS	USA (1990)	USA-266 (IIF) recently launched in February 2016
3	GLONASS	Russia (1993)	Kosmos-2516 (M) recently launched in May 2016
4	GALILEO	European Union (2016 (EOC))	Galileo-FOC FM11 recently launched in May 2016
5	BDS	China (2011 (Regional)	Compass-G7 recently launched in June 2016
Regional Navigation Satellite System (RNSS)			
6	NAVIC	India (2016)	IRNSS 1G recently launched in April 2016
7	QZSS	Japan (In Development)	Michibiki was launched in September 2010
Satellite Based Augmentation Systems (SBAS)			
8	WAAS	USA (2003)	EUTELSAT 117 West B launched in June 2016 also has a WAAS transmitter
9	GAGAN	India (2013)	GSAT-15 was launched in November 2015
10	EGNOS	European Union (2005)	Astra 5B and Inmarsat 3-F2 are active satellites
11	MSAS	Japan (2007)	MTSAT-2 was launched in February 2006

*EOC-Early Operational Capability

Chandrayaan-1 - India's first lunar mission

A. S. Kiran Kumar

Introduction

Using space technology to address national developmental activities has been the prime objective of the Indian Space Programme. The space infrastructure as well as the host of applications put in place over the years in areas of communication, remote sensing and navigation has become an integral part of societal developmental processes in the country.

Space science and allied research have been important aspects of the Indian Space Programme to build capacity in the country. Having established itself in different aspects of space technology viz., the spacecraft, launch vehicle, ground systems and space-based applications, India's Space Programme, spearheaded by ISRO, rightfully thought of venturing into a Mission to Moon. The idea of undertaking a lunar mission was initially mooted in a meeting of the Indian Academy of Sciences in year 1999, which was followed-up through discussions in the Astronautical Society of India in the year 2000. Based on the recommendations made by the learned members of these fora, ISRO set up a National Lunar Mission Task Force. ISRO got the Study Report brought out by this task force, reviewed by a group of around 100 eminent scientists of the country, in the year 2003, who endorsed ISRO undertaking such a mission.

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ISRO further took up the matter with the Government and, on August 15, 2003 the Prime Minister of India announced from the ramparts of the Red Fort that India would send a Mission to Moon by the year 2008. He also named the mission as 'Chandrayaan-1', making it clear that it would be the first of many such missions to come. Following, India's first mission to moon, Chandrayaan-1, was launched on-board the indigenous and versatile launch vehicle, the Polar Satellite Launch Vehicle (PSLV), on October 22, 2008 and was successfully inserted into the lunar orbit on November 8, 2008.

This brief article portrays how the mission was realised and gives highlights of the major scientific outcomes of the effort.

Earlier missions to moon

Space age began with the launch of Sputnik-1, the world's first artificial satellite, on October 4, 1957 by the Soviet Union; and with this, the Moon, which was circling the Earth all alone, got a tiny companion. Following, a series of satellites were launched by space-faring nations for communication, remote sensing and navigation purposes. After launching a series of satellites for studying the Earth, the Soviet Union launched Luna-1 on January 2, 1959, which was the first spacecraft to fly-by Moon. The Luna-2, an unmanned Soviet probe, was the first man-made object to reach the Moon on September 14, 1959. Luna-9 was the first

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spacecraft to land successfully on the Moon on February 5, 1966, and Luna-10 was the first spacecraft to successfully orbit the Moon on April 3, 1966.

In parallel, United States sent Ranger, Surveyor, Lunar Orbiter and the Apollo missions to the Moon. Apollo 8 - the first manned mission to the Moon - entered the orbit around the Moon on December 24, 1968 and completed 10 orbits around Moon before returning to Earth on December 27, 1968. Apollo 10 was launched on May 18, 1969, and it was a dress rehearsal for the first Moon-landing, testing all of the components and procedures, just short of actually landing. Apollo 11 was the first spaceflight that landed the first two humans on the Moon on July 20, 1969, and the rest is history. Over 10 astronauts have landed on Moon till date.

While United States was focussing on manned missions, Soviet Union continued with unmanned missions that deployed rovers and returned samples to the Earth. Japan, Europe and China have also launched Orbiter Missions to study the Moon.

The Chandrayaan-1 mission

The basic objective of Space Science and Exploration is to understand the universe we live in. Space platforms enable scientific studies through synoptic vantage in space and time, which cannot be performed through ground based approaches. One of the main objectives of inter-planetary space research is to understand the evolution of the Solar System and that of the Planet Earth, resource utilisation, exploitation, and the kind. A few of the most enigmatic questions about the Moon are on its origin, topography and composition. It is in this context that the 'Chandrayaan-1' - *Vehicle to Moon* in Sanskrit, was conceived with a lunar orbiter and an impactor. Chandrayaan-1 was conceived as a Polar Orbiter Mission around the Moon at an altitude of 100 km. Realization of the Chandrayaan-1 mission is briefed in the following sub-sections:

Objectives: One of the mission objectives was to design, develop, launch and orbit a spacecraft around the Moon using an Indian-made launch-vehicle. The scientific objectives were (i) to conduct scientific experiments using instruments on board the spacecraft, which would yield data for the preparation of a three-dimensional atlas of both the near and far sides of the Moon, and (ii) chemical and mineralogical mapping of the entire lunar surface at high spatial resolution.

Payloads: In order to realise the scientific objectives, a suite of payloads were identified, *viz.,* (i) **Terrain Mapping Camera (TMC)**- for systematic topographic mapping of the entire lunar surface, including the far side and the Polar Regions and prepare a 3D atlas of the Moon with high spatial and altitude sampling for scientific studies (*Kiran Kumar AS, et al., 2009*). A 5m sampling camera was chosen to be commensurate with 1:50,000 scale mapping and desirable contour interval of less than 10m for height information. TMC imaged the lunar surface in push-broom mode in the panchromatic spectral band of

0.50-0.75 µm. To get the elevation information, the camera had along-track stereo viewing, acquiring stereo triplets of the target scene in fore, nadir and aft views. The base to height ratio (B/H) of the camera was 1, and the swath of the instrument was 20 km; (ii) **Hyperspectral Imager (HySI)** - for mapping the entire lunar surface in the visible and near infra-red band in 64 contiguous bands in the spectral range of 0.421-0.964 µm with a spectral bandwidth of 20nm at a spatial resolution of 80m over a swath of 20km in push-broom mode (*Kiran Kumar AS, et al., 2009*). The spatial and spectral data from HySI were so chosen to improve the knowledge of mineral composition of the lunar surface; (iii) **High Energy X-ray Spectrometer (HEX)** - designed to study low-energy (30-270 keV) natural gamma rays emitted from the lunar surface due to decay of Uranium and Thorium (*Sreekumar P, et al., 2009*), and the Field of View was limited to 30km x 30 km from the 100 km orbit; (iv) **Lunar Laser Ranging Instrument (LLRI)** - designed to provide altimetry data that would accurately map the topology of the Moon (*Kamalakar JA, et al., 2009*). As per the mission requirements, a 10 mJ diode-pumped laser (Nd: YAG Laser: 1064nm) together with 200mm diameter telescope and a silicon avalanche photodiode formed the principal components of this active remote sensing instrument; (v) **Moon Impact Probe (MIP)**- conceived to be part of the Chandrayaan-1 mission, as a unique, stand-alone microsatellite, designed to impact at a pre-decided location near the South Pole of the Moon (*Ashok Kumar Y, et al., 2009*). It carried a Moon Imaging System for surface photography along its path, a Radar Altimeter for terrain topography at close distance and a Mass Spectrometer (ChASE) for measuring the neutral composition on the sunlit side of the Moon.

Payloads carried on-board through international cooperation: Apart from the indigenous payloads/experiments, ISRO solicited proposals through an Announcement of Opportunity (AO) from International and Indian Scientific Community for participating in the mission by providing suitable scientific payloads, complementing the overall Chandrayaan-1 scientific objectives. There were 26 proposals from various laboratories/ agencies across the globe seeking opportunity to fly their science instruments on board Chandrayaan-1. Out of these, six experiments were selected for inclusion in Chandrayaan-1 mission. They were (i) **Chandrayaan-1 X-ray Spectrometer (C1XS)** – an instrument jointly developed by Rutherford Appleton Laboratory, UK and ISAC/ISRO to measure elemental abundance of Mg, Al, Si, Fe, Ti on the lunar surface using X-ray fluorescence technique (1-10 keV), and X-ray Solar Monitor (XSM) for observations of solar X-ray spectrum from 1-20 keV; (ii) **Near-Infrared Spectrometer (SIR-2)**- from Max Plank Institute/ESA, UK to detect and measure lunar mineral abundances using grating NIR spectrometer (0.93-2.4 µm); (iii) **Sub-keV Atom Reflecting Analyser (SARA)** - a collaborative instrument jointly developed by Swedish Institute of Space Physics/ESA, JAXA and SPL/ISRO to image lunar surface magnetic anomalies, solar wind-surface interaction and Moon's surface composition using low energy neutral atoms (10 eV-3.2 keV); (iv) **Radiation Dose**

Monitor (RADOM) from the Bulgarian Space Science Institute to measure particle flux, radiation dose rates and deposited energy spectrum in the near lunar space; (v) **Moon Mineralogy Mapper (M^3)**- from JPL/NASA to assess and map lunar mineral resources and to characterize the lunar surface in 0.7-3.0 µm; and (vi) M**iniature Synthetic Aperture Radar (Mini-SAR)**- from Applied Physics Laboratory (APL)/ NASA to estimate and detect water/ice in the polar cold traps up to a depth of a few meters (*Goswami JN, et al., 2009*).

The spacecraft: As highlighted, 11 payloads were identified to be carried on-board the Chandrayaan-1 mission. As regards spacecraft configuration, a judicious mix of IRS and GEOSAT bus systems of ISRO was identified to meet this (India's first) lunar mission objectives (Goswarmi *JN and Annadurai M, 2009*). One of the prime requirements was that the spacecraft should protect the scientific instruments in harsh environment and provide the right environmental conditions for the instruments to function. The spacecraft configuration was arrived at with adequate margins in terms of mass, power and real-estate to house the payloads. The spacecraft was shaped like a cuboid, each side measuring approx. 1.5m. The total mass of the spacecraft was about 1380 kg, including about 675 kg of propellant, which the spacecraft required to reach the lunar orbit and orbit further around the Moon. The mass of all payloads was only about 100 kg. Diligent configuration control of electrical, mechanical interfaces, mass, power, mission and science plans, schedule, budget and anomaly resolution, etc., called for a quantum jump in the system engineering practices (*Annadurai M, 2016*).

Ground infrastructure: The task team constituted had also identified the need for establishing a Deep Space Network station for communicating with lunar craft. The Indian Deep Space Network (IDSN) consisting of two large parabolic antennae - one with 18 m dish antenna (IDSN-18) and the other with a 32 m wheel and track antenna (IDSN-32) was established at Byalalu near Bengaluru. The Deep Space Network was necessary for communicating with the Chandrayaan-1 spacecraft, that was to be about 3,85,000 km away from the Earth. Both these Antennae were used to receive the spacecraft health data as well as the scientific data sent by the Chandrayaan-1 spacecraft.

Launch and manoeuvring: After detailed mission studies in terms of traditional as well as non-traditional approaches, a launch strategy using Elliptic Parking Orbit (EPO) with PSLV was chosen for this first Indian lunar Mission. The Chandrayaan-1 spacecraft was launched from the Satish Dhawan Space Centre (SDSC), Sriharikota on-board PSLV-C11, using XL Version, on October 22, 2008 in a highly elliptical orbit with perigee of 255 km and apogee of 22,900 km, with an inclination of 17^0 54' (*Adimurthy V, 2016*). A series of precise phasing orbits were performed in the subsequent days placing Chandrayaan-1 in the Lunar Transfer Trajectory on November 4, 2008. In the most critical operation on November 8, 2008, the liquid engine of the spacecraft was fired to reduce its velocity to insert the spacecraft in the lunar orbit and to enable lunar gravity to capture it.

As a result, the spacecraft went into an elliptical orbit with periselene (nearest point to the moon) of 504 km and aposelene (farthest point to the moon) of 7502 km. Subsequently, after a series of manoeuvres, the final 100 km circular orbit of Chandrayaan-1 was achieved on November 12, 2008. By any standard, the accuracy with which the final orbit was achieved was a great pride for any space-faring nation. The Moon Impact Probe (MIP) was separated on November 14, 2008 from the main orbiting spacecraft to precisely reach its impact location on Moon's South Pole at the designated place near the Schakleton Crater, and this place of impact has since been named as 'JawaharSthal'. MIP has taken around 3000 pictures of the Moon's surface features and 650 mass spectra of lunar atmospheric constituents before touching the lunar surface.

Scientific Results: Results obtained by the Chandrayaan-1 mission have given an insight into various surface-atmosphere interaction processes operating in the lunar environment, further evidences of a global magma ocean on the Moon in the past and also indication of more recent volcanic activities on the Moon, suggesting that the Moon is still active and dynamic. This has been in contrast to the concepts prevailing prior to the Chandrayaan-1 mission; when the Moon, based on the study of Apollo rocks, was considered to be bone-dry and dormant with little geological activity (*Bhandari, 2014*). Observations made by four experiments *viz.*, CHACE, M^3, Mini SAR, and SARA have contributed significantly to the understanding of the processes operating on the lunar surface rocks, in the lunar atmosphere and atmosphere-surface interaction. This evidence of an active hydrosphere on the Moon has been a major scientific outcome of the Chandrayaan-1 mission.

A major discovery of the Moon Mission was the presence of water (H_2O) molecule and hydroxyl (OH) on the surface layers of exposed lunar surface (rocks and soils) that is prominent near the cooler regions of the Moon by the M^3 instrument (*Goswami, 2015*). ChACE, an instrument on board MIP of Chandrayaan-1, provided the first in-situ detection of water in its vapour phase in the sunlit side of the moon. Analysis of Mini-SAR data provided evidence for the presence of sub-surface water ice deposits near the Moon's North Pole. It has found more than 40 small craters (2-15 km diameter) with sub-surface water ice located at their base. SARA provided information on solar wind interaction with the Moon and showed that almost 20% of incident solar wind protons get reflected as neutral hydrogen from the lunar surface. Observations of SARA indicated the formation of mini-magnetosphere, of size 360 km, above the strong magnetic anomaly near the Gerasimovic Crater on the lunar far side. C1XS has detected the presence of Magnesium, Aluminium, Silicon, Calcium and Sodium on the lunar surface even during low intensity solar flares. RADOM data has provided lunar radiation environment parameters during quiet solar activity periods, which is very useful for future lunar missions, both manned and unmanned. The HySI and TMC have provided detailed maps of important features of the Moon's surface including craters on both poles of the

Moon. LLRI has provided detailed three-dimensional perception of many of the polar craters of interest. High resolution data from Chandrayaan-1 TMC has found evidence of surface reflectance anomalies or Halo in and around the vicinity of the Apollor-15 landing site (*Prakash Chauhan, et al., 2009*). TMC datasets also have been used for crater counting and crater diameter measurements for age dating using Crater Size Frequency Distribution (CSFD) technique (*A.S. Arya, et al., 2012*). TMC datasets have helped in identifying partially preserved lunar lave tube or lava rille. It is named as 'Cobra' Rille and the detailed study has shown a well-preserved portion of the rille of more than a km in length and 360m width. This lave tube can serve as an effective radiation shield and provide adequate space for a reasonable habitat for future lunar astronauts exploring the Moon over longer duration.

A new Lunar mineral Mg-Spinel (a hard glassy mineral of magnesium and aluminium oxide) was discovered at the central peak of Crater Theophilus on the near side of the Moon using spectral reflectance data from M^3 (*D Lal et al., 2012*). Carbon dioxide was observed earlier by Apollo 17 LACE experiment during pre-dawn period; but the high value of CO_2 measured by ChACE was the first direct day time measurement over Moon. M^3, HySI and SIR-2 provided information on lunar surface composition on a global scale and also very high resolution data for specific lunar regions. These instruments identified huge blocks of aluminium-rich rocks over a large portion of lunar surface and confirmed 'Global Magma Ocean' hypothesis that the surface of the early Moon was molten up to a certain depth in the initial stage of formation of the Moon.

Current Status of Chandrayaan-1: Chandrayaan-1 was orbiting around the Moon at a height of 100 km from the lunar surface for chemical, mineralogical and photo-geologic mapping of the Moon from November 12, 2008. The spacecraft had carried 11 scientific instruments built in India, USA, UK, Germany, Sweden and Bulgaria. After the successful completion of all the major mission objectives, the orbit of the spacecraft was raised to 200 km during May 2009. The satellite has made more than 3400 orbits around the moon, and the mission was concluded when the communication with the spacecraft was lost on August 29, 2009 due to technical snag after nearly ten-months of operation.

Conclusion

The Chandrayaan-1 mission has demonstrated India's capability in undertaking Planetary Exploration, and has yielded significant scientific results. Following the success of Chandrayaan-1, ISRO has initiated more planetary missions. India, as may be recalled, has created another history in interplanetary exploration by successfully launching the Mars Orbiter Mission (MOM) on November 5, 2013, and the spacecraft inserted into Martian orbit on September 24, 2014.

India is planning for its next mission to Moon, 'Chandrayaan-2' towards end-2017. It would be an Orbiter-Lander-Rover mission. The primary technical objectives of this mission include, testing the

capability of soft-landing at a predetermined site on the Moon and perfecting the technology of rover navigation and hazard avoidance. The orbiter, lander and rover are equipped with several instruments to validate and extend the findings of Chandrayaan-1. The orbiter will have 5 payloads, rover - 2 payloads and lander - 4 instruments.

Space Science, besides creating newer research opportunities for scientists, inspires students and younger generation to take up scientific research and motivate them to choose scientific career.

Acknowledgements

It is the contribution of the Chandrayaan-1 Project Team(s) at ISRO, the Lunar Mission Task Force and the Scientific Advisory Board; the participation of the different institutions/ laboratories from India and abroad which contributed innovative scientific instruments/ payloads for studying different parameters of the Moon; and, the large numbers of scientific studies carried out and the results brought-out thereon using data provided by the different instruments on-board, by researchers from across the world; that have made the Chndrayaan-1 Mission a major milestone in India's Space Programme.

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Science & Technology of Remote Sensing - A future perspective

Y. V. N. Krishna Murthy, S. S. Raja Shekar and D. Giribabu

Science and technology of Remote Sensing has seen an exponential growth in the last few decades from being a reconnaissance survey tool to a global system of near real time earth and planetary observation platforms. The definition describing Remote sensing as an art and science of obtaining information through interpretations of satellite imagery has now changed its role to the science of identification of earth surface features and estimation of their geo-biophysical properties using electromagnetic radiation as a medium of interaction. Spectral, spatial, temporal and polarization signatures are major characteristics of the sensor/target, which facilitate target discrimination and information extraction.

Remote Sensing satellites, more comprehensively called Earth Observation systems, have started their journey with first generation of Corona on board during 1950s with a capability of acquiring film based imagery to second generation of scanning radiometers and then push broom linear arrays up to 90s. Landsat, Spot, IRS sensors like AWiFS and LISS and microwave platforms have established a continual support to the science of Remote Sensing.

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Having proved as a major beneficiary technology for Natural Resources Management and climate studies, an enormous growth in the number and variety of space platforms is seen in the late 90s and start of 21st century. Present space based remote sensing assets range from optical, thermal to microwave sensors along with very high resolutions in the orders of tens of centimetres resolution data and very high manoeuvrability as per the user's customised requirements. With the advent of miniaturisation technologies, sizes of satellites have plummeted to more than 100 times and numbers have grown into swarms. Magnitude of coverage and availability of earth imaging has changed the nature of applications to near real time information providers.

Keeping in line with the present trends of real-time decision support systems in all fields of science and technology, next generation of Earth Observing Satellites are being visualised as growth of intelligent systems i.e. a space-based configuration with agile and comprehensive on-board integration of sensors, data processors and communication systems. This enables simultaneous, global measurement and timely analysis of the earth's environment for real-time, mobile, professional and common users in the remote sensing, photogrammetry, GIS, and others. User communities will be less concerned with the technical complexities of image processing, domain expertise, processing

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engines and other overheads to get value added products and services. The journey is to go towards establishing a knowledge based community, empowered with real-time decision making capability just like selecting a TV channel using remote or checking messages in mobile.

In Indian scenario Earth Observation system had a very focussed mandate of national development with inclusive participation of all the stake holders towards providing solutions to societal requirements. Accordingly IRS and INSAT series of satellites have been designed with periodic, synoptic and systematic data collection pertaining to land, ocean, atmosphere and several aspects of environment. This information inferred from the data has become an inevitable key ingredient in the programmes of the government at the Centre and State towards ensuring food and water security, sustaining our environment and eco-system, understanding weather and climate, monitoring and management of natural resources, planning and monitoring of developmental activities, support to management and mitigation during disaster events, and information for better governance. Resourcesat provides continual support for thematic applications like agriculture and water resources, while Oceansat together with Scatterometer data helps in identifying potential fishing zones, wind speed and directions, sea surface temperature etc. Sea state forecasting and precise sea surface heights are obtained using SARAL ALTIKA satellite using its altimeter and Argos data collection payloads. Satellites with stereoscopic capability at very high resolution, have provided India with a rich store of Digital Elevation data that is a vital ingredient for most of the on-ground simulation and analysis applications viz, flood forecast and vulnerability analysis, coastal zone analysis, Himalayan ecosystem studies, Smart cities infrastructure development and Panchayat level planning activities. Navigation is the heart of geospatial applications and ISRO strengthened this arena by establishing its first navigation series IRNSS with operational name "NAVIC" and providing accurate real-time positioning and timing services for Indian Region.

Diverse weather conditions is a challenge for Remote Sensing data acquisition. Optical sensors are severely limited for data acquisition during cloudy or rainy days as lower wavelengths (optical) cannot penetrate through dense particles. Especially, disaster events like floods and cyclones require continual data during the events including day and night capability. Satellites with microwave sensors overcome this as longer wavelengths penetrate through clouds and active sensors (self-illuminating) can also provide night time imagery. RISAT series of satellites provide data in multiple modes and resolutions, which complement the availability of data for all weather conditions. Hyperspectral imaging is used in advanced applications like mineral prospecting, precision agriculture, preparation of spectral libraries and many more. Upcoming GISAT carries such payload along with optical and long wave sensors including the capability of providing observations within intervals of few hours. Such a single early-warning

satellite, giving constant, complete coverage of the country, is unique and a great boost to near real-time disaster management.

Study of earth atmospheric structures and environment prediction still awaits challenges in achieving the degree of precision and accuracies required for a reliable and robust decision making. Microwave remote sensing has seen a rapid growth with numerous expeditions like TRMM, TERRA, SENTINEL, etc. ISRO with its advanced observation and modelling capabilities provides near real time weather & oceanographic data and predictions from MOSDAC (*http://www.mosdac.gov.in*).

Mission Chandrayan has already established the capability and purpose of scientific missions by ISRO. Next major leap in the near future is planned with more advanced scientific expeditions like mission Aditya, sensor designed to study sun's atmosphere, second Mars mission and mission to Venus. Aditya satellite will be placed in the halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system that has the major advantage of continuously viewing without any occultation/eclipses for studying Sun's Photosphere (soft and hard X-ray), Chromosphere (UV) and corona (Visible and NIR). Instruments onboard these missions cover a wide range of capabilities including ultraviolet, x-ray and magnetic field measurements.

National Remote Sensing Centre, Hyderabad is the main arm of ISRO that is responsible for remote sensing satellite data acquisition and processing, data dissemination, aerial remote sensing and decision support for disaster management. (*https://www.nrsc.gov.in/).* A multifaceted geospatial platform Bhuvan (*https://bhuvan.nrsc.gov.in/)* is the dissemination front end for all Remote Sensing and GIS data and services in India. It's a vast datastore for terabytes of historic time series satellite imagery that can be viewed or downloaded freely by all academia and stake holders for integration into their own process chains or research activities. Entire country's natural resources, disaster warning information, infrastructure and assets are made available for empowering national development plans.

Today bigger challenges are being addressed to navigate through knowledge sharing to bring machines to talk to each other and communicate with an interoperable sphere of data and services so as to bring out holistic understanding of earth as a "single system of moving pictures of a changing planet" rather than snapshots of imagery of land, ocean and atmosphere bound by virtual divide of nations. Datacube technology, BigData and IoT (Internet of Things) are growing at a rapid pace across the institutions.

ISRO's initiatives towards empowering academic interface is multi pronged with its dedicated efforts through RESPOND projects, in-curriculum student projects, technology development programs and outreach activities. Remote Sensing and GIS collectively called geospatial technologies is also pursued in masters degrees in many institutions. Facilities for

advanced studies in Remote Sensing is made available to national and international students through Indian Institute of Remote Sensing, Dehradun and CSSTEAP centres. Indian Institute of Space Technology is another bright prospect for all the students aiming specialisation in these domains. In order to promote skill development and support to start-ups in geospatial platforms, NRSC will be providing incubation facilities apart from academic interfaces.

Renewable energy technologies for future energy options

D. N. Reddy

Abstract

Solar is currently high on absolute costs compared to other conventional sources of power such as coal. The objective of the Solar Mission is to create conditions, through rapid scale-up of capacity and technological innovation to drive down costs towards grid parity. The Mission anticipates achieving grid parity by 2022 and parity with coal-based thermal power by 2030, but recognizes that this cost trajectory will depend upon the scale of global deployment and technology development and transfer. The cost projections vary — from 22% for every doubling of capacity to a reduction of only 60% with global deployment increasing 16 times the current level. India is endowed with vast solar energy potential. About 5,000 trillion kWh per year energy is incident over India's land area with most parts receiving 4-7 kWh per sq m per day. Hence both technology routes for conversion of solar radiation into heat and electricity, namely, solar thermal and solar photovoltaic's, can effectively be harnessed providing huge scalability for solar in India.

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Solar thermal vs. Photovoltaic technologies

It is important to understand that solar thermal technology is not the same as solar panel, or photovoltaic technology. Solar thermal electric energy generation concentrates the light from the sun to create heat, and that heat is used to run a heat engine, which in turn runs a generator to make electricity. The working fluid that is heated by the concentrated sunlight can be a liquid or a gas. Different working fluids include water, oil, salts, air, nitrogen, helium, etc. Different engine types include steam engines, gas turbines, Sterling engines, etc. All of these engines can be quite efficient, often between 30% and 40%, and are capable of producing 10's to 100's of megawatts of power. Photovoltaic, or PV energy conversion, on the other hand, directly converts the sun's light into electricity.

This means that solar panels are only effective during daylight hours because storing electricity is not a particularly efficient process. Heat storage is a far easier and efficient method, which is what makes solar thermal so attractive for large-scale energy production. Heat can be stored during the day and then converted into electricity at night. Solar thermal plants that have storage capacities can drastically improve both the economics and the dispatchability of solar electricity.

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Competing with fossil fuels

Solar thermal power currently leads the way as the most cost-effective solar technology on a large scale. It currently competes other PV systems, and it also can beat the cost of electricity from fossil fuels such as natural gas. In terms of low-cost and high negative environmental impact, nothing competes with coal.

With an increasingly industrializing planet, the leaders in solar thermal technology have an ever-growing market. The issue is, and will always be, how to make solar thermal technology more economical. There are currently two methods for solar thermal collection. The first is line focus collection. The second is point focus collection. Line focus is less expensive, technically less difficult, but not as efficient as point focus. The basis for this technology is a parabola-shaped mirror, which rotates on a single axis throughout the day tracking the sun. Point focus technique requires a series of mirrors surrounding a central tower, also known as a power tower. The mirrors focus the sun's rays onto a point on the tower, which then transfers the heat into more usable energy. Point focus, though initially costlier and technically more advantageous, outshines line focus when results are concerned. The point of focus in a line focus mirror array can only reach temperatures around 250 °C. That is a sufficient temperature to run a steam turbine, but when compared to the 500 °C and higher temperatures that point focus can reach, the extra effort and cost is balanced out by its greater efficiency capability. High efficiency matters because it drives down both the land usage, and the effective cost per kWhr of the plant.

Cleaner technology and climate change

Such technological replacements allow the exploitation of the Leapfrog Effect, which will be an important factor in global development and emergent markets in an era facing serious climate change. The Leapfrog Effect is a principle that certain technological progressions are necessary, but only once. The end result, or product, is autonomous from all the preceding stages. For example, look at the slow transition that industrialized nations are making right now from coal to alternative energies. They all needed coal technology in order to develop new, cleaner methods of energy production. Now that these new technologies are developed, however, developing nations and emerging markets need not follow the same path, but instead could just leapfrog over coal-fired to the cleaner technologies.

Infrastructure requirements

Another challenge for solar thermal is the availability of space that gets consistent amount of direct sunlight required for efficient production of energy. Solar thermal power plants typically require 1/4 to 1 square mile or more of land. One silver lining of global climate change and human impact on the land is that more and more farmland is becoming unsuitable for agricultural production. This land, presumably originally chosen for its sun exposure, begs to be used for solar thermal energy production. Utilization of desertification can prove to be a boon for

solar thermal real estate procurement and growth.

With solar thermal technologies being developed and advanced by companies such as eSolar, Bright source, Abengoa, Acciona, Ausra and Schott Solar, the world has a new alternative. The benefits of eliminating coal from our energy diet are many. By not burning fossil fuels, countries can be truly energy independent. Also, by limiting, and hopefully eliminating, carbon emissions, a nation's pollution will not be windswept into another nation's territories, further cementing the concept of independence.

Solar thermal plants are being built around the world, and many new planned plants are in the works. Solar thermal is the current solar electricity cost champion, but more improvements are needed to beat the cost of the lowest-cost fossil fuels in a legislative climate without subsidies or carbon taxes.

Hybrid solar technology

- The hybrid solar technology uses a rooftop-mounded 48-inch diameter collector and secondary mirror that track the sun throughout the day using GPS
- The collector system focuses the sunlight into 127 optical fibers connected to special light fixtures equipped with diffusion rods similar to fluorescent light bulbs
- The rods spread light in all directions.

Conclusion

Renewable Energy Technologies are providing technology options for replacing Fossil Fuels, thereby ensuring cleaner and user friendly technologies for future energy needs of people, particularly in India.

Materials chemistry

T. P. Radhakrishnan

Introduction

Materials mark the evolution and progress of human civilization. The type of materials that humans have developed and deployed in their daily life have become the signature of the times they lived in. From the early periods of stone, copper, bronze and iron ages, we have evolved into the modern eras of plastic, silicon and carbon ages (Figure 1). Materials play an integral role not only in the basic necessities of life such as food, clothing and shelter, but also in improving the quality of life through the development of a wide range of technologies including health and medical, energy and environment, and communication and entertainment. Chemistry being a central theme unifying many aspects of physics, electronics and materials science on the one hand and biology, medicine and pharmaceutical sciences on the other, it is natural that materials chemistry has emerged as a critical link in the development of contemporary and futuristic technologies. Materials chemistry harnesses the power of synthetic chemistry, the fundamental insights of condensed matter physics and the versatility of engineering to meet the demands of emerging concepts and technologies in the domain of materials.

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Early developments in the field of materials chemistry were focused on the utilization of the chemical understanding of atoms, molecules and their interactions to design and fabricate materials with specific attributes such as electronic, magnetic or optical. The basic classification of solids based on the nature of the bonding interactions, into ionic, covalent, metallic and molecular (van der Waals) is now expanded to include more complex situations involving combinations of such interactions. The familiar families of metals, alloys, semiconductors, ceramics etc. have been augmented by more exotic systems with the emergence of composites, conducting plastics, biomaterials and molecular materials. Materials chemistry has played a pivotal role in these developments.

Another important development has been the shift of focus from bulk materials to molecular, supramolecular and nanometric systems. The critical idea is to control and manipulate materials at the molecular level, to extract novel and unique responses, and realize unprecedented functions. This has led to the terminologies such as advanced materials and smart materials, and the general paradigm of nanomaterials. The canvas of modern materials chemistry is vast; we discuss below a few general classes of systems in order to impart a flavor of the field.

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Nanomaterials

The unifying theme in this field is the emergence of size as a parameter to tune the properties of materials; this goes beyond the traditional idea of chemical composition and structure as the defining signatures of materials. Figure 2 shows the role of chemical composition, structure and now, size as factors that control the properties of materials. Color of materials change with the chemical composition as shown for copper, chromium and nickel compounds. A wide range of properties like hardness, electrical/thermal conductivity, solubility etc. vary significantly with the structure as shown for carbon in different forms, the chemical composition being the same. With the chemical composition and structure remaining the same, change in the size of particles of silicon from millimeter to micrometer does not affect the properties much, but going down to nanometer-sized particles leads to significant change in color (indeed the color can be tuned by varying the particle size in the nanometric range). The last example captures the essential idea of nanomaterials. Unique characteristics such as quantum confinement of charge carriers and localized surface plasmon resonance extinction, as well as the large surface-to-volume ratio of nanoparticles are exploited in a wide variety of applications including smart devices and sensors, photonics, display and imaging technologies, medicine and theranostics, catalysis and energy applications. Emergence of nanoscopy as a viable tool, using a range of probe and electron microscopy techniques has been vital in understanding and designing nanomaterials. The fabrication of nanomaterials and nanostructures is often realized using top-down approaches where larger particles are broken down into smaller particles, or by bottom-up strategies of assemblies of atoms or molecules. Chemistry is the basis of most of the latter approaches; the classic example is the synthesis of 'divided gold' by Faraday in 1857, the simple chemistry involved being the reduction of Au^{3+} to Au^{0} by phosphorus, with the reaction carried out in carbon disulfide. Besides synthesis, chemical functionalization plays a vital role in many nanotechnology applications. Materials chemistry has contributed to the development of many novel nanomaterials based on organic conjugated polymers, inorganic semiconductors and hybrid perovskites that have emerged as key components in energy harvesting technologies.

Carbon materials

The family of carbon materials include, in addition to the classical allotropes such as diamond and graphite, molecular forms like fullerenes and nanotubes, as well as single and few-layered graphene. Exfoliation through chemical means is one of the commonly employed routes to graphene fabrication. Once again chemical functionalization enables the utilization of these exotic materials in a wide range of applications related to energy and sensing; it also enables effective formation of composite materials. Various chemical transformations that lead to covalent functionalization of graphenes are shown in Figure 3. Functionalized carbon nanotubes find application in a number of

areas including electronic devices, electrochemical sensors etc. Non-covalent interactions are also effectively employed in developing carbon based functional materials; an interesting example is one of the earliest organic molecular ferromagnet based on the charge transfer complex of C_{60} with the organic π-electron donor, tetrakis(dimethylamino)ethylene.

Molecular materials

Molecular materials are some of the finest manifestations of the power and beauty of materials chemistry. The fundamental theme in the field of molecular materials is the design and synthesis of molecules (including macromolecules) and their organization into assemblies (nanocrystals, colloids, thin films, crystals) so as to elicit materials responses and functions that are not only characteristic of the molecular building blocks and their interactions, but also unique to the supramolecular structure. The versatility of synthetic chemistry is brought to bear upon tuning the molecular structure which in turn optimizes the supramolecular structure and their materials attributes. The relatively weak non-covalent interactions between molecules can be exploited to fine-tune the materials characteristics.

Liquid crystals which find extensive applications in a wide range of contemporary technologies, form the earliest, well-defined examples of molecular materials. The discovery of semiconduction in purely organic materials in the 1950s was soon followed by the discovery of synthetic metals and superconductors as well as conducting polymers. Nearly all solid state properties such as ferromagnetism, nonlinear optical responses and ferroelectricity, established in the domain of materials like metals, alloys and semiconductors, have been realized in the domain of molecular materials. Figure 4 shows examples of subtle chemical changes such as substitution of metal ions or molecular components and oxidation/reduction processes that have a profound impact on the magnetic or electrical properties of molecular materials. The first relates to a wide range of magnetic phenomena that can be realized through changes in the metallocene based complexes; the second one shows the fantastic increase of 9 orders of magnitude in the electrical conductivity of polyacetylene upon doping with electrons and holes. One of the outstanding challenges in the field is the realization of molecular scale devices.

Conclusion

In this brief article, we have attempted to impart a feel for the significance of materials in general, and the prime role of chemistry in their development. The coverage is far from exhaustive; the hope is that the selected examples that are projected would illustrate how chemical ideas and explorations are key to the design and fabrication of materials that impact upon many aspects of modern technology.

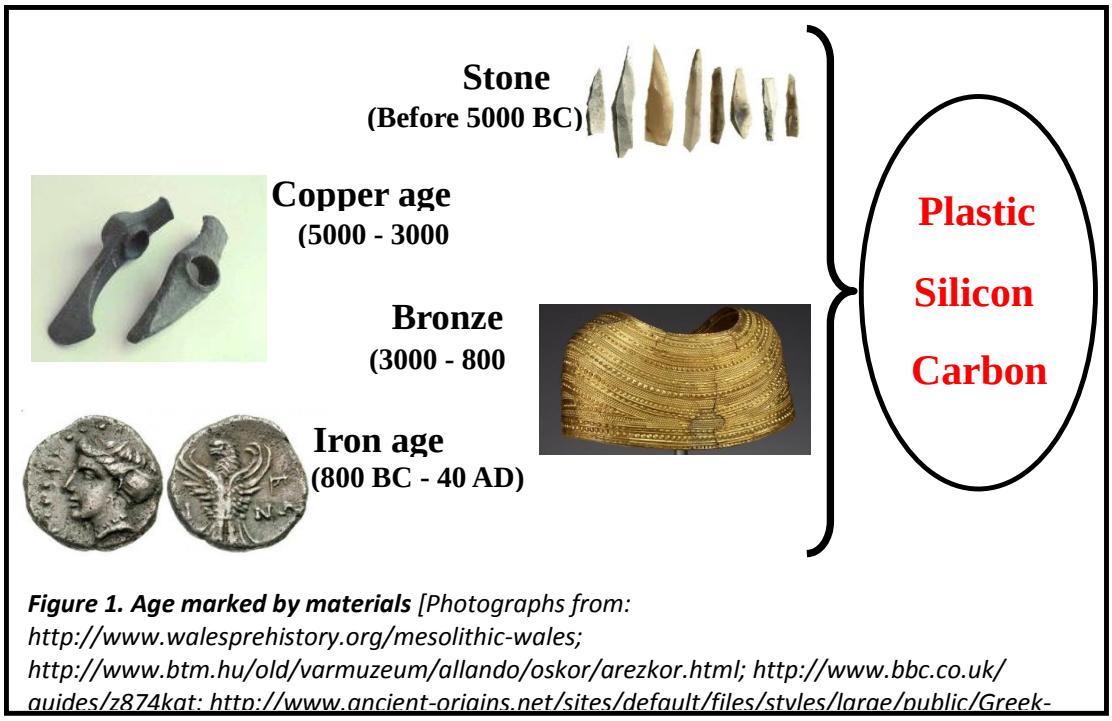

Figure 1. Age marked by materials *[Photographs from: http://www.walesprehistory.org/mesolithic-wales; http://www.btm.hu/old/varmuzeum/allando/oskor/arezkor.html; http://www.bbc.co.uk/guides/z874kat; http://www.ancient-origins.net/sites/default/files/styles/large/public/Greek-*

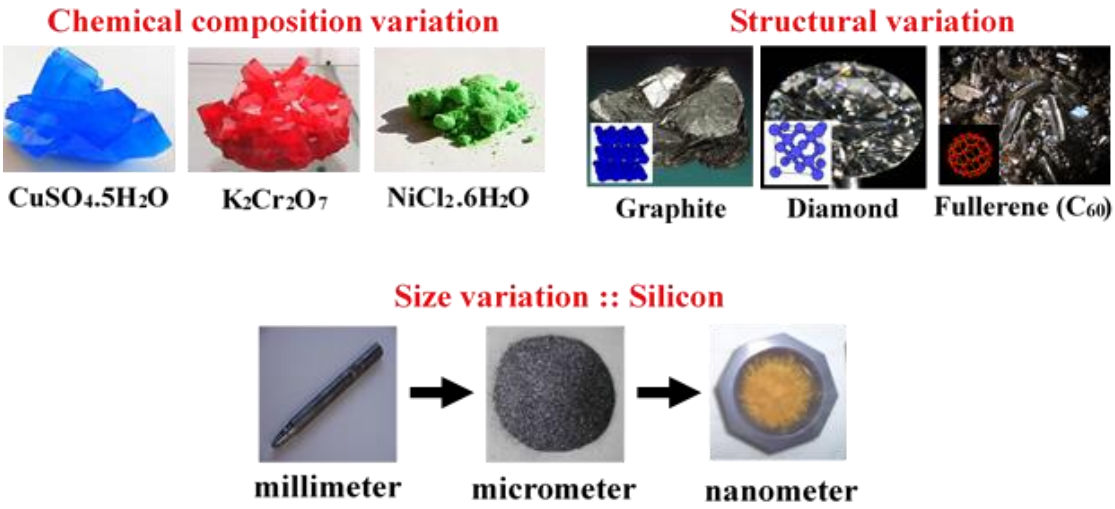

Figure 2. Impact of chemical composition, structure and size on the properties of materials.

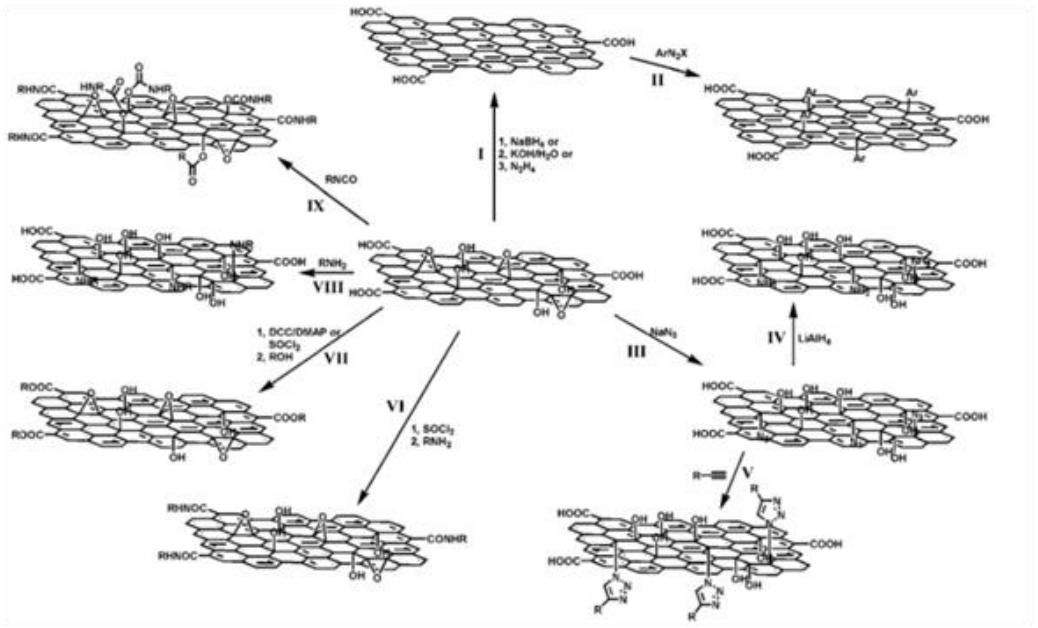

Figure 3. Chemical functionalization of graphene *[Ref. Paula Marques, Gil Gonçalves, Sandra Cruz, Nuno Almeida, Manoj Singh, José Grácio and António Sousa (2011). Functionalized Graphene Nanocomposites, Advances in Nanocomposite Technology, Dr. Abbass Hashim (Ed.), InTech, DOI: 10.5772/18209. Available from: https://www.intechopen.com/books/advances-in-nanocomposite-technology/functionalized-graphene-nanocomposites]*

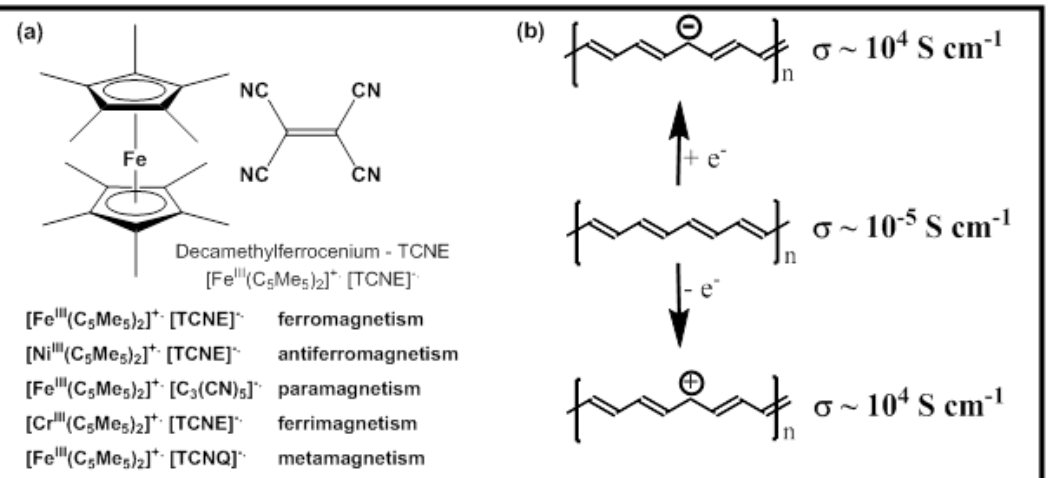

Figure 4. Tuning materials by chemical modifications: (a) Change of metal ions and π-electron acceptors transform the magnetic behavior of the solid metallocene complexes; (b) Oxidation or reduction of all trans-polyacetylene changes dramatically, the electrical conductivity (σ) *[Ref.: T. P. Radhakrishnan, Resonance, 1998, 3(7), 8]*

Research trends in smart materials and systems

G. Prasad and S.V. Suryanarayana

"Smart materials are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as strain, stress, light, temperature, moisture, pressure, pH, electric or magnetic fields etc." From times immemorial, human beings used materials in smart ways for new purposes for which they were not originally intended. The intense activity of research on smart materials has increased with changing life styles and requirements in peace, war, entertainment, transport, comfort, health related issues and probably in all areas where sensing is needed. All such requirements necessitated to look for either new materials or to exploit by proper tuning of the physical properties of the known materials or to synthesize composite materials with differing physical and chemical properties. The advantage of composite materials or structures is the ability to tune a particular property to the desired end-property for a specific purpose of sensing. The most important issue in the use of smart materials is the repeatability and accuracy. The ultimate benefit from successful research in smart materials will be the creation of physical structures that perform their functions without human intervention.

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The development of smart materials is truly a multi-disciplinary science, drawing on expertise ranging from materials science and manufacturing to engineering design and control. Smart materials and systems have a wide range of applications. In terms of the definition given at the beginning of this article, a smart material shall necessarily integrate the functions of a sensor, actuator and control mechanism under the given stimulus. Sensing by a material is to monitor environmental changes and generate signals proportional to the changing measure and actuation is to change properties of the smart material in order to achieve the desired response. The control capability continually monitors the sensor's signal, processes the information in order to determine whether an action is required. If required, then a signal is applied to an appropriate actuation. Table 1 presents certain smart materials or which can be made into composite structures with enhanced capability of sensing or actuation.

The use of smart materials is continuing to grow due to increasing effort to optimize operating systems. Some examples include: Pyroelectrics, Piezoelectrics, Electrostrictors, Magnetostrictors and Shape memory alloys.

Smart structures and systems that are built with these materials allow for more flexibility and greater functionality over conventional materials systems in various applications. Smart materials find

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applications in many areas, a few of them are: Aerospace, Defence, Automotive, Civil Engineering, Medical diagnostics etc.

There are yet numerous unexplored avenues for the application of sensing and actuating materials, but their development is still far from complete. Continued research on the materials themselves will spawn new as-yet-unknown applications, and will also provide improved performance in existing applications. Although these special materials will not simply replace conventional hydraulic, pneumatic and electric motor actuators altogether, the new actuators may eventually be implemented more widely than their long-established counterparts, as they have a high energy density, large band-width, and simple packaging. Traditional actuators can be large and complex systems, adding weight and various additional costs to the application. Sensor and actuator materials can decrease manufacturing, operating and maintenance costs, reduce weight and improve system performance. Therefore, when designing new systems, these materials should be given proper consideration as they present a very legitimate alternative to conventional systems.

In the late eighties, the research thrust in the area of smart materials and structures was initiated. Specifically, new ideas were sought for research related to: embedded sensors and actuators (including optical, magnetic, electrical, chemical and mechanical); phase transitions such as those involved in shape memory; electro-rheology; layered structures and composites; defect crystal structures (e.g., photochromic glasses); biocomposites; piezoelectric ceramics; multifunctional macromolecules, and mathematical issues related to smart materials and structures. Initially, the research was ramped up with individual and collective multidisciplinary groups of investigators. New processing techniques are required to produce entire sensor, actuator and control functions in unit cells of less than 1 mm cube. At this scale of architecture, the array is perceived to act as smart materials. Micro printing of metal, insulator and actuator materials has been demonstrated. Additional composite architecture is achieved by tape layering and by 3D-rapid prototyping photolithography techniques. Local and global response requires micro printing of circuits and elements. The latest research is addressing the mathematical issues in local-global control, simulation and modeling.

Future requirements/opportunities

Various forward-looking scenarios suggest areas of high priority research in smart materials and structures. Some of the identified areas are:

a. Lightweight materials and systems for global deployment

b. Urban environment: 360-degree close range threats (not stand off 2-3 kilometers)

c. Terrorist threat call for vigilance and detection

d. Drug interdiction, detection and tracking

e. Explosives, nuclear detection, tracking, and neutralization

f. Multifunctional requirements for materials, e.g., strength, erosion resistance, and stealth

g. Simplification of tasks (automatic controlled response)

h. Laser eye protection

There is a need to recognize and support this area with multidisciplinary programs involving aspects of materials science, electronics, biosystems, earth sciences, engineered systems and mathematical modeling. Specifically, new ideas are sought to embed or integrate sensors and actuators at the mesoscale or molecular level, for optical, magnetic, electrical, chemical, and mechanical devices. Computer logic chips may also be embedded in a distributed way. One large area for future civilian and military dual use is the need for a biomimetic nose to detect, discriminate and alarm the presence of chemical explosives, illegal drugs and biological agents. Molecular recognition and signal transduction must be highly sensitive and selective yet robust and regenerative. The use of actuators and sensors at milli and micro-scales is changing the way we think about the design and control strategies of smart and adaptive structures. The possibility of using biologically inspired designs for the control of large numbers of micro actuators suggests a solution to the problem of designing muscle-like systems that are suitable for robotic fingers and arms. One of the advantages that needs to accrue from smart and adaptive materials is their ability to repair themselves and to be fault tolerant. Related to this is the necessity for smart systems with their multiple sensors and actuators to organize themselves into a system which is capable of overall functioning with both normal and degraded modes of operation.

The most notable shift in the recent research activity is moving toward macro-scale embedded systems and meso-scale integrated smart composites. Rather than discrete actuators or sensors, more attention is given to a composite material response: a slab of material that warps purposefully or changes its surface contour, or monitors its health locally; or alters its physical characteristics locally. Small-scale architecture was presented as a means to achieve an engineered negative Poisson's ratio utilized to increase the sensitivity of hydrophones. New techniques of patterning and constructing sub millimeter sensors, actuators and distributed control elements suggest many structural and medical applications for this technology.

The level of integration in biological systems is far more advanced than in synthetic smart materials and systems. However, our evolving understanding of how biological organisms organize, create, and synthesize systems with smart functions has inspired the research community and lead to biomimetic material systems. Concepts from biological systems can be used in the synthesis and

design of the next generation of advanced materials which function as smart systems. Recent developments only promise opportunities that lie ahead.

The advent of 'knowledge revolution' — digitization of manufacturing, mass-customization and personalization combined with an increasing need of social and environmental responsibility, sustainability etc., — has elevated significantly the role of smart materials as essential building blocks of increasingly small and intricate devices and processes. They represent enabling scientific breakthroughs for numerous innovative solutions to global societal challenges, ranging from smart materials applications for pediatric cardiovascular devices to cellulose based biodegradable flexible electronics and thermochromic windows. For several years, annual lists of Top 10 Emerging Technologies have included innovations that are dependent on smart materials (e.g. green concrete, microscale 3D printing, recyclable, thermoset plastics). Moreover, the European Union's list of Key Enabling Technologies (KETs) also includes several large families of smart materials (e.g. photonics, micro- and nanoelectronic, advanced materials).

A most recent publication (Nature Scientific Reports) lays out a theoretical map to use a ferroelectric material to process information using multivalued logic - a leap beyond the simple 'ones' and 'zeros' that makeup our computing systems process much more efficient. The novel logic unit will enable information processing using not only "yes" and "no" but also "either yes or no" or "maybe". This is the way human brains operate. However, no such material is discovered yet. Once done it is up to one's imagination as what type of "smartness" or "smart material" is in store for future?

Table 1. Smart Materials

Material class	Stimulus	Response
Pyroelectrics	Temperature Change	Electric Polarization
Piezoelectrics	Mechanical Strain	Electric Polarization
Electrostrictors	Mechanical Strain	Electric Polarization
Magnetostrictors	Mechanical Strain	Change in Magnetic Field
Electroactive Polymers	Mechanical Strain	Electric Polarization
Electroluminescent Materials	Electric Field	Light Emission
Photoluminescent Materials	Incident Light	Light Emission
Electrochromic Materials	Electric Field	Color Change
Piezoelectrics	Electric Current	Mechanical Strain
Electrostrictors	Electric Current	Mechanical Strain
Magnetostrictors	Magnetic/Electric Field	Mechanical Strain
Shape Memory Alloys	Temperature Change	Mechanical Strain
Electroactive Polymers	Electric Field/pH change	Mechanical Strain
Electrorheological Fluids	Electric Field	Viscosity Change
Magnetorheological Fluids	Magnetic Field	Viscosity Change

Materials which revolutionize and engineer our future

P. Venugopal Reddy

Materials science continues to develop new materials with remarkable attributes, as well as invent new combinations of traits. Sophisticated smart phones, robotics to intelligent machines made of new materials are already playing a major role in engineering, medicine, design and manufacturing, etc. Here are a few examples of futuristic materials that will give a new turn to present day technology.

Aerogel

Aerogel is a synthetic, highly porous and ultra light material with a density of 3mg/ Cm^3 . The material is prepared from a gel, in which the liquid component of the gel is replaced with a gas. The result is a solid with extremely low density and low thermal conductivity. It is also known as *frozen smoke*, *solid smoke, solid air, or blue smoke* owing to its translucent nature. Aerogels are already used in wetsuits, fire fighter suits, windows, cosmetics and nuclear weapons. They're also expected to be used in body armour, non-deflectable tyres and as a heat shield for space craft re-entry. Infact, Aerogel was used as an insulating material in Mars Rover space vehicle.

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Although aerogel was first produced in 1931, because of its extraordinary properties and innumerable applications, the material is still considered as a futuristic material. Moreover, this material holds 15 entries in the Guinness book of world records, apart from finding a variety of novel applications.

Carbon nanotubes

Carbon nanotubes are long chains of carbon atoms held together by the strongest bond ever seen in Chemistry. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of materials science and technology. Owing to their exceptional strength and stiffness, nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1, significantly larger than for any other material. The specific strength of carbon nano tubes is 48,000 KN-m/Kg, when compared to that of the strongest material- high carbon steel (154KN-m/Kg). Single/double/multi walled carbon nano tubes, with extraordinary thermal conductivity, mechanical and electrical properties, find applications in a variety of devices.

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Metamaterials

Metamaterials are exotic composite materials that display properties beyond those available in naturally occurring materials. Metamaterials derive their properties not from the properties of the base materials, but from their newly designed structures. Their precise shape, geometry, size, orientation and arrangement gives them their smart properties capable of manipulating electromagnetic waves: by blocking, absorbing, enhancing, or bending waves, to achieve benefits that go beyond what is possible with conventional materials. Metamaterials have been used to create microwave invisible clocks and 2D invisible clocks. Because of negative refractive index exhibited by these materials, they may be used as holograms in 2D display.

Topological insulators

Topological Insulators are materials with non-trivial topological order that behaves as insulators in their interiors but whose surface contains conducting states. However, the conducting surface is not the unique character of topological insulators, since the ordinary band insulators can also support conductive surface states. The surface states of topological insulators are symmetrically protected by particle number conservation and time reversal symmetry. The unusual properties of these materials have generated a lot of interest in the condensed-matter community in recent years. They bring a great opportunity to expand understanding of the Physics of materials and could lead to applications in quantum computation. Topological insulators are also promising materials for thermoelectric science and technology.

Graphene

Graphene is an allotrope of carbon in the form of a two-dimensional, atomic scale, hexagonal lattice in which one atom forms each vertex. It is the basic structural element of other allotropes, including graphite, charcoal, carbon nanotubes and fullerenes. But graphene's simple structure belies its unmatched electronic and physical properties. Graphene has many unusual properties. It is about 200 times stronger than the strongest steel. It efficiently conducts heat and electricity, which is a million times better than copper and is nearly transparent to visible light. Graphene shows a large and nonlinear diamagnetism, greater than graphite and can be levitated by neodymium magnets. Potential applications of this material include light weight, thin, flexible, yet durable display screens, electric/photonics circuits, solar cells, and enhancement of various medical, chemical and industrial processes.

Transparent Alumina

Alumina, high temperature refractory material, which can exist in different phases, has high strength, super hardness and excellent resistance to corrosion. The transparent alumina ceramics are good materials for electromagnetic windows, domes for halide lamps, transparent armor replacing sapphire. Besides the applications for lighting and domes, transparent nano structured alumina

ceramic was also used as humidity sensor which is stable up to 2 years.

Metal foam

When a foaming agent such as powdered titanium hydride is added to molten aluminium and cooled, the resultant material is metal foam. It is very light with 75-95% of empty space. Because of this, the metal foam can be used in the automobile industry to reduce weight, in armour industry for stopping the bullets, to enhance the energy absorption properties of a structure without increasing its weight, or for sound and mechanical shock isolation. Due to its favourable strength to weight ratio, the metal foam is proposed as a construction material for space colonies. Some metal foams are so light that they float on water, which would make them excellent material for floating buildings.

Transparent concrete

Light-transmitting concrete was invented in 2001, contains glass optical fibers that transmit light through the entire length of the block, thus bringing sunlight through a wall. Concrete isn't transparent, though — it's merely light-permeable. Architects can use these blocks to make things such as floors lit from below or translucent walls, and a company has already made 20-meter-long beams capable of transmitting light across its entire length Transparent concrete uses sunlight as source of light instead of electrical energy and reduces power consumption. This concrete can also be used in cold countries to transmit heat alone with sunlight.

Smart garments

Smart garments are fabrics that enable digital components (including small computers), and electronics to be embedded in them. The basis of this new functionality is the integration of textiles and electronics. From clothing to bandages, bed linen to industrial fabrics, new products integrating e-textiles are being created. The unique combination of properties, like flexibility, softness, permeability, strength, thermal, and electrical resistance of textiles, provides several reasons for research and development. Such combination of properties is not seen in several other materials including metal, ceramic, plastic, wood, glass, paper etc. The electronic fabric can monitor one's health, guards and tells if there is any danger, measures the chemical mixture of body fluids and do many more such things.

Scope for developing new materials

In order to discover novel materials with extraordinary properties and applications, one may have to adopt innovative experimental approaches for finding new materials along with developing suitable computational procedures. For this purpose, construction of an information library of materials with comprehensive databases based on their crystallographic unit cell of crystalline phases is necessary. In order to achieve this, a Materials Genome was established in 2011. In addition, development of suitable high throughput computing for the optimization of lattice configuration, elastic, electronic, dielectric and thermodynamic properties is

essential. The new materials, due to their extraordinary properties, paints a vivid picture of our future lives. This suggests that the way we live, work and play, will change beyond recognition over the period of the next century.

Green buildings

Gregory H Kats

Over the last 20 years green building standards including LEED (adopted globally), BREEAM (adopted Europe-wide and in the Persian Gulf), CASBEE (Japan) and Green Star (S Africa) have become widely adopted. LEED, for example, is the design basis for almost half of new non-residential square footage in the US. This is an extraordinary achievement and has made for healthier, happier and greener homes, workplaces, schools, hospitals and public spaces for tens of millions of families, students and workers around the world.

But in a world of accelerating climate change and a US government that denies this scientific reality, the climate change impact of these standards is no longer adequate. Green building standards typically deliver only a 15% to 25% improvement in CO2 reduction compared to new conventional buildings. Given the scientific reality of accelerating climate change, such a small improvement is entirely inadequate. And because of cost-effective energy efficiency and renewable energy options, far deeper CO2 reductions are now cost-effective. To be a legitimate green building standard today, a rating system must require large reductions in CO2.

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The scientific consensus on climate change is now overwhelming. As a March 7, 2013 Scientific American article noted: “An astounding variety of data supports the conclusion that our earth’s climate is changing due to increasing greenhouse gas (GHG) concentrations in the atmosphere. The economic, social, and environmental implications could be catastrophic. Moreover, scientists have reached a consensus that the increase in GHGs is indeed anthropogenic”.

The moral dimension of climate change responsibility has also had its deniers. Some people who accept the reality of anthropogenic climate change argue that it is not our responsibility now – that responsibility for global warming can be left to future generations who will experience the largest costs of climate change but may have more money or technologies to manage or mitigate climate change. The moral or ethical aspects of when we take on responsibility for our own contamination of the earth, has been spoken to directly by our leading moral figures, including the Pope. Pope Francis, on Nov 30, 2016, discussing climate change stated that “Every year the problems are getting worse. We are at the limits. If I may use a strong word I would say that we are at the limits of suicide”.

A green building that cuts CO2 and energy consumption by only 20% is not a material step toward decarbonization. Because buildings represent over 40% of energy use

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and close to half of climate change, building decarbonization is essential to our rapid transition to a low carbon economy - and established green building standards must be central to this transition. To do so they should immediately be revised to require very deep carbon reductions as a requirement for certification for new and retrofitted buildings, and for green building rating renewals.

Most green buildings can achieve 100% reduction in CO2 cost-effectively. For most buildings, a combination of energy efficiency, onsite renewable energy (primarily solar PV) and direct purchase of renewable energy can today cost effectively deliver 100% reduction of CO2 from building operations. Energy efficiency technologies such as LED lights, solar PV, wind and batteries have over the last decade experienced deep and sustained reductions in cost, making zero net carbon buildings increasingly cost effective. On-site energy efficiency and renewable energy combined with purchase power agreement contracts to buy carbon free electricity under long term fixed price contracts makes zero net carbon buildings the lowest cost energy option in a rapidly growing number of cities and states. Where purchase power agreements are not currently permissible, legislation should be adopted to permit this long term power contracting, which benefits buyers, sellers and society as a whole. Deep cost reductions in energy efficiency and renewable energy have also made financially viable far more aggressive green building standards like Passivhuas, Zero-Energy Buildings, and the Living Building Challenge. But these newer, more demanding standards effect far less than 1% of buildings and cannot drive the deep carbon reductions we must achieve in the building sector if we are to limit the worst effects of global warming.

Adopting deep carbon and zero carbon requirements would also create millions of new jobs because energy efficiency and renewable energy is 3 to 4 times as labor intensive as fossil fuel and power plants. The World Bank estimates that US wind and solar creates about 13.5 jobs per million dollars of spending, and that building retrofits - energy efficiency - creates 16.7 jobs per million dollars of spending. This is more than 3 times the 5.2 jobs/$1 million for oil and natural gas, and more than 2 times the 6.9 jobs/$1 million for coal. See:
http://siteresources.worldbank.org/INTOGMC/Resources/Measuring_the_employment_impact_of_energy_sector1.pdf

Similarly, a November 2014 United Kingdom Energy Research Center report entitled “Low Carbon Jobs: The Evidence For Net Job Creation From Policy Support For Energy Efficiency And Renewable Energy”, found that renewable energy creates 4.3 times as many jobs as coal and 5.4 times as many as natural gas. It also finds that job creation from clean energy generally (renewables plus energy efficiency) is 5.3 times greater than from coal and 6.7 times greater than from natural gas. See:
http://www.edie.net/downloads/Low-carbon-jobs-Net-job-creation-for-energy-efficiency-and-renewable-energy/63

Renewable energy and energy efficiency are far more labor intensive than fossil fuels. Clean energy jobs are also more distributed and are largely higher quality jobs. Cities and corporations should update their building requirements by adding 100% CO2 reduction requirements and incentives (such as accelerated permitting, flexibility on floor area ratio, and tax benefits). LEED, BREEAM and other national leading green building standards have the market penetration and platform to allow a broad and rapid shift to zero net carbon buildings., these established standards can renew their leadership role and fulfill their potential to be transformative.

If green building standards fail to incorporate deep or 100% CO2 reductions as a requirement they will become increasingly irrelevant. Worse, green building standards that enable buildings that are only marginally better on CO2 to claim a green mantle would be an impediment to the rapid deep decarbonization that we must achieve if we are to heed the Pope's moral call to pull back from "the limits of suicide". Stepping up to this role is both a moral necessity and financially cost effective.

Climate change is the defining issue for our species' future. Adopting green building standards as a requirement for all new construction and building retrofits it is the most cost effective and compelling opportunity for cities, corporations, schools and public institutions to demonstrate real leadership at a time of accelerating climate change peril. To do less when deep carbon reduction is now cost-effective is both financially imprudent and morally irresponsible.

India's water future

Asit K. Biswas[1] and Cecilia Tortajada[2]

Introduction

Water planning in India has been on an unsustainable path for centuries. In the 16th century, Mughal Emperor Akbar decided to build a new capital in Fatehpur Sikri (City of Victory). In 1589, Robert Fitch, one of the earliest English travellers to India, noted that Agra and Fatehpur Sikri were "two great cities, either of them much greater than London and more populous".

The history of the new capital was not so auspicious. Akbar used it only for 13 years and then abandoned it completely to return to his old capital on a permanent basis. The main reason was very simple. There was not enough water in Fatehpur Sikri in the arid plains of northern India to function as an effective capital.

Fatehpur Sikri is a magnificent monument to India's poor water planning. Over the centuries India's water planning has improved only incrementally whereas its drivers of water uses have increased exponentially.

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Consequently, the complexities and magnitudes of water management in the country have steadily increased. Sadly, even though India has now become a major global economy power, its water management practices and processes are at least 50 years behind time. Thus, not surprisingly, all over the country, there are continuous signs of water stress because of scarcity or excess of water, as well as its quality and reliable availability over both space and time.

Drivers of India's increasing water requirements

There are many drivers for steadily increasing water use. Some of these drivers have been traditional and recognized for centuries. Others are non-traditional and are of comparatively recent origin. Among the traditional factors are increasing population, rapid urbanization, escalating demands for food and energy, accelerating industrial and commercial activities, as well as changing technologies and lifestyles.

Among the non-traditional and recent ones are steady economic growth which is changing the nature and magnitudes of water requirements, both in terms of quantity and quality and over space and time, higher education and skill levels which are contributing to higher income levels as well as to meet increasing aspirations and expectations of the average Indians. All these activities

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invariably require water since it is one of the threads which interlink them.

Population has been historically a major driver of increasing water use. In 1947, the total population of undivided India was 390 million. By, 2050, total population of the three countries that constituted undivided India will be 2,206 billion, a 5.66-fold increase in little over a century. Furthermore, India is expected to overtake China by 2022 as the most populous country of the world. By 2050, India is estimated to have 400 million more people than China.

Population growth and scientific and technological advances and steadily higher standards of living have contributed to exponential growth in human activities over the past century. This has resulted in higher water requirements for all types of water uses: human, thermo-electric, industrial and agricultural. Sadly, because of consistent bad planning and management, efficiency of water use in all sectors has only increased marginally.

In addition, for centuries domestic and industrial wastewaters have been indiscriminately discharged into water bodies without any, or at best, partial treatment. Consequently, all water bodies within and near population centres have already been contaminated seriously with domestic and industrial pollutants. This has posed serious health and environmental problems. This has also meant that some water sources have now been so polluted that they cannot be used for many purposes without additional expensive and sophisticated treatments.

Along with population, another major factor over the past 60 years has been that India has witnessed steady urbanization. This has contributed to rapid growth of megacities, that is cities having more than 10 million population. At present India has five megacities: Delhi (26.5 million), Mumbai (21.4 million), Kolkata (15 million), Bengaluru (10.5 million) and Chennai (10.2 million). By 2030, two more will become megacities: Hyderabad (12.8 million) and Ahmedabad (10.5 million). In contrast, even as late as 1980, India did not have even a single megacity. The most populous Indian city then was Kolkata at 9.03 million. It was then 9th most populous city in the world.

During the past four decades Indian cities have undergone rapid urbanization. Delhi is now the most populous Indian city and is likely to grow even more. By 2030, Delhi's population is expected to increase by another 9.5 million people to become 36 million. This addition is almost another megacity.

The issue is with such rapid population growth cities like Delhi or Mumbai have simply been unable to provide basic services like clean water, proper wastewater and solid wastes disposal. Megacities like Delhi and Mumbai have also seen equally rapid growths of mega-slums, primarily because of migration from rural areas. The city administration during the last 50 years never had the management and administrative capacities to cope with such rapid exponential growth. Pervasive corruption, perpetual rent-seeking by politicians, bureaucrats and business people have meant such

cities not only did not receive appropriate investment funds but also were seldom spent properly. Thus, not surprisingly, water supply and wastewater management in all Indian cities leave much to be desired.

Even though water and wastewater management practices and processes in the megacities are poor and will continue to be unacceptable over the next 2-4 decades, it should be noted that megacities are in much better shape compared to mid-size cities, and will remain so in the coming decades. This is because all the megacities are centres of political and economic power. These are places where the Indian elites live. They also have significantly better technical, managerial and administrative capacities than the mid-size cities. Thus, they are literally sucking in all types of resources from their hinterlands for their survival.

The mid-size cities do not have the same political, economic and media clout. Accordingly, in the coming years these mid-size cities are unlikely to prosper as much as the megacities, not only in terms of availability of clean water and sanitation but also are likely to lag all types of development needs which could provide them with a good standard of living and quality of life, including availability of food, energy and services like health, education, transportation and communication. This is a fact that has been consistently ignored by the Indian policy makers and bureaucrats.

In addition, with steady economic growth, higher literacy and increasing skill levels, the number of Indian middle class families has gone up exponentially. This trend is likely to continue. The median income of Indian households is expected to reach over $10,000, by 2030, in 2014 prices. One of the direct results of this affluence has been the rapid changes in dietary patterns and energy consumption levels of the affluent people which now number in hundreds of millions. As the country has prospered, the people have steadily moved to a much higher protein-based diet like milk products, fish and meat, all of which need significantly more water to produce than cereal-based diets. Their energy consumption also has gone up because of increasing use of air conditioners, refrigerators, washing machines and cars. All these need extra energy to produce and operate, and no energy can be generated without significant quantities of water.

Also, even though Central Electricity Authority claims that India will have electricity surplus of 1.1% in 2016-17, some 300 million Indians still do not have access to electricity. Power cuts in many parts of the country are still rampant, and India's per capita electricity consumption is significantly lower than the world average. It is even lower than a country like Bhutan. It is less than one-third that of China, which is another developing country. Thus, India will need to generate a massive quantity of electricity to meet the needs of all Indians and also meet their aspirations. This does not include an additional 400 million people who will need more electricity. These increases in generating capacity will mean tremendous needs for additional water for cooling. This will add to all the extra water needed for food, industrial and domestic sectors.

Accordingly, in terms of water, the country now is facing a perfect storm. This means water management practices and water use efficiencies in India need to change dramatically in the coming years. However, we do not see any sustained political will that will be absolutely essential to take some hard decisions in the future, either at the Central or state levels.

Interstate water disputes

The problem is further exacerbated by the fact that all important rivers in India are interstate, and water management is basically a state subject on which the Centre has very limited influence or control, except indirectly like provision of funds.

Because of poor water management in all the Indian states and steadily increasing water demands, India is now witnessing increasing conflicts on water allocations in interstate rivers. This has become a serious challenge to the regional stability of the country.

Interstate water allocation conflicts have triggered numerous protests, violence and property destruction. If these conflicts continue and grow, they may prove to be one of the biggest political constraints to India's future economic growth and social cohesion.

A major challenge now is the absence of permanent and efficient dispute resolution mechanisms for water allocation in interstate rivers. Under the Interstate Water Disputes Act of 1956, ad hoc tribunals can be established on a case by case basis whenever conflicts between two states cannot be resolved by mutual discussion. The initial objective and expectation of this Act was to allow the states to discuss and resolve the conflicts before engaging in adjudication. This simply has not happened.

Our research indicates that interstate water tribunals have often contributed to long-drawn negotiation processes which have mostly led to hardening of the positions of the individual states, instead of promoting acceptable compromises. The Act has now become part of the problems rather than solutions. This Act should have been amended decades ago.

There are several problems with the existing tribunal system. First, there are no uniform, logical and common processes which could act as guidelines for the tribunals to follow. They have considerable discretions in terms of processes to arrive at settlements as also underlying concepts under which settlements are made. Fundamental assumptions have often varied from one tribunal to other significantly. Thus, not surprisingly states now are reluctant to accept its verdicts for one reason or another.

Second, tribunal results are non-binding to the states. Thus, there is no way states can be forced to accept the awards, especially when states consider them to be unjust, contrary to their interests and will not be acceptable by their people.

Third, the Centre has been consistently reluctant to establish institutions for implementing the awards. There are now

discussions to see what can be done, but whatever is proposed and accepted is likely to be too little, too late and unlikely to be a major improvement, in terms of time, acceptability to all the parties and effectiveness.

Fourth, there is no fixed stipulated timeframe for negotiations and adjudications. The Cauvery Tribunal took 17 years. Karnataka then promptly decided to file a Special Leave Petition to the Supreme Court to thwart the final award, further delaying the settlement. Currently, such adjudications are taking about 20 years. By then, most of the initial conditions would have changed, and thus the verdicts, whatever they may be, are mostly not acceptable to the disputing parties. Sadly, we have not seen even very preliminary discussion of how to formulate living treaties which could change with time and differing conditions, a fact that the country will have to face in the future.

An important factor linking water disputes to state politics is often the power of state campaigns in distracting voters from the real issues of poor governance and lack of administrative skills and actions. Unfortunately, water has now assumed the role of a political weapon for interstate water disputes. Because of the emotional nature of the water problems and the states are organized on a linguistic basis, it has been easy to inflame the people to believe the awards of the tribunals are unfair and unjust.

With a number of states defying orders of tribunals and recently even the Supreme Court, water is rapidly becoming an important threat to India’s federalism as well as to its future social and economic development and political cohesion.

Improving water management practices and processes

In order to ensure that economic growth and industrial developments continue, that enough food and energy are available for an increasing population demanding steadily improved standards of living and quality of life, one resource is absolutely essential: water. Demands for water are steadily increasing. However, its management practices are decades behind the time.

If current dysfunctional and inefficient water management practices continue, with a free or highly subsidized domestic water supply and excessive groundwater pumping with free electricity, the country will only get progressively worse.

Yet, India's water management need not to be so dire. Unlike oil or coal, water is a renewable resource. Oil or coal, once used, cannot be utilized again. With good water management practices, water can be used, wastewater can be collected and treated, and water can be reused. This process can continue indefinitely.

Yet, treatment of wastewater and its reuse are alien concepts in India. Estimates by the Third World Centre for Water Management indicate that less than 10% of wastewater generated is collected and properly treated. Unsurprisingly, all water bodies within and around urban centres are now seriously contaminated. This has

had significant human health and environmental costs, which are likely to increase at least over the medium-term.

With existing knowledge and available technology, water can be significantly better managed so that the country has enough water for all purposes—not only now, but also for the year 2050 when the population is estimated to be one-third higher.

Take domestic water supply. Indian norms should be based on scientific criteria and not plucked out of thin air. Currently, communities with over 100,000 people with flush toilets are expected to use 150-200 litres per capita per day (lpcd).

Many European cities, such as Leipzig and Tallinn, have already reduced their water consumption between 90–95 lpcd. For Denmark as a whole, the average consumption is 107 lpcd. Studies in Singapore indicate that once water use exceeds 80 lpcd, there are no incremental health benefits.

Indian urban utilities routinely lose 40–60% of water produced. In Tokyo, losses are 3.7%, Singapore 4.9% and a less developed Cambodian city, Phnom Penh, 6.5%. Instead of reducing these losses, in India, the preferred option has been to increase supply, even though nearly half of the new supply is unlikely to reach the designated beneficiaries because of system leakages, inefficiencies and unauthorized connections.

Herein lies one of the chronic and fundamental problems of India's water management. The focus always has been on increasing supply. No effort has been made to manage demand and increase efficiencies. The general feeling of the politicians has been that there is enough water and it is the task of the government to provide free or subsidized water to all. There is not a single water utility or an irrigation authority in India that has a financially viable model.

Take the century-old conflict between Karnataka and Tamil Nadu over the sharing of Cauvery waters. On a dry year, with steadily increasing urban, industrial and agricultural demands, with no proper water management, there is simply not enough water in the river to satisfy all the demands unless they are managed.

Politicians of all parties seeking rural and urban votes have been reluctant to institute proper and equitable water pricing and thus take hard decisions. Water is also a very emotional issue. Thus, on 12 September, water riots in Bengaluru left two dead, 1000 vehicles burnt and 400 miscreants arrested. Major businesses like Infosys, TCS, Flipkart and Amazon had to shut their offices. Assocham estimated that Karnataka suffered losses of Rs. 22,000–25,000 crores.

Even though the Cauvery dispute is over a hundred years old, demand management has not entered in the agenda of either Karnataka or Tamil Nadu. Sadly, even now, basic hydrological, water use and demand data are not available to do any rational planning. The situation is very similar all over India.

Conclusions

In spite of the widespread belief, India is not facing a water crisis because of actual physical scarcity of this resource. However, it is facing a serious water crisis because of continuing poor management practices. Nowhere is the problem more obvious than in Cherrapunji, the world's rainiest city. With an annual average rainfall of 11,777 mm (463.7 in), it has been having serious water problems in dry months for over a decade.

In the absence of functioning water institutions and proper water management practices at central, state and municipal levels and lack of political will to take hard decisions at all political levels, water problems in India, in terms of quantity, quality and equity, will become increasingly more difficult to resolve. It proves Mark Twain’s adage “Whiskey is for drinking, water is for fighting over.”

How automation can address India's water and food security challenges

Sumith Choy[1] and Justin Simon[2]

Introduction

Two of the great issues confronting India in the next 100 years will be water security and food security. The vast volume of water used in agriculture ensures the two are inextricably linked.

Many unfamiliar with the irrigation sector will be surprised to learn that around 80 percent of the fresh water withdrawn from the environment is used for agriculture. People are often equally surprised to learn that more than half of this water is 'lost' before it reaches farms. By improving the management of water used for irrigation using readily available automation technology, India can meet the water and food security challenges the next 100 years will present.

The looming water crisis

Over the next 100 years much of the world, including India will face water crises. Water scarcity is already a major problem in many parts of the world as the global population grows and per capita consumption increases. Currently, 500 million people live in countries chronically short of water. By 2050, that number will rise to more than four billion, due to climate change and unsustainable extraction from rivers, lakes and groundwater sources. But the problems are going to hit well before 2050.

With India's population expected to reach 1.6 billion by 2050 (presently about 1.28 billion), rapid urbanisation, industrialisation and pollution of water sources will put further pressure on water resources. Feeding this population will require about 380 million tonnes of food grains annually compared to 260 million tonnes currently.

Assuming no efficiency gains, unconstrained global freshwater demand is forecast to increase by approximately two percent per year through to 2030. In aggregate, this will mean that the existing accessible, reliable and sustainable supply of fresh water is 40 percent below forecast 2030 demand.

As we come to live in a more water-constrained world, attention will inevitably turn to the agriculture sector, which accounts for 70% of global fresh water use, with most of this used for irrigation. In India, the figure is even higher at around 80%. The challenge will be to feed a bigger population without withdrawing additional water. The answer lies in improving the efficiency of irrigation water delivery and increasing the productivity of farms.

Irrigation canal system inefficiency

In India, much of the water withdrawn from dams and rivers is lost in open canal distribution systems before it reaches farms. A lack of measurement makes it difficult to come up with reliable figures

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but India's irrigation canal supply systems are typically about 40% efficient, that is about 60% of the water is lost before it even reaches farms.

The poor efficiency of India's open canal distribution systems presents a tremendous opportunity to cost-effectively close the gap between future water demand and supply.

The inefficiency stems from the complex nature of managing the delivery of water in canals due to the long distances irrigation networks traverse, the travel time for water to move from one point to another and the changeable dynamics of canal networks. Typically, a large irrigation canal network in India can be up to 75,000km long and serve service more than a million farmers as well as supplying drinking water to villages and cities. The bulk of losses result from the inability of operators to control water effectively so that supply is matched with ever-changing demand.

Traditionally, the movement of water in these systems is controlled by operators periodically physically opening and closing gates that span the canals (called cross-regulators). A lack of accurate measurement of flow rates and water levels at these cross-regulators means that gate adjustments are made based on guesswork rather than sound data. The timing of water supply to individual farms is largely dictated by the logistics of moving water through the system, rather than plant demand.

Canal automation

The efficiency of canal systems can be greatly improved using canal automation technology in combination with canal refurbishment and redesign. Automation has the potential to improve efficiency to 90% as has been achieved in Australia, recovering substantial quantities of water for productive use.

Canal automation meets changing water-use requirements by precisely measuring water level and flow data at cross regulators and farm service points and automatically making gate adjustments in response to the data. The following are required to achieve this:

- Automated gates with integrated flow and water level measurement that operate autonomously in synchronisation with other gates in the canal network. The gates can make hundreds of adjustments per day. This networked operation and integrated flow measurement enables the gates to precisely match supply with demand.

- High availability, high throughput and low latency radio communication infrastructure that wirelessly connects the gates and enables inter-communication between them and a central control centre computer.

- Management software that collects and automatically schedules water orders, then manages the operation of the gates to deliver water where and when required. By processing and prioritising water orders it ensures that the canal capacity is fully utilised.

Under autonomous control, software and hardware automatically act upon the data at very minute intervals to ensure that the high-level control objectives are met, without any human intervention.

For example, a single gate operating under autonomous control can precisely control the water flowing through it by making several hundred adjustments per day, something that a human operator managing many kilometers of canal cannot physically do.

Australian experience

This technology is not new and has been successfully operating in Australia for over twenty years. The Australian experience with canal automation provides an example of what could be achieved in India. After suffering the worst drought on record from the late 1990s, Australian governments made water reform and investing in canal automation, the primary means of increasing water availability.

One of the largest automation projects undertaken in Australia is the automation of the Goulburn-Murray Irrigation District (GMID) in the state of Victoria. Using Rubicon Water's TCC Network Control automation solution, the project aims to increase the efficiency of irrigation water use from approximately 70 percent to at least 85 percent, which will mean an annual water saving of about 429 million cubic meters when the project is complete. That is equivalent to the annual consumption of Melbourne, a city of four million people. The water savings are being retained in storage and made available to cities, returned to farmers and released into environmentally significant rivers and wetlands.

Already in the parts of the district where modernisation has been completed efficiency levels of 90% have been achieved. This is water that would otherwise be lost in the sense that it was not able to be applied where society required it.

Additional benefits

By improving water distribution efficiency, canal automation increases water availability. But the improved responsiveness of an automated system better meets farmer needs by delivering the water on-demand in as much as this is physically realisable. This is in contest to manual systems that require farmers to order water many days in advance or supply water at times according to a pre-set timetable that individual farmers have little influence over. With canal automation, farmers end up with a much-improved supply service, which means they can use their water much more productively. The benefits of this improved service include:

Improved farm productivity. By enabling farmers to irrigate at the optimal time, crop growth improves, giving higher yields and quality. Productivity is also assisted by the consistent flow rates that automation delivers. High and consistent flow rates reduce waterlogging and improve the consistency of application, factors that enable higher biomass and higher value crops to be grown.

More equitable distribution. Canal automation improves equity by ensuing water supplied is accurately measured and all farmers get the same standard of service no matter where their land is located. Aside from the obvious social implications, equitable distribution means the productive potential of all land in the irrigation region is exploited, whether close or far from the dam or river that supplies water to the canal network.

Reduced farm water use. Water supplied at consistent and high flow rates enables farmers to irrigate much more quickly and precisely. This avoids applying excess water that is not used by the plant. A reliable supply also gives farmers the confidence to invest in modernised on-farm equipment to further improve water application efficiency.

Realising these benefits will not only help farmers feed a larger population, they will also go a long way to achieving the Modi government's goal of doubling farm incomes by 2022 .

Conclusion

Canal automation presents a tremendous opportunity to mitigate the impact of the water and food security issues that India will face during the next 100 years. The technology is not emerging; it has already been proven over many years in other parts of the world.

Given the vast proportion of fresh water that the irrigation sector uses, together with the poor efficiency of existing manual systems, reducing these losses is the obvious starting point in closing the predicted gap between fresh water supply and demand. Canal automation also has the added benefits of improving equity of distribution, improving crop productivity and further reducing water use on-farm.

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Neuroendocrinology: A short historical review and where we stand today

Roger Guillemin*

Keywords: neurosecretion; peptides; somatostatin; hypothalamus

The term *Neuroendocrinology* appeared in the mid-1900s when it was demonstrated that neurons in the hypothalamus control the functions of the pituitary gland by releasing some substance(s) still to be characterized, in a recently discovered system of capillary vessels reaching the anterior pituitary. These substances were characterized as peptides, reproduced by total synthesis, now used to treat a variety of medical problems. The most unexpected discovery is that these peptides and receptors exist in various areas of the brain and peripheral organs and are implicated in functions of these organs and also overall behavior.

To the best of my knowledge, the word "Neuro-Endocrinologie" (in French, with the hyphen) appeared for the first time in 1946 on the cover and as the title of an enormous treatise by Roussy and Mosinger.[1] What I will recount here will be the successive observations, discoveries, and their interpretations that led to "neuroendocrinology" as we know it today as such and in its current extraordinary conceptual expansion.

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In the 1800s, Volta and Galvani produced contractions of the muscles of the legs of dissected frogs by applying an electric current to the nerves of the spinal cord. Here, it was established that the nervous system functions as an electric machine.

However, in the 1860s, Claude Bernard showed that the chemicals in the poison "curare" will inhibit the effects of the electrical stimulation, thus concluding that some substance, other than the electrical changes of the potential involved when applying electrical current to the nerve, must be involved in the ultimate result of the electrical stimulation of the nerves. Thus, the concept of a neuromuscular junction was established.

In 1886, the neurologist Pierre Marie described and named "acromegaly," which he considered, possibly, to be some sort of rheumatism. The pituitary gland as such was not even mentioned in his text, except for a note quoting a colleague practitioner who had observed an enlarged "mass in the sella turcica" during the autopsy of one acromegalic patient. But in those times, nothing was known about any function(s) of the pituitary gland.

In 1905, in one of the Croonian Lectures, Starling and Bayliss reported the existence in duodenal extracts of a substance, which they purified and

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named secretin, which will stimulate the secretion of gastric acid when injected intravenously. Starling introduced the word *hormone*, short for chemical mediator.

In 1904, the neurosurgeon Harvey Cushing performed the first hypophysectomy in a patient with a pituitary tumor compressing the optic nerve and, in 1912, published his book, *The Pituitary Body and its Disorders.*

In 1921, in one of the most astute experiments of classic Bernardian physiology, Otto Loewi, in Graz, Austria, showed that while electrical stimulation of the vagus nerve of an isolated heart will slow down or inhibit the contraction of that heart, the perfusion of another heart with saline irrigating the first heart will also produce similar changes of the heart contractions, thus implying that some substance is released at the contacts of the vagus nerve and the myocardial muscular fibers that can be transferred to another heart and produce the same effects without electrical stimulation of that heart. Loewi proposed the existence of some *Vagustof* so involved and, 2 years later in 1923, Sir Henri Dale, in London, showed the molecule in question to be acetylcholine, which he had been studying and had characterized in extracts of ergot. It was concluded that the stimulation of nerves releases some substance at the junction of the nerve and its target muscle.

Starting in the 1920s, several groups in France and the United States began to recognize that hypophysectomy in laboratory animals arrests body growth and inhibits functions of the newly recognized endocrine glands (thyroid, testes, ovaries, and adrenals). In the group around Herbert McLean Evans in Berkeley, the early purification, then isolation and molecular structure of six different hormones from the anterior lobe (GH, TSH, LH, FSH, ACTH, and PRL), was established. In 1952, Vincent du Vigneaud, and his group in New York, isolated, characterized, and synthesized two hormones— *oxytocin* and *vasopressin* —isolated from extracts of the posterior lobe of the pituitary. All these molecules of pituitary origin are peptides or proteins of various lengths (from 9 to over 100 residues).

In 1939, one of the most important events in the history of neuroendocrinology took place: a meeting in New York of the Association for Research in Nervous and Mental Diseases that revolved around the theme, "The Hypothalamus and Central Levels of Autonomic Function," which was followed the next year by the publication of its proceedings under the title *The Hypothalamus*.[2] It was at this meeting that the Scharrers (Ernst and Berta)[3] proposed the concept of *neurosecretion* by presenting histological images of neurons of the hypothalamus of a series of vertebrates and their equivalent in invertebrates, which are best explained by the concept of these neurons secreting substances, most likely of proteinic–peptidic nature.

And, in 1955, a book by Geoffrey W. Harris, *Neural Control of the Pituitary Gland*,[4] appeared, which presented the results of Harris' research showing that highly localized electrolytic lesions in the hypothalamus (rabbit, ferret) will specifically inhibit the secretion of one or another hormone of the anterior pituitary lobe, the electrical stimulation of the same locations leading to secretion of the same pituitary hormones. And since it had been established by that time that the anterior lobe—in contradistinction with the posterior lobe—does not receive nerve fibers of hypothalamic origin, the recently described capillaries in the pituitary stalk, extending from the median eminence to adenohypophyseal tissue were thought to be the conduit for some substances of hypothalamic origin that would act as necessary controllers of the secretions of pituitary hormones.

Jacques Benoit and Ivan Assenmacher, in France, were working with birds (primarily ducks), where the anatomy is somewhat different and had arrived at the same conclusion at about the same time. And Bernardo Houssay, in Buenos Aires, working with frogs and other animals, showed that the flow of blood in these capillaries is indeed from the brain to the pituitary.

Meanwhile, following his earlier observations published in 1936, Hans Selye in Montreal was developing his concept of the organism response to stress, in what he called "the general adaptation syndrome," with an acute pituitary–adrenal cortex response to exposure to stress (the "alarm reaction") followed by a stage of adaptation but ending in a stage of exhaustion and death, should the animal be exposed to extended periods of stress. In addition, the acute response of the adrenal cortex was shown to be prevented by hypophysectomy, thus implying a corresponding acute secretion of ACTH, which, in turn, could be prevented by one of the hypothalamic lesions as shown by Harris and others. And at the same time, Selye kept asking "What is the nature of this hypothalamic trigger of the stress-induced release of ACTH?"

As a student of Selye, I was early on intrigued by this question. Following the demonstration that none of the classic neurotransmitters (acetylcholine, norepinephrine, serotonin, etc.) was the answer, I decided to search for whatever substance coming from the hypothalamic neurons would trigger that pituitary response to stress. With the methodology of those days (1950s), it was out of the question to collect microliters of hypothalamo–hypophysial portal blood and isolate and characterize in it some unknown substance—assumed to be a peptide, as were vasopressin and oxytocin—which obviously would be present in very minute quantities.

In my own laboratory, then at Baylor College of Medicine in Houston, Texas, I first demonstrated the unquestionable existence, in crude extracts of hypothalamic tissues, of such a substance that triggered the release of ACTH in/by *in vitro* tissue

cultures of the anterior pituitary.[5] This unknown substance was named CRF, for corticotrophin releasing factor, on the proposal of Murray Saffran in Montreal, who had also been working on this problem. It became rapidly obvious that substance was present in each fragment of hypothalamic tissue (from sheep) that we were obtaining at slaughterhouses, in extremely small amounts, to be processed and characterized with the then-available methodology. Eventually, we collected several million fragments of sheep brains weighing over 50 tons, and, in 1969, we were able, with the group at Baylor, to isolate the first of these hypothalamic re- leasing factors, TRF (TRH) releasing thyrotropin.[6] Because of difficulties and uncertainties with the bioassays for ACTH, we had shifted from studying the release of ACTH to that of TSH as I had designed a highly reliable bioassay for such a substance. We showed that TRF was indeed a peptide, composed of three amino acids, glutamic acid, histidine, and proline, and we established the molecular structure by mass spectrometry as pyroGlu- His-Pro-NH_2. A synthetic replicate prepared for us by chemist friends at Hoffmann-La Roche Pharmaceuticals in Switzerland—at that time we were not equipped to synthesize peptides—had full biological activity. In some species (human and bovine) TRF also stimulates the release of prolactin. That molecular structure was confirmed about a year later in porcine hypothalamus extracts by the group of Andrew Schally—who had been my first post-doc fellow at Baylor and with whom we had been searching for CRF—now on his own.

All along, we had also shown the existence of a gonadotropin (LH) releasing factor and, in 1972, it was the group of Schally who first reported the complete structure of porcine LRF (LHRH)[7] as that of a decapeptide that turned out to be also that of LRF (LHRH) of ovine origin as we established a few months later.[8]

The synthetic replicates of these two peptides now available in large quantities were shown to be highly active in humans, and we started designing and synthesizing many analogs of these native sequences with the aim of producing superanalogs—in view of the short half-life of the native molecules, as well as competition antagonists in view of the multiple clinical implications.

By that time (1970), we had moved to the Salk Institute in La Jolla, California and had established a well-equipped laboratory, including the new radioimmunoassays developed by Sol Berson and Rosalyn Yalow, an extensive program of peptide synthesis by the new solid phase method of Merrifield, and, in our freezers, large quantities of ovine hypothalamic fragments. We then decided to look for the growth hormone releasing factor, the existence of which had been formulated as early as 1960 by Reichlin. We went back to our *in vitro* pituitary, adding crude saline or acetic acid extract of hypothalamus, following the secretion of growth hormone by a

just-established method of radioimmunoassay for rat GH. To our surprise, the addition of the crude hypothalamic extract inhibited the release of growth hormone, rapidly and in an obvious linear dose response. That was so unexpected that we suspected some mistake in the experiment; however, the observation was confirmed repeatedly. There was no previous solid evidence for a negative control of growth hormone secretion by the hypothalamus. But the results were so striking and consistent that we decided to proceed, and, in a few weeks, Roger Burgus, the chemist of the group, had isolated a 14-residue peptide that he sequenced, Jean Rivier synthesized, and that I named *somatostatin*.[9] Antibodies were generated for possible radioimmunoassay, histochemistry, and the synthetic somatostatin was largely distributed in response to many requests. It was also tested in collaboration with Sam Yen, University of California, San Diego, in some acromegalic patients with dramatic results in lowering blood levels of growth hormone. It was also observed in these patients and in normal individuals that infusion of somatostatin would lower glycemia and decrease levels of plasma glucagon and insulin, an observation that had first been made by the group around Charlie Gale, in Seattle working with baboons, but which we had never made in our studies in the rat. With a very short plasma half-life as we had measured it, and the circulation time between hypothalamus and periphery, if somatostatin was physiologically involved in the control of glucagon and insulin secretion, it had to be locally generated. In addition, I suspected that it would be found in the vagus terminals in the pancreas in keeping with its original discovery and location in hypothalamic nuclei. To everybody's surprise, immunohistochemistry by Maurice Dubois, INRA, Nouzilly, France and independently Rolf Luft and Tomas Hökfelt in Stockholm, showed the peptide to be located in the ∂-cells of the pancreas. This discovery was followed by the demonstration of the presence of somatostatin in the duodenum, the stomach, the small intestine, in several locations of the brain cortex and hippocampus, and some amacrine cells of the retina, along with five different kinds of receptors also recognized in several types of tumors. In all these locations, somatostatin was shown to be inhibitory to whatever were the classic functions of these tissues–organs. These investigations are still in progress, including the recent reports by Reubi *et al.*[10] of specific analogs of somatostatin labeled with radioactive markers to localize not only the primary, but also the minute metastases of various kinds of tumors (pancreas, gut, lung). See also the report by Córdoba-Chacón *et al.*[11].

We still had to characterize a growth hormone releasing factor (GRF, GHRH). At that time (mid-1970s), several groups in the United States, England, and Sweden were reporting about the presence in the brain of receptors for opiates, suggesting the existence of endogenous opioid ligands. Since it was

known that injection of morphine in animals, as well as in patients, was a strong stimulator of GH release as measured by plasma levels, we asked whether these endogenous opioid ligands could be the postulated GRF. Using our large store of hypothalamic fragments and a simple *in vitro* bioassay—the rat myenteric plexus—in a few weeks we had isolated three peptides of 13, 14, and 31 amino acid residues, which I decided to name *endorphins*, a name suggested earlier by Eric Simon in New York. Then, as we were starting their characterization, there appeared the paper by Hans Kosterlitz and John Hughes that reported their isolation and sequencing of two pentapeptides with opioid activity, which they named enkephalins. To our surprise, the five residues N-terminal of our endorphins were identical to met-enkephalin, all of which turned out to be fragments of the molecule named β-lipotropin isolated years earlier by C.H. Li. In the bioassays, enkephalins and endorphins did release growth hormone *in vivo* but not by direct exposure to pituitary tissue *in vitro*. Thus, they were not the growth hormone releasing factor we were looking for.

Eventually, GRF (GHRH) was isolated, from two rare pancreatic tumors from two acromegalic patients without pituitary tumors, as a 44-amino acid linear peptide in our laboratory[12] and that of Wylie Vale who had, in 1981, finally isolated from our ovine hypothalamic fragments the long sought after CRF, the corticotropin releasing factor—a 41-residue linear peptide[13]—of which we had shown the existence in 1955 but had never succeeded in isolating.

Thus, this discovery closed the search started in 1955 for the postulated hypothalamic releasing factors for each pituitary hormone, a search that also revealed the unexpected inhibitor somatostatin and many other facts of what is now neuroendocrinology.

Indeed, and again, the unexpected: every single peptide originally named and considered to be a "neuropeptide" because originally found in the cell body of neurons, has now been located along with its mRNA in practically all tissues where it has been searched for (see below). Similarly, many "peripheral" peptides (e.g., angiotensin, cholecystokinin, ghrelin, glucagon, leptin, melanocortin, secretin, etc.) have now been located in neurons—and some astrocytes—from which they are released with or without one of the "classic" neurotransmitters (5-HT, acetylcholine, norepinephrine, serotonin, etc.). Single type or, more usually, multiple types of receptors mediate in various tissues the pertinent, local activities of each and all of these peptides—for example, the presence of CRH, CRH-BP–binding protein, CRH-R1, CRH-R2 proteins and the corresponding mRNAs demonstrated in fat cells (human SZ95 sebocytes) where CRH as an autocrine secretion promotes lipogenesis.[14]

In addition, there is increasing evidence of the synthesis and secretion of

peptides by neurons throughout the brain. Oxytocin and vasopressin have been shown in multiple brain locations other than the hypothalamus where they were originally recognized, and their availability and release is being correlated with social aggressiveness or attachment;[15] these observations were first done in rodents and then were confirmed in other species including primates and, very lately, humans. Similarly, there is evidence of extensive distribution in the cortex, the amygdala, and the cerebellum of CRH receptor 1 and 2 mRNAs, where the deletion of one or the other leads to different behavioral aspects (aggressivity, passivity) of the animals (mice, rats).[16,17]

Since so many of all these effects can be correlated with the local, ubiquitous, though not random, presence of these peptides, their autocrine release in many locations, along with their originally described hormonal characteristics, therefore, the concept of hormone as originally defined by Starling in 1905 may be reconsidered in view of the current and expanding observations mentioned here regarding the ubiquity of distribution and effects of these peptides. Thus, "neuroendocrinology" has become "neuro-psycho-entero-immuno-oculo-dermato-endocrinology". All of that shows also the importance of basic research, as such, as it always leads to answers of practical significance to understand and treat patients.

Conflicts of interest: The author declares no conflicts of interest.

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The impact of genomics and genetic diversity in Indian populations on public health

Lalji Singh

Diversity in Indian population

There are about 4,635 anthropologically well defined human populations including 532 tribes, 72 primitive tribes and 36 hunters and gatherers in India. Now, it is generally agreed that modern humans diverged from the common ancestor of chimpanzee and human nearly 6 to 7 million years ago. Based on fossil records found in Africa and the finding of greater genetic diversity within Africa when compared with outside, Africa is the most likely place for the Modern human origin and dispersal.

It is now established fact that modern human originated about 160,000 years ago in East Africa. Our study on the Negrito tribes of Andaman and Nicobar Islands, such as onge, Jarawa and Great Andamanese, using complete mitochondrial DNA sequences and its comparison with the mitochondrial DNA sequences of the world population available in the database, lead to the theory of southern coastal route of migration to India against the prevailing view of northern route of migrations via Middle East[1].

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Our study was the first to reveal that the Negrito tribes of Andaman and Nicobar Islands are probably the descendants of the first man to move out of Africa following the southern route about 65,000 to 70,000 years ago. Analysis of the archaeological assemblages at Jwalapuram in southern India revealed the presence of Modern humans in India about 74,000 years ago[2]. Based on genetic and Archaeological data, this was further substantiated that modern humans from eastern Africa migrated to southern Asia following the coastly oriented dispersal about 60 to 50 thousand years ago[3]. Oppenheimer,[4] based on further evidence concluded that Modern human left Africa via single southern exit about 70,000 years ago and spread around the Indian Ocean long before a small branch left a southern Asian colony earlier on the trail to populate Europe and single southern route out of Africa from the Red sea along the Indo Pacific coast to Australia, including likely extension to China, Japan and New Guinea.

Ancient roots for India's rich diversity

Although the genome sequences of any two unrelated people differ by just 0.1%, it provides information that can help to reconstruct the historical origins of modern populations. It also points to genetic variations that highten the risk of certain diseases.

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To shed light on the genetic variability across the Indian subcontinent, 132 Indian samples from 25 groups were analyzed on an Affymetrix 6.0 array of one million Single Nucleotide Polymorphisms (SNPs) spanning the widest range of ancestry in India. Tribal groups were sampled from 13 states and 6 language families (Indo-European, Dravidian, Austro-Asiatic, Tibeto-Burman, Great Andamanese and Jarwa-Onge). Some caste groups mostly from Uttar Pradesh and Andhra Pradesh were sampled to permit comparison of traditionally "Upper" and "Lower" caste groups after providing some control for geographical spread[5].

Ancestry of mainland Indian groups

There is a strong evidence for two ancient and genetically divergent populations that are ancestral to most Indian groups today. The "Ancestral North Indians" (ANI) are genetically close to Middle Easterners, Central Asians, and Europeans, while the "Ancestral South Indians" (ASI) are not close to any group outside the subcontinent. It is shown that ANI ancestry ranges from 39-71%, and is higher in traditionally upper caste groups and Indo-European speakers. Groups with only ASI ancestry may no longer exist in mainland India[5].

Our study[5] has revealed that nearly all Indian groups descend from mixtures of two ancestral populations, ASI and ANI. This applies to traditional "tribes" as well as "castes". It is impossible to distinguish castes from tribes using the data. The genetics proves that they are not different. This supports the view that castes grew directly out of tribal-like organizations during the formation of Indian society. The one exception to the finding that all Indian groups are mixed is the indigenous people of the Andaman Islands. The Andamanese appear to be related exclusively to the Ancestral South Indian lineage and therefore lack Ancestral North Indian ancestry. In this sense, they are unique. Understanding their origins provides a window to look into the history of the Ancestral South Indians and the period of thousands of years ago when they diverged from other Eurasians. The Andamanese are the only surviving remnant of the ancient colonizers of South Asia.

Our study provides evidence that nearly all Indian groups including traditional "tribes" and "castes" are admixture of ASI and ANI populations. There was rampant mixing of North and South populations. However, about 1,900-4,200 years ago strict endogamy (marrying within the tribe and caste) developed[6]. (Fig. 1).

Implications of Genomics on public health

Present health care system has paid scant attention to genetics and genomics on public health. This is now changing by the advances made by genomics. Our study[5] has important medical implications. These have serious impact on occurrence of genetic diseases.

The origin of certain genetic disorders can be traced back to the origin of our populations

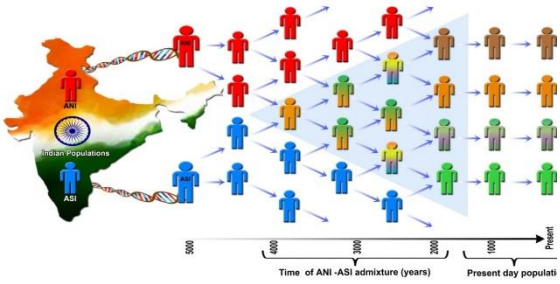

Fig. 1 How India transformed from a country where mixture between different Populations was rampant to one where endogamy, that is, marrying within the local community and a key attribute of the caste system, became the norm.

The myosin-binding protein–C3(MYBPC3 gene) is involved in about 45% of the total cardiomyopathy. This is associated with inheritable cardiomyopothies in the Indian patients in which 25 base pairs of intron between exon 32 and 33 is deleted which causes skipping of wild type exon 33 during the translation of the protein. Presence of both copies of this mutated gene (homozygous) is lethal, the affected child dies before birth or at a very early age. In heterozygous condition, where only one of the two genes has the deletion mutation (heterozygous), the individual lives up to the age of 50 to 55 years and then dies because of sudden cardiac arrest without showing any prior symptoms. This mutation is found throughout the Indian sub-continent and absent in all other countries particularly the western countries. Our detailed study revealed that this mutation originated about 33,000 years ago. It's distribution shows the relatedness of these populations[7]. We have developed PCR based screening for carrier detections.

Founder effect

We discovered that many groups in modern India descended from a small number of founding individuals and have since been genetically isolated from other groups. This means that India is genetically not a single large population, but instead is best described as many smaller isolated populations. There are a number of genetic diseases caused by the same gene in Caucasians and Indians but the mutations found in that gene are different between the two populations. Therefore, it is a must that mutations in those genes are worked out in Indian populations for prenatal diagnosis, carrier detection and genetic counselling. We cannot use the data from western populations to extrapolate for our populations. This is also a big challenge, considering the complexity of Indian population.

The chances of both defective genes being inherited in a child are much more in endogamous populations. It is, therefore, predicted that many novel recessive gene defects will be found in many endogamous populations of India. It is only now that molecular diagnosis, carrier analysis, prenatal diagnosis and genetic counselling are beginning to be used for the prevention and treatment of genetic disorders in India. However, the availability of these diagnosis still remains confined to various urban sectors and the larger section of the country, especially the rural people still do not benefit from these services. In view of the fact that about 70% of Indian population lives in villages and most of the health-statistics of the country does not include these areas. There is an

urgent need to establish facilities and utilize the knowledge available in the public domain for the welfare of the people of India, especially the underprivileged and uncared for with an aim to enhance their quality of life.

More than 6,000 human diseases are currently being classified as resulting from the action of a single mutant gene. It is indeed unfortunate that only after there is an affected child in the family that parents or relatives get concerned with the genetic nature of the disease. Prospective approaches are required for combating disorders of high prevalence and with known genetic basis such as thalassemias, sickle cell anaemia, haemoglobin e disease, muscular dystrophy, neurodegenerative diseases, mental retardation, haemophilia, etc.; and this demands a high level of awareness among the general public as well as the clinicians.

Reduction of the burden of genetic disorders in India

Thalassemia was completely eradicated in Sardinia by adopting mandatory screening and genetic counselling for the whole population. In the absence of specific treatment and gene therapy being a long cherished goal, it is very important to follow the concept of molecular diagnosis, carrier detection, genetic counselling, pre-pregnancy monitoring, pre-implantation genetic diagnosis and prenatal diagnosis. The identification of genetic defects(s) in the patients can be utilized as a handle to track the inheritance of defective gene in the foetus by performing foetal sampling procedure during early pregnancy. In this backdrop, genetic diagnosis has immense potential with particular stress on prospective screening and counselling for common disorders such as thalassemias, muscular dystrophies, etc.

Several diseases prevalent in India are yet to be identified and reported; and their genetic basis is unknown. For example, in our preliminary survey of the rural part of U.P in northern India, we observed a family whose female members, over four generations, do not have fingers and toes; families having several male and female individuals affected by muscular dystrophy and many families which have only disabled children born. This is just a tip of the iceberg. These cannot be explained on the basis of our current knowledge; and therefore, their genetic basis needs to be established.

Preventive medicine

Due to their genetic makeup, Indians are known to be susceptible to common diseases such as diabetes mellitus and coronary heart diseases. It might soon be possible to use biomarkers of genetic susceptibility to identify individuals with either enhanced or reduced risk of disease and to create clinically useful diagnostic as well as therapeutic methods. Such a programme would be a quantum leap forward in preventive medicine, practiced on genotype-specific basis. Unfortunately, majority of the existing molecular diagnostic facilities in our country are inadequate and cater mainly to the rich urban population. Such facilities are beyond the affordability of the rural

population and under-privileged people from urban populations.

In developed countries, as a result of several generations of genetic screening, it is predicted that, in future, people will be more intelligent, symmetrical, healthy, beautiful and emotionally stable. In India, genetic screening has not yet begun significantly, even in the urban population; the rural population is completely deprived of it. If necessary steps are not taken, our rural populations and under-privileged people will be riddled with genetic defects, not only hampering the economic growth and development of the country but creating two distinct India, one which lives in villages and who are exploited by quacks because of prevailing superstition and are over burdened by genetic disorders; and the other which lives in cities and are economically better off and have access to all the latest developments for keeping them healthy and relatively better looking.

Precision medicine based on individual's genotype

It is perhaps very pertinent to point out that the concept of personalised medicine based on each person's prakriti (Vata, Pita and Kapha) or constitution to maintain balance between mind and spirit, for the first time in the world was laid out in the Veda (Ayurveda) at about 4000-200 B.C. Recently[8], it has been suggested that "the phenotypic classification of India's traditional medicine has a genetic basis and its Prakrity-based practice in vogue for many centuries resonates with personalized medicine".

Future medicine will move to predictive and preventive medicine

It can be stated that all diseases are genetic. Genes are involved in everything, from behaviour to infectious diseases. Susceptibility to infectious diseases is also in our genes. Finding a disease-gene enables one to predict those who are at risk even before they develop the disease, or those whose children might be at risk even before the conception. Much more common diseases such as heart disease, cerebral vascular disease, emphysema, bronchitis, pneumonia, influenza, cancer, diabetes, suicide, liver diseases all of these are genetic. The diagnosis of disease – predisposing genes will alter the basic practice of medicine in future. The medicine will move to preventative mode (keeping people well), which should enable most individuals to live a normal, healthy, and intellectually alert life without disease.

Why do some drugs work better in some patients than in others? Some drugs may even be highly toxic to certain profiles of patients. The pharmacogenomics[9, 10] correlates therapeutic responses to drugs and the genetic profiles of patients. The individual's genetic profile can be used to optimize drug prescription (Pharmacogenetics).

In nearly 20 genes, inherited variations have been identified which affect about 80 medications and are actionable in the clinic. Pharmacogenomic variability is now being used for improving the effectiveness of medication thereby providing cornerstone for precision medicine[11].The success of personalized medicine therefore

depends on accurate diagnostic tests that identify patients who can benefit from targeted therapies[11].

The biggest challenge faced by Indian Society

The key question therefore is whether the genomic medicine/personalized medicine will improve the health of all people or whether it will just widen the technology gap between the rich and the poor. In India about 70% of the people live in rural areas who are deprived of genomic technology because they cannot afford to buy a full analysis of their personal genetic makeup and then purchase designer therapies. It therefore has to be provided at affordable costs to those who are underprivileged. The development of policy for taking these services, particularly to underprivileged and poor must start now, in view of the need to educate and train people in the principles of Genetics and Genomics.

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Precision/personalized medicine

Raju Kucherlapati

In the State of the Union address of 2015 in the United States, President Obama described a new program that was being initiated that he called Precision Medicine. The goal of Precision Medicine, also referred to as Personalized Medicine, is to use genetic and genomic information from individuals for assessing the role of genetics in individual health and disease and take action to improve the lives of individuals. This program and effort is not limited to the United States because health and disease have no national boundaries. I will briefly describe how these concepts of precision/personalized medicine have evolved, how they are impacting our health and how these concepts can be used to enhance healthcare in India and elsewhere.

There are several critical drivers for the evolution of the concepts of precision medicine. The first is the recognition that genetics plays an important role in human health and disease. One way to demonstrate the role of genetics in disease is to study identical and fraternal twins. Identical twins have the same genetic composition and fraternal twins are like siblings who have 50% probability of sharing the same genetic information at any given location in the genome.

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It has been shown that if a member of an identical twin pair develops obesity or diabetes the probability that the second members also develops the same disease is greater than 90% while that number if less than 50% in fraternal twins. Such twin studies have revealed that many complex disorders have a genetic component to them.

It is also well established that individuals born with specific genetic mutations might be susceptible to develop particular diseases later in life or in other instances such mutations may be manifested in childhood disorders. For examples women who are born with mutations in either BRCA1 or BRCA2 have a high probability of developing breast and ovarian cancer before they reach age 50. Recessive mutations in such genes as CFTR result in cystic fibrosis. Based on this knowledge, it was thought that simple and rapid methods for cloning disease genes would be very helpful. The beginning of this effort was the Human Genome Project.

The goal of the Human Genome Project was to map and sequence the genomes of several organisms including human and mouse genomes. A large international effort to map and sequence the human genome was initiated in 1990 that culminated in the publication of the first draft human genome sequence in 2001. This sequence was considered a great accomplishment of human kind because it has for the first time provided the

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complete blueprint of the genetic architecture of humans and is now paving the way for many basic science and clinical developments. At the time of completion of the human genome sequence the public and private efforts have spent more than $2.5 billion and the cost of sequencing a single human genome was estimated to be several hundreds of thousands of dollars. In the last 15 years this cost has gone down very significantly and it is now estimated that a complete human genome sequence can be obtained for $1,000 and this cost might be further reduced in the future. These technological developments have provided a strong basis for precision medicine. It is now possible to sequence the entire genome, all of the coding genes (whole exome) or subsets of the 22,000 or so genes encoded by the human genome at a reasonable cost and this is fueling the advances in precision medicine.

Applications of the use of gene and genome sequencing can be found in many areas. Different countries and different ethnic groups have variable levels of mutations and certain genes are more frequently mutated in certain populations. For example, Caucasian populations in the United States have a 25% carrier frequency for mutations in CFTR that, in the homozygous state, leads to cystic fibrosis. It is possible to screen the high risk populations for mutations in certain genes can help reduce the societal burden of some genetic disorders. Such testing procedures were already shown to be effective in select populations around the world.

The risk for certain types of disorders such as Down syndrome and trisomy 18 increases with the age of the pregnant mother. Therefore many older pregnant mothers are recommended to have fetal genetic testing. Such testing was accomplished by obtaining samples of fetal cells through amniocentesis or chorionic villus sampling. It has been recognized recently that some amount of fetal DNA can be found in maternal circulation and that the modern testing methods can detect certain fetal abnormalities by examining circulating fetal DNA (cfDNA). This non-invasive method of sampling fetal DNA has the potential to transform the way the genetic composition of the fetus can be assessed.

Of the millions of children born every year around the world, a substantial number (more than 5%) are born with genetic abnormalities. Although several genetic diseases can be diagnosed during early childhood, several disorders remain undiagnosed and may receive less than optimal treatments. It is now possible to sequence the whole exome of such children and it has been shown that in as many as 30-40% of the cases, disease causing variants in the genome can be found. As our understanding of the genetic basis for human disease increases the chances of success in identifying a causal variant increases and it is conceivable that gene sequencing can be used as a screening method for all newborns.

There are many genes, mutations in which may result in diseases that would become manifest later in life (for eg., certain forms of type I diabetes, certain forms of

movement disorders, several neurological diseases) and mutations in other genes may result in high levels of susceptibility to certain types of disorders (eg., APC mutations in colorectal cancer, BRCA mutations in breast cancer). Since many such features run in families, members of such high-risk families can undergo genetic testing that might help prevent or delay the onset of the disease.

Genetic testing can also play a critical role in clinical decision support in some diseases such as cancer. Cancer is known to be genetic/genomic disease in that a constellation of genetic/genomic changes initiate cancer development and progression. During the past ten years the genomes of several thousand tumors have been examined. Such genetic studies have revealed that some genetic changes are common among many cancer types (for eg., TP53 mutations are present in 60% of all solid tumors, mutations in KRAS and NRAS genes can be found in 40% of tumors). The genetic profiling of tumors is resulting in new ways of classifying tumors that is based on the genetic changes rather than the tissue of origin. The identification of genetic changes has also resulted in the development of novel drugs and therapies that show high response rates and less toxicity in specific sub-populations of cancer patients. It is now becoming common practice that all cancer patients be tested for a subset of the human genes and using such information for clinical treatment decisions.

As shown above, clinical genetic testing is becoming an important tool in assessing the risk for certain diseases, accurate diagnosis of other diseases and helping clinical decisions in others. The genetic and genomic era is in its early stages and is expected to be a mainstay in clinical care. Precision medicine is already transforming care of many different diseases and it is expected to play an even greater clinical role in the future.

Future of Biology: Challenges and opportunities

Seema Mishra[a], and Seyed Ehtesham Hasnain[b,c,d*]

Biology today has advanced to such an extent that it is very difficult, if not impossible, to catch up with it, let alone run or jog side-by-side. Virtually scrambling to even get a whiff of modern biology, scientists and researchers of today are grappling to make sense of a large amount of data and information flow. The Biology world today is witnessing an inter-mingling of several sciences to help it deal with this surge of information. Physics, Chemistry, Mathematics and Information Sciences are playing key centralized roles; and researchers of today need to gear up to be all-rounders if they are to level themselves in the biology cricketing field.

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Ever since the discovery of Mendel's Laws of Inheritance and the discovery of the Double Helix by Watson-Crick-Wilkins-Franklin, DNA has always been a subject of great admiration, interest and stable foundation on which many innovative useful products of immense benefit to the society and beyond have developed. This led to further advances in our understanding of the transcription product of DNA - the RNA; and the translation product of RNA – proteins and their functions. While the 'blow' to human ego, caused by the presence of just a marginally higher number of genes in humans as compared to the tiny little fruit fly, is being 'satisfied', thanks to the presence of the so-called intrinscially disorderd regions (IDRs) within proteins. These IDRs or unstructured proteins, that can adopt any structure to perform a given function, account for about 30% of open reading frames (ORFs) present in the human genome.

Amongst the new technologies and emerging disciplines within the ocean of biology are synthetic biology, high throughput technologies such as next generation sequencing, RNA sequencing, chromatin immunoprecipitation sequencing, mass spectrometry among others, and equally powerful and highly efficient computational biology databases and tools. Advances in molecular biology have made possible the efficient editing of genes using Clustered regularly interspaced short palindromic repeats- CRISPR

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associated system (CRISPR-CAS9) technology. When the target DNA is found, Cas9 – one of the enzymes produced by the CRISPR system – binds to the DNA and cuts it, shutting the targeted gene off. Using modified versions of Cas9, researchers can activate gene expression instead of cutting the DNA, thereby enabling researchers to study the gene's function. An example of its application to human health, CRISPR-CAS9 technology can enable editing of genomes including human genomes in the womb even before a child is born in order to correct genetic diseases or even predisposition to certain diseases like cystic fibrosis and thalassemia, or genetic limb malformation. In another example, a CRISPR gene drive that can cause an infertility mutation in female mosquitoes to be passed on to all their offspring has been reported which could help eliminate mosquitoes that transmit malaria. Proof-of-concept laboratory experiments have shown promise in this regard. However, although the mutation increased in frequency as expected over several generations, resistance to the gene drive also emerged.

Next generation sequencing technologies currently in the market are: IlluminaHiSeq 2000 and 2500, PacBio, Life Sciences'Qdot technology, Oxford Nanopore, to name a few. These have evolved to provide longer sequence readouts, higher resolution and lower background noise. Huge amount of data generation, running into 1 terabases (10^{12} base pairs of sequences) is possible. The increased sequencing capacity enables 10 whole human genomes (one human genome is equivalent to over 3 billion (10^9) base pairs) to be easily sequenced in just a single machine run in a matter of less than an hour.

With the sequencing cost plummeting, genomics has spread its wings across all stages of life forms, from pre-conception to conception to adulthood. This has given rise to increasing need for more powerful and efficient computational tools, and artificial intelligence is increasingly being resorted to. It is defined as 'the computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages'. IBM Watson is one shining example of such an AI system. It is being used as a clinical decision support system, to recommend drug treatments for patients, and in India just last year, Manipal Hospitals and IBM Watson had a tie-up to launch cancer care for oncology patients for personalized, evidence-based cancer care options.

Ever heard or even wondered about other types of RNA molecules beyond the usual hnRNA, mRNA, rRNA and tRNA? Yes, there are these novel molecules identified through transcriptomic and bioinformatics analysis, non-coding molecules currently being churned out in thousands. These are called by the names long non-coding RNA, short non-coding RNAs, microRNAs, circular RNAs, tRNA-derived fragments and so on. These serve to function mostly at the regulatory level and are found to be involved in cancer, cardiovascular and Alzheimer's disease, autism among others. There is currently a lot of investigation on the exact biological role of these novel molecules, and their functional prediction

needs further validation. The microbiome is also being exploited to trace the migration of human populations, as a new 'avatar' of geographic genomics.

Human microbiome comprising all the 3 life domains, bacteria, archea and eukarya has emerged as a new paradigm in treating not only infectious diseases but also metabolic disorders and cancer. This microbiome enables a human being to live functionally healthy life. In medical practices, starting from 'medical procedures, birth processes, pregnancy and dietary management, applications of personalized medicine, drug design and therapies, end-of-life care, and safety evaluation', this human-microbe superorganism enables integrated healthcare to help maintain an ecological balance. Research is continuing on the potential diagnostic and therapeutic benefits of human microbiome.

The latest technology on the anvil, 3D-printing, has made its presence felt with Spritam (levetiracetam) the first 3D printed U.S. Food and Drug Administration (FDA)-approved (in 2016) drug to treat epilepsy. 3D printing enables these drugs to be so porous even at high dose loading that these get dissolved inside the mouth with just a sip of water. It was MIT, USA that developed the basic technology of 3D printing of drugs using an inkjet print head. In essence, this technology entails spraying of different combinations of active ingredients and excipients in fluid form known as ink. These sprays are in the form of small droplets in varying sizes sprayed layer by layer into a non-powder or powder substrate. The sprayed ink then solidifies into a solid dosage form. This layer-by-layer fabrication can be done in a computer-controlled environment. Even an automated synthesis robot has been constructed. This robot operates on the fused deposition modelling approach. Here, a melted polymer of interest is extruded through a movable heated nozzle. The polymer is ejected layer by layer and this is repeated along x-y-z directions. This is then followed by solidification to create a shape designed using the computer aided design models. Reaction vessels were 3D-printed with this approach and then these fabricated vessels were used to synthesize the nonsteroidal anti-inflammatory drug ibuprofen using another approach.

Using 3D printing technology, drug production customised for each patient can be achieved with desired precision and accuracy. It is of very high interest to note that out of 104 satellites put into orbit by the Indian Space Research Organisation (ISRO) in Feb 2017, one satellite is being sent to help prepare several medicines from a single raw material. This is a collaboration of University of Glasgow and Space Pharma. This will help astronauts carry less medicine load from earth. Through this venture, ISRO has broken another frontier, this time as an enabler for space medicine.

A stem cell perspective on cell fate specification and personalized medicine

Nibedita Lenka

Genesis of Life: Biology that defines the "Science of Life" portrays the very basis of intricate organismal architecture, the living machinery, starting from unicellular organism to complex multicellular ones with defined functional attributes commensurate with the specific physiological demand. Over the years scientific pursuits have been channelized towards understanding the genesis of life forms and the associated evolutionary complexities and intricacies in development. The "origin of life" has remained a conundrum pertaining to whether it involves "Abiogenesis", i.e naturalistic origin, or "Biogenesis". While Philosophical perspective supports the former by attributing five physical elements/entities as life constituents, the biological stand point infers the dictum, "Life begets life". However, the recent demonstration of synthetic life/organism by the groups of Craig Venter (Gibson et al., 2010) and G. M Church (Ostrov *et al*., 2016) has added another level of complexity to this debatable issue. Indeed various model organisms including both invertebrate and vertebrate species have been employed to uncover the developmental proceedings and to identify the key players underlying the same.

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Organismal development that begins from a single cell follows precision to the minutest extent during the intricate developmental process, further culminating in a full fledged multicellular organism. Indeed, the very basis of this organismal architecture with defined physiology does draw our attention to the cells underlying this complex living machinery, the "Stem cells".

Stem cells, the *in vitro* developmental model: Various model organisms such as *Drosophila*, *Xenopus, C. elegans*, *Zebrafish* and even mouse embryos have been explored for understanding the fate specification during early embryogenesis. However, the recent focus has been drawn towards using cellular models *in vitro* and chalking out the developmental hierarchy thereof, by unfolding the central dogma as well as following reverse genetic tools and approaches. The most enigmatic cellular source in that context pertains to "Stem cells" that are the basic units of development and are otherwise known as the "Founder Cells" or the "Mother of all cells". The uniqueness of stem cells resides in their potential to self renew and differentiate into wide array of cell types. Based on the source of their derivation they are categorized into (i) embryonic stem cells (ESCs) residing in the developing embryo, and (ii) the fetal and adult stem cells (ASCs) residing in distinct subsets in various organs of foetus and adults,

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respectively. Moreover, these cells have the competence to participate in the regeneration process as well. Unlike the plant stem cells that are totipotent, the stem cells in animals except the initial 1-2 cell stage during embryogenesis could be regarded as either pluripotent/multipotent or unipotent, depending on the extent of their differentiation potentials. Though considered unspecialized, these cells ingrain the cyto-architectural blueprint of an organism and upon induction they transform into a more specialized/ differentiated state, based on their intrinsic genetic makeup and the environmental cues that they are exposed to. Hence, stem cells are judged as an enigmatic *in vitro* model to understand the normal development that would eventually lead to addressing what goes errant during a diseased state. Indeed, these cells have generated considerable interest and excitement among the scientific, public, and clinical communities and the stem cell biology has emerged as a most sought after area of research in the field of Biotechnology today.

ESCs: Following the pioneering report by Evans and Kaufman (1981) on successful establishment of ESC lines from mouse embryo, a paradigm shift has been noticed in utilizing the pluripotent ESCs as an elegant *in vitro* model system for understanding embryonic development. Eventually there has been a surge in attempts in subsequent years to establish ESC lines from various species (Thomson et al., 1995, 1996; Buehr *et al*., 2008, Li *et al*., 2008; Cao *et al*., 2009) including that from human (Thomson et al., 1998, Shamblott *et al*., 1998; Cowan *et al*., 2004). ESCs being derived from the inner cell mass of the blastula stage embryo bear the complete repertoire of the complex organizational blueprint of an organism. These cells are bestowed with distinctive characteristics of pluripotency, i.e. they are capable of giving rise to all the three germ layers derivatives of a developing embryo both *in vitro* and *in vivo*. In fact, a chain of intrinsic genetic and extrinsic environmental stimuli brings about the committed status to these cells signifying the representation of the stem cell/progenitor population for specific lineages. Moreover, considering the recurrence of embryonic phenotypes in adults in most cases after injury, whether as a means of repair or merely a default state, it becomes necessary to investigate the early embryonic events in order to understand the significance of this intricate phenomenon. Indeed ESCs do recapitulate the early developmental events occurring *in vivo* in a relatively precise manner and hence may provide vital clues to what may go errant in a diseased state. The promising potential of ESC system has led to the discovery of various cell signalling cascades governing temporo-spatial cell fate decision (Ying *et al*., 2003; Martinat *et al*., 2008; Verma and Lenka, 2010, Ramasamy and Lenka, 2010; Verma *et al*. 2013; Festuccia *et al*., 2016, Takarta *et al*., 2016; Zhang *et al*., 2017, to enlist a few) whose functional significance during development has been ascertained by generating several transgenic and knockout mice. Moreover, the therapeutic usage has also been explored by transplantation of ESCs derived tissue progenitors into various animal models with cardiac infarction, neural degeneration, and spinal cord injury etc.

However, generating the tissue type of interest in substantial quantity in order to study their potential implication in therapy still remains a major challenge. Investigations are indeed going on world-wide to chalk out the underlying genetic and epigenetic cell fate decision machinery (Festuccia *et al*., 2016) that would eventually facilitate accomplishing this cherished goal.

ASCs: ASCs are considered to be uni-/multipotent and they ingrain the potential to give rise to tissue specific cell types of the organ that they reside in. Moreover, these cells having the competence to participate in the regeneration process bring hope as a source for cell replacement therapy in treating various degenerative diseases. The well prevailed dogma regarding the limited proliferation and differentiation potential of ASCs has been challenged recently with a number of reports suggesting their plastic nature, where they undergo trans-differentiation into various cell types crossing the lineage barrier. Accordingly, efforts are being made to isolate and characterize various tissue specific ASCs and demonstrate their trans-differentiation potential and the underlying mechanism thereof (Miladpour *et al*. 2016; Li *et al*., 2016, Huda *et al*., 2016; Komuta *et al*., 2016; Wystrychoski *et al*., 2016; Bonilla-Porras *et al*., 2017; Yang *et al*., 2017, to name a couple of recent ones). Although conflicting reports exist regarding their plasticity (Gnecchi *et al*., 2016, Marks *et al*., 2017), the competence of ASCs, especially the bone marrow derived ones that harbour both hematopoietic and mesenchymal stem cells, have been explored further using various animal models and also in clinics in treating various hematological, neural, cardiac and pancreatic disorders. Never-the-less, it is too early to envisage bone marrow as the panacea for all the degenerative disorders, as proclaimed and exploited by some clinicians that has in fact been raised as a major concern in many of the stem cell scientific forums worldwide (Marks *et al*., 2017). Indeed a lot of ground work is required before reaching at such tall claims. Among the well proven success stories so far and apart from the well prevailed clinical implication of bone marrow transplantation in treating leukaemia, limbal stem cells have drawn a lot of attention and have also been used successfully in clinics worldwide in restoring vision in patients with accidental vision loss or corneal defect (Khan-Farooqi and Chodish, 2016; Atallah *et al*., 2016; Meller and Thomasen, 2017).

In recent years, the identification of VSELs (very small embryonic-like stem cells), a discrete population residing in various organs having pluripotent differentiation potential (Zuba-Surma *et al*., 2011, Ratajczak *et al*., 2011; Shaikh *et al*., 2017), has unleashed another avenue for exploration. The plausible reason behind the existence of VSELs in various organs might be due to their escape from the differentiation inducing signals during gastrulation and their localization to particular tissue/organ might be facilitated by the niche that they reside in. Interestingly, ASCs reside mostly in a quiescent state in an organ and based on the cellular demand they come to the mainstream of renewal and differentiation, the disarray in the same leading to cancer

– the so called cancer stem cells (CSCs) being the underlying basis. Hence, the determination of CSC-specific antigens might facilitate discriminating these cells from other cells and thereby promote their identification and purification. This in turn would lead to assessing their characteristics as well as the causalities underlying the attainment of CSCs status and cancer and also in devising targeted therapies thereof. Interestingly, MSCs have been proven to have immunomodulatory influence and hence have been considered as the vehicles for targeted delivery of various drugs and nano-conjugates to cancer cells (Nakamizo *et al*., 2005, Ruan *et al*., 2012; Kang et al., 2014). Taken together it may be comprehended that, ASCs could function as a double edged sword where in on one hand they cause cancer by going haywire and on the other, they would serve as the future tool for treating cancer.

Reprogramming: The pioneering technology developed by two Nobel Laureates, Dr. Gordon and Dr. Yamanaka, with respect to reprogramming of somatic cells to their embryonic or naive counterpart where they attain ESC-like state, the dedifferentiation event, has opened up a wider horizon in this fascinating area of research. This is accomplished either through somatic cell nuclear transfer (SCNT) (Gordon, 1962) or by incorporating ESC-specific factors (iPSCs: induced pluripotent stem cells) (Takahashi and Yamanaka, 2006, Takahashi et al., 2007). Subsequent attempts have also been made to directly reprogram either the ASCs or the somatic cells taken from one tissue type and convert those to another (Vierbuchen *et al*., 2010; Szabo *et al*., 2010; Tanabe *et al.*, 2015; Cheng *et al*., 2016). In fact, the advent of reprogramming has addressed the limitations associated with ESCs and ASCs from therapeutic stand point by combining the potentials associated with both. While ESCs, due to their indefinite self-renewal and pluripotent characteristics, are capable of giving rise to the cells of interest in sufficient number for their subsequent use in transplantation therapy, immunocompatibility remains as the major concern with these cells. Similarly, ASCs from autologous sources even though have a definite edge over ESCs for patient specific use, they may be limited in number due to their limited self-renewal and differentiation ability. In this context, patient specific iPSCs ingraining the characteristics of ESCs and without any immunological concerns similar to that of the autologous ASCs may serve as promising cell types for future medicine. Moreover, these iPSCs could be considered as elegant *in vitro* models for respective diseases, the so called “disease in a dish” that would not only facilitate understanding the disease better, but also in correcting the genetic defects by utilizing the advanced gene editing approaches. A number of disease specific iPSCs have already been reported by various groups (Onder and Daley, 2012). Investigators worldwide are in fact trying to devise strategies for improving the efficiency of iPSCs generation that would eventually lead to their possible implication in clinics. While human ESCs have been contemplated for treating macular dystrophy both in USA and UK by Advanced Cell Technology headed by

Robert Lonza (Schwartz *et al*., 2015; Song *et al*., 2015), iPSCs have been used by Takahashi and late Sasai's group (Mandai *et al*., 2017) for treating retinal/macular degeneration in patients. The success rate in these trials would certainly evoke the promising potentials of stem cells from bench to bedside.

Stem Cells and fabrication of Designer Organs: The need of the hour is not only to have the cell based therapy that replenishes the damaged cells with their healthier counterparts, but to develop as well the functional organs retaining their 3D stature similar to that seen *in vivo*. This would involve the amalgamation of the technical knowhow for Cell Biology and Engineering with the prerequisites of having biocompatible and biodegradable scaffold in conjunction with the cells of interest. Undoubtedly, these bioengineered tissues and organs with 3D stature would serve as the ideal designer organ substitute suitable for transplantation. These can overcome the limitations of donor availability and can also be used in lieu of inert prostheses being considered as orthopaedic implants, in addition to their usage *in vitro* as models for drug screening. A number of groups have indeed been successful in developing artificial skin, miniature brain (Lancaster and Knoblich, 2014), heart (Lu *et al*., 2014; Gao *et al*., 2017), trachea (Hamilton et al., 2015; Butler *et al*., 2017), liver (Pang *et al*., 2016), kidney (Davies, 2014), retina (Nakano *et al*., 2012; Sasai, 2012; Assawachananont *et al*., 2014; Shirai *et al*., 2016) etc. with the hope that these would one day serve as the designer organ substitutes that can be used for transplantation. Needless to say, the fabricated trachea and retina have already shown promise in patients. Recent years have noticed further advancement in the said arena and the advent of 3D bioprinting strategy through its interdisciplinary connotation has indeed revolutionized the field of Bioengineering (Murphy and Atala, 2014; Pati *et al*., 2014; Zhong *et al*., 2016; Lee *et al*., 2017). The computer assisted precision in fabricating the organ skeleton followed by 3D printing of suitable scaffold laden with stem cells especially the patient specific ASCs or iPSCs that can be coaxed into the cells of interest has added another feather to the overwhelming potentials of stem cells. In fact, the most recent report on developing synthetic self-developing embryo (Harrison *et al*., 2017) has opened up a new vista in the field of Reproductive Medicine.

Conclusion: Despite being associated with hypes, ethical and immunological concerns, the stem cells have drawn a lot of attention these years due to their immense potentials in the field of both basic Biology and applied avenues pertaining to Pharmacological and Clinical implications. While the knowledge gained using ESCs as a model has been furthering our understanding on the early embryonic development by monitoring the differentiation ladder into specific cell types; the investigation with ASCs is educating us with regard to how these cells maintain their stemness while being surrounded by more specialized cells. In fact, this is opening an avenue for triggering tissue specific resident stem cells to differentiate into the respective desired tissues as a therapeutic substitute

following any insult/injury to replenish their degenerating counterparts. The current focus worldwide has also been directed towards reprogramming the somatic cells from adults either by nuclear cloning or by introducing defined reprogrammable factors that make them attain the embryonic state and facilitate generating patient specific cell types to curtail immunological complications following transplantation. In fact, the efficacy of stem cells is being explored further in the field of gene therapy, since these are amenable to genetic manipulations, and also in engineering the tissues and organs with 3D stature as a suitable designer organ substitute. Indeed these fascinating cells, the stem cells, with wide gamut of implications have opened up a wider horizon for exploration by laying a stronger foundation for future personalized medicine. However like a doctor's knife, these cells when used wisely can have immense therapeutic implications, else their misuse may lead to cancer and other hitherto known and unknown detrimental effects. Hence, rather than portraying these cells as the "Panacea" for treating various diseases, a lot of ground work is yet to be carried out prior to claiming a substantial breakthrough in this promising endeavour and "caution" is the word that is required to be practiced with the current state of knowhow.

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Nutrition research in the Osmania University area

Sesikeran Boindala

While Osmania University (Jamia Osmania) celebrates its 100th year, the University in its glorious history also took into its fold several central institutions and among them the largest was the National Institute of Nutrition (NIN). In an area of about 40 Acres leased to the Indian Council of Medical Research the nutrition research labs (NRL) was set up in the 60's after shifting from Coonoor in Tamil Nadu. This institution would also complete 100 years in 2018. The NRL was subsequently christened as NIN. There was a symbiotic relationship with OU. All research scholars and postgraduate students of NIN were registered with the OU and to this day receive their PhD's from the University. The departments of Biochemistry, Zoology, Psychology and Botany and even Physics have conducted joint research with the NIN scientists for over 50 years.

During the 60's the nutrition problems in the country were largely due to protein energy malnutrition and clinical syndromes like Kwashiorkor and Marasmus were frequently encountered in the lower socioeconomic groups. Interventions with energy dense and adequate protein containing indigenous foods led to a gradual decrease to the present state when we don't see such children any more.

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However mild to moderate malnutrition and occasional pockets of severe acute malnutrition (SAM) or Moderate Acute Malnutrition are still existent. NIN has done extensive research on iron deficiency anemia that has also seen a downward trend with iron and folic acid supplementation. However overall prevalence of anemia is still unacceptably high among women and young children. The development of an iron and iodine fortified salt by the institute should be able to bring down significantly the large scale prevalence of iron deficiency. Apart from iron, multiple micronutrient deficiencies exist. Research has shown that single nutrient supplementation rarely works and there is a need to give multiple micronutrients through food fortification. Simultaneously NIN has also advocated food-based approach to provide the micro nutrients. Dietary guidelines have been prepared and made available for people to practice and obtain their nutrients through the foods that they eat in their homes.

Nutrient deficiencies contribute to a large extent to the infant and maternal mortality. One of the success stories has been Iodized salt, which has greatly brought down the incidence of cretinism and mental retardation due to iodine deficiency. The first 1000 days in a child's life right from conception is now recognized as the critical period of child development and inadequacy of nutrition to the mother as well as the growing fetus and through infancy and early childhood in

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this time could permanently leave a child stunted with improper or sub optimal physical and mental development. While these issues still remained unsolved the problem of overweight and obesity and other non communicable diseases like Diabetes, Hypertension, heart disease etc due to excessive food intakes and decreased physical activity emerged in the 80's and has reached epidemic proportion in the new millennium. NIN has carried out extensive research on dietary fats and has provided guidelines for the safe use of various cooking oils and fats and the ways of reducing the risk of cardiovascular disease. NIN also flagged the harmful effects of Partially Hydrogenated Vegetable oils (PHVO).

The two forms of malnutrition co-exist and research on fetal origins have shown that most of these are in adults who when they were in their first 1000 days of life had history of inadequate nutrition. This is now defined as a double burden of disease. Vitamin D and B12 deficiencies, which we thought was not a common problem has now become rampant to the extent that it is prevalent in some states to as high as 90% and even in areas of adequate sunshine. The NINs arm the National Nutrition Monitoring bureau has constantly monitored the food and nutrient intakes of rural population in 10 states and this has led to several policy initiatives to combat malnutrition. NIN has had good collaboration with OU scientists in helping the Government to solve problems of food safety like Aflatoxicosis, Fluorosis, Heavy metal and microbial contamination and others.

Modern biotechnology has in recent years led to the scope for development of nutrient enhanced food crops as a means of tackling the problem of micronutrient deficiency through food based approaches and the Center for Plant Molecular Biology (CPMB) at the University is actively pursuing this research and NIN will collaborate in this initiative. Safety issues are being addressed through agricultural research as well as analytical means. The NIN has recently published the Indian Food Composition tables providing information on over 300 varieties of foods and their regional variant's nutrient compositions. This data would help researchers, policy makers, nutritionists, dieticians, physicians and the industry to calculate the nutrient content of formulated foods as well as estimate the nutrient intakes of the population.

NIN has grown over the years holding hands with the Osmania University and will be always indebted to their generosity and good will and look forward to jointly solving the emerging problems in nutrition and food security.

Prospects of nutrigenomics for public health nutrition in India: Opportunities & challenges

G. Bhanuprakash Reddy

Food intake and environment are the two main factors that affect the health or illness of an individual [1]. Studies in the area of nutritional science have given insights about the links amongst health, diseases and dietary habits. The execution of the Human Genome Project has brought forth a wealth of information about the structure of the genome, which can now be used to study how the interplay between our genes and factors from the environment such as diet and nutrition relate to a state of health or disease. Genomics is a branch of genetics that represents the study of genomes. A variety of omics sub-disciplines have emerged that will not only have an impact on our understanding of biological processes including health, but on diagnosis and treatment of disease. To enable such studies, novel technologies have been designed in particular to monitor the activity of multiple genes simultaneously at the level of the DNA/RNA by genomics or transcriptomics, or the level of the proteins or metabolites by proteomics or metabolomics. However, the term genomics is generally used with a broader meaning encompassing all the three major omics: genomics, proteomics and metabolomics.

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The concept that diet influences health is an ancient one. Now an emerging body of evidence and research effort point to the potential for genetics to significantly affect nutrient metabolism and disease risk. The maintenance of health and the prevention and treatment of chronic diseases are influenced by naturally occurring nutrients and chemicals in foods. It has been predicted that the human diet contains more than 20-25 thousand unique compounds, but only handful of these are essential for life. However, emerging information indicates that many food components, although not essential for life, are capable of modulating health and disease risk. Therefore, identification of bioactive compounds present in foods and the elucidation of their absorption, metabolism and molecular mechanisms of action continue to attract interest in the nutritional/medical community. Nutrigenomics or nutritional genomics refers to the application of genomics in nutrition research, enabling associations to be made between specific nutrients and genetic factors, e.g. the way in which nutrients and other food ingredients influence gene expression and subsequent biological information flow in terms of proteome and metabolome (2). Nutrigenomics facilitates greater understanding of how nutrition affects metabolic pathways and how this process goes erroneous in diet-related diseases. Nutrigenetics is the study of individual

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differences at the genetic level influencing response to a diet. In addition, genome information has boosted approaches to study the role of genetic variation to explain individual differences in responses to nutrition, underlying in part the susceptibility for nutrition-related disorders. For example, phenylketonuria is caused by a change (mutation) in a single gene. Affected individuals must avoid food containing the amino acid phenylalanine. Similarly, common polymorphisms in genes that code for proteins/enzymes required for folate uptake have been shown to alter the catalytic activity or expression of these proteins, which can have a substantial influence on development or degenerative disease risk, providing further support for the central role of vitamins in normal growth and maintenance of health (3). These new areas of science will increase our fundamental knowledge of the interaction between life processes and our diet or specific components thereof, which may in time lead to the development of novel approaches to improve the health or to prevent the onset of nutrition-related disorders. Nutrigenomics thus bridges the gap between nutritional science and the frontiers of biology that were once perceived to be different disciplines.

The fundamental concepts of the field are that the progression from a healthy phenotype to a chronic disease phenotype must occur by changes in gene expression or by differences in activities of proteins and enzymes and finally the differences in executor molecules i.e. metabolites. In other words, the dietary chemicals directly or indirectly regulate the expression of genomic information. Studying the other facets of biological complexity, such as proteins and metabolites, is especially important with the realization that the principle of one gene leads to one protein leads to one metabolite is a simplistic and often incorrect notion, as experimentally demonstrated. Therefore, proteomics aims to characterize all proteins in a biological sample, including their relative abundance, distribution, post-translational modifications, functions, and interactions with other biological molecules. Metabolomics can be simply defined as the quantitative analysis of all metabolites in an isolated cell system, tissue, or biological fluid. Genetic mechanisms (or genomics) alone cannot explain how some biological features or characteristics are propagated. Epigenetics is the study of heritable changes in gene expression or cellular characteristics caused by mechanisms other than changes in the underlying DNA sequence (4). Rapid advances in the field of epigenetics are now revealing a molecular basis for how heritable information other than DNA sequence can influence gene function. These advances also add to our understanding of transcriptional regulation, nuclear organization, development and disease. Basically, epigenetics studies the causal interactions between genes and their products, which bring the phenotype into being.

Challenges and opportunities

Since the beginning of 21st century, India is undergoing a socio-economic, demographic, epidemiological and nutritional transition. Undernutrition and its attendant problems continue to affect large sections of the population.

Simultaneously, the problem of overnutrition, manifesting as overweight, obesity and attendant chronic lifestyle disorders such as diabetes, cardiac problems, cancers are also casting a dark shadow over the public health scene. Although the global burden of malnutrition is increasingly shifting to overnutrition, undernutrition continues to persist in South Asia, particularly in India, and thus, undernutrition, overnutrition, and micronutrient deficiencies likely to coexist in the Indian context and manifest in increased susceptibility to infection and chronic disease (5-9). Although substantial improvement in child nutrition outcomes was noted in the last decade, about 40% of Indian preschool children (<5 years) are still stunted and underweight, and stunting is prevalent across all socioeconomic groups (7-9). In general, the rural Indian population can be described as subsisting on inadequate diets, as the mean intakes of all the food groups were found to be below the RDI and intakes of all the nutrients were also below the RDA for Indians (8). Particularly, micronutrient deficiencies are widespread in India, and, even in schoolchildren of affluent families, high prevalence of anemia (14–88%) and low dietary iron intakes have been observed, and 44–66% of the affluent schoolchildren had vitamin A, B2, B6, B12, and C deficiencies (8). Because of changes in dietary and lifestyle habits-a phenomenon that can be linked to the whole globalization process-developing countries including India now face a fast “epidemiological accumulation” of non-communicable and infectious diseases and must cope with urgent and competing health priorities. Non-communicable diseases (NCDs), especially cardiovascular diseases, cancers, chronic respiratory diseases and diabetes, caused 60 % deaths globally in 2005 (approximately 35 million deaths). By 2020, it is predicted that NCDs alone will account for 80% of the global burden of disease, causing seven out of every 10 deaths in developing countries (10). Thus the potential promise of nutrigenomics and allied omics technologies must be utilized and translated in the context of this current growing epidemic, both in developed and developing countries.

Nutritional genomics will be a key area of nutritional science over the next few decades. The significance of its rapid development lies not only in the problems that can now be addressed, but also as a reflection of closure of the cultural gap between nutrition and the front-line of modern biology. Some of the potential implications of nutrigenomics on public health are listed below:

Micronutrients play a vital role in a broad range of biological functions and have implications for the regulation of various metabolic processes in the body. There is overwhelming evidence that a majority of micronutrients are required as cofactors for enzymes or the essential structural components of proteins involved in numerous physiological functions. The burden of NCDs has been on the rise in Indian population. Although the contribution of dietary factors in the development of chronic NCDs has been well established, little is known about the diet patterns and subclinical status of micronutrients of Indians with regard to

the prevalence of NCDs. Particularly, status of micronutrients, assessed by dietary intake may not reflect the body levels due to several experimental limitations and host related factors. The type of food and pathophysiological status including the genotype of individuals determine the bioavailability and nutritional status and is reflected in plasma nutrient levels. For instance acute phase response during inflammation deliberately reduces the plasma nutrient levels independent of actual nutritional status, leading to pseudo deficiency. Further, the plasma nutrients levels are homeostaticaly regulated to ensure adequate supply to the tissues, and therefore, until the reserves are depleted the plasma levels remain unchanged leading to mischaracterization as adequacy. In addition, high inter-individual variability among plasma nutrient levels is evident in many populations, but is poorly explained and could be linked to genetics. For instance, vitamin A status and its precursor carotenoid levels are recently reported to be associated with single nucleotide polymorphisms in transport proteins (11), implying genetic predisposition to nutrient deficits, even in the backdrop of adequate dietary intakes. Also, developing or identifying biomarkers of micronutrient intake (with due consideration to genetic background) is of immense value, a challenge and an opportunity. Exploring these aspects is not a challenge, but an opportunity for nutrition scientists, and nutrigenetics and nutrigenomics approaches could aid in realizing these achievements.

Another area of research that can exploit the potential of nutrigenomics is to investigate the impact of micronutrient status on health status or disease burden by testing the association between micronutrient levels and various health conditions observed in the population. Indians have a high prevalence of vitamin B12 and vitamin D deficiency (12,13) but little is known about the genetic determinants of circulating concentrations of these vitamins in Indians. It was found that hyperhomocysteinemia in diabetic retinopathy was associated with B12 deficiency (14), however the genetic determinants are yet to be studied. Through exome analysis, a novel mutation in the RBP4 gene was identified in patients with retinal dystrophy and developmental abnormalities due to severe vitamin A deficiency (15). Recently, a genome-wide association study along with meta-analysis identified novel genetic variants in FUT6 to be associated with circulating B12 concentrations (16). There is a tremendous scope to extend and expand on these lines to provide the connection between genetics, nutrition and disease.

The recommended dietary allowance or safe upper limits are designed for the general population and not optimized for genetic subgroups which may differ critically in the activity of transport proteins for a micronutrient and /or enzymes that require the micronutrient as a cofactor. Therefore future studies should address to (i) match the nutrient intake combination (nutriome) with the genome profile so that the gene expression, metabolism and cell function can occur in a homeostatically sustainable manner, and (ii) provide better mechanistic interpretation of data from

epidemiological and clinical intervention studies regarding health impacts of dietary factors that may help to refine recommendations so that they can also be specifically targeted to individuals and genetic subgroups.

Nutrition cannot be viewed independently of agriculture in the country. The staple cereals based diets in India (rice and wheat) have very low amounts of essential micronutrient such as iron and zinc which may explain high prevalence of anemia and other micronutrient deficiencies. Interestingly, primitive cultivars of wheat and rice appear to have favorable nutritional characteristics compared to the currently used high yielding varieties. Thus, it is logical that agronomic necessities could have contributed to the current state of nutrition-related health problems. Therefore, enrichment of nutrients in cereal crops by plant breeding utilizing the large genetic heterogeneity among genotypes or genetic manipulation are being considered to improve the micronutrient content in foods, through a process referred as bio-fortification (17). Realization of this technology depends on the characterization of genetic determinants of nutrient content, identification of genetic markers for assessing the transfer of these target triats during breeding. Again we need to fall back on nutrigenomics to ensure the nutritional quality and health benefits of biofortied foods Hence, marriage between argrigenomics and nutrigenomics is the way forward to connect the disconnect between agriculture and nutrition.

The efficacy and safety of nutritional intervention is dependent on a thorough understanding of (i) which nutrients may be deficient or in excess in a population, (ii) the pathologies induced by specific nutritional imbalances at the genomic, transcriptomic, proteomic and metabolic levels, and (iii) appropriate diagnostic tools to monitor outcomes at the population and genetic subgroup level. The emerging sciences of nutrigenomics and nutrigenetics can address these issues so as to contribute substantially to the elimination of malnutrition and in optimizing the health outcomes to a greater extent than would otherwise be possible by using conventional approaches alone.

Traditional medicine (TM) holds a great potential to improve people's health and wellness. TM is found in almost every country in the world. The Indian subcontinent harbors many traditional health care systems, most importantly Ayurveda. TM can contribute greatly to addressing emerging non-communicable diseases and other age-related diseases. Nevertheless, the revival of the holistic approach- the TM, the diet & nutrition, genetic make-up, and lifestyle has not been focused upon. In addition, evidence has surfaced connecting the concepts of *tridosha* and *prakriti* with metabolic pathways, chronic diseases, and various genotypes (18,19). Such evidence has thrown up insights about the universality of TM, particularly Ayurvedic concepts, as well as its apparent association with concepts in modern science. Hence, it is necessary to generate evidence of such associations which exist between *prakriti*

and metabolic systems, chronic diseases, and genotypes. Most importantly, the effect of TM under conditions of malnutrition (under and over nutrition), particularly under the deficiencies of micronutrients needs in-depth investigation.

We now live in an era when it has become increasingly affordable to have one's genome determined, providing information on a wide spectrum of genetic variations (e.g., single-nucleotide mutations, insertions-deletions, inversions or copy number variants) in critical genes involved in nutrient metabolism and pathways requiring micronutrients as cofactors. Gender itself is a critical genetic variation that affects micronutrient requirements for health maintenance. The key challenge is to determine whether it is possible to utilize this information meaningfully to provide reliable and predictable personalized dietary recommendations for specific health outcomes. Better health outcomes can be achieved if nutritional requirements are customized for each individual or genetic subgroup, taking into consideration both inherited and acquired genetic characteristics depending on life stage, dietary preferences and health status.

Thus, nutrition in the 21st century is poised to be an exciting and highly relevant field of research, as each new day is accompanied by advances in our understanding of how the interactions between lifestyle and genotype contribute to health and disease. Therefore, nutrition science will have to be persued in the future to ensure that it compliments India's food sufficiency state with nutrition security to achieve the optimal health of our population……in the journey of the Swasth Bharath.

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Nutrition and epigenome

Mohammed A. Junaid

The primary function of human diet and nutrition is to provide proper nourishment to sustain necessary metabolic activity. Alterations in nutrition patterns are involved in the etiology of several metabolic and autoimmune conditions, thereby contributing to the morbidity and early mortality. Nutritional disease may stem from either deficiencies or excesses in any of the dietary components, either as a single component or as a group. The exact nature of how diet impacts health and disease has only began to be elucidated in recent years. Classic studies that examined children of famine cohorts clearly demonstrated that nutrition is not only important at every stage in life of an individual, impacting health and disease from the *in utero* stage through adult age, but also show effects on future progeny. More recently, with the advent of improved high-throughput genomic technologies, the effects of nutrients are beginning to emerge in the form of lasting epigenetic phenomena resulting in altered gene expression that modulate protein and metabolite levels in target tissues, modify cellular and metabolic pathways, and alter response to drugs.

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Epigenetics refers to changes to the genetic information (the genome) that is stored in cells without modification of the inherited genetic code itself, and the epigenome comprises various mechanisms that alter the genome and affect the information encoded by the genetic code. Epigenetic modifications can be A) in the form of covalent modifications of the genetic code itself, such as i) methylation and hydroxymethylation of certain nucleotides in a deoxyribonucleic acid (DNA) sequence (called epigenetic code), ii) changes (methylation, acetylation, ubiquitination, and phosphorylation) to the histone proteins (called histone code) associated with the DNA that help package the genome; or B) through expression of non-coding ribonucleic acid (ncRNA) molecules that regulate expression of the genes. Cytosine residues occurring in CG dinucleotides are targets for DNA methylation, and increased DNA methylation is associated with transcriptional silencing. This silencing can be achieved either by repressing the binding of transcription factors due to methylation or by recruiting proteins that specifically bind to methylated CGs, which can further recruit co-repressors. Such modifications are dynamic and are altered in a number of pathological conditions. In situations involving epigenetic or histone codes, these modifications are controlled by two sets of enzymes: one that adds, and another that removes, the modification. The presence of such modifications is recognized by specialized protein domains

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which upon binding to the genome affect the expression of genes. Epigenetic modifications are quasi-stable changes to the genome that play a major role in tissue differentiations, and that once written on the genome, can be propagated through cell divisions, creating a memory for a cell's lineage.

Nutrition plays a prominent role in modifying the epigenome, and numerous experimentally proven studies have provided evidence of the power of simple nutrients alone in affecting phenotypes through epigenome modification. These nutrient-host interactions thus influence an individual's predisposition to disease and potential therapeutic response. A classic proof initially came from experiments with laboratory mice (agouti) whose diet was modified to provide methylation-specific epigenetic modification, which resulted in changing fur color by increasing DNA methylation. Nutritional regulation of DNA methylation modification also regulates reproductive status in honeybees, determining whether a female honeybee will become the queen laying eggs for a future colony or will become a worker bee. Our studies using a pregnant mouse model demonstrated that a vitamin commonly taken during pregnancy and affecting DNA methylation can modify the epigenome of the progeny, resulting in altered brain development and modified behavior.

In the context of nutrition in India, there has been a dramatic shift in recent years in the feeding habits of the population at large. People are eating more fatty and processed foods, while at the same time increasing sugary beverage consumption. The impact of such change in dietary habits is not yet clear. However, there is an upward trend in several metabolic conditions including diabetes, coronary heart disease, and several autoimmune conditions. Previous nutritional research methodologies often failed in exploring nutrient-phenotype interactions beyond associations. However, current sequencing techniques combined with the ability to ascertain the methylation/ hydroxymethylation status of nucleotides in the DNA or reading marks on the histone code are identifying the effects of nutrients on phenotypes in experimental animal models and human tissues. Nutritional diseases–any of the nutrient-related diseases and conditions that cause illness in humans include deficiencies or excesses in the diet that cause multifactorial abnormal conditions. Such conditions are remediable by proper nutritional habits.

Genomic imprinting/Transgenerational inheritance

Epigenetic signals are erased in primordial germ cells and pre-implantation embryos, wherein the epigenome is comprehensively reprogrammed towards a basal state that enables relaxation of the epigenetic constraints imposed on cell potential, thereby resetting the life cycle. While most genes are expressed from both alleles that an individual inherits from the two parents, certain genes are silenced partially and are expressed only from one allele. This mechanism of partially silencing a gene's allele, called genomic imprinting, plays a very critical function, especially in women who carry two copies of X-

chromosomes. Several other genes are also mono-allelically expressed only from one of the two alleles, and disruption of such parent-of-origin allele expression may lead to disease conditions such as Prader-Willi syndrome, Beckwith-Wiedemann syndrome, Silver-Russell syndrome, and Angelman syndrome. Genomic imprinting of the X- chromosome and several other individual genes (*PEG1*, *IGF2*, *IGF2R*, etc.) is through epigenetic silencing. Thus, epigenetic insults at a sensitive developmental period when the epigenome is reset and rewritten can therefore cause a lasting imprint on the developing phenotype and may play a prominent role in multifactorial conditions such as type 2 diabetes, coronary heart disease and autoimmune conditions. The expression of two genes, *H19* and *IGF2*, is under epigenetic control, and disruption in their expression has been found in diabetes, obesity, and chronic cardiovascular disease. Researchers have shown that parental high-fat diet renders offspring more susceptible to developing obesity and diabetes in a sex- and parent of origin–specific mode, again as a result of genomic imprinting errors. Disturbance of genomic imprinting also assumes significance, especially in the developing brain, where more than 1,300 imprinted loci are reported to be present.

Epigenetics also displays a transgenerational inheritance pattern, i.e., not only does a pregnant mother exposed to certain nutritional conditions expose a developing fetus to this environment, but this fetus also carries germline cells for future progeny, which also are exposed *in utero*. Such exposure establishes a situation wherein a mother's diet affects the phenotype of her future grandchild. Cigarette smoking has also been shown to influence the epigenome marks in sperm DNA. Thus, not only maternal, but also paternal, diet and environmental exposures are responsible for fetal epigenome modifications. The epigenetic inheritance of acquired metabolic disorders may in part explain the current obesity and diabetes pandemic in India resulting from changes in dietary habits.

Future directions

While the nutrition-epigenome field is still in its initial stages, the application of the -omic approaches to animal and human nutritional intervention studies and disease models will improve our understanding of the impact of nutrients on host metabolism. In the genomic era, the high-throughput -omic technologies are emerging as reliable technical platforms for generating multi-dimensional biological data on various biological pathways affecting human health and disease. Thus, whole-genome, followed by methylation-specific sequencing in conjunction with gene expression data, can build up a powerful correlation to gauge the impact of nutrition. Opportunities are available to carry out such studies with relative ease in a cost-effective manner and to apply these methodologies to nutrition research. The field of nutrigenetics explores the impact of genetic variants on nutrient metabolism, whereas nutrigenomics explores gene expression, function, and regulation in response to nutrient intake. Collectively, these approaches will involve genomics/epigenomics, transcriptomics,

proteomics, and metabolomics, which enable analysis of DNA/methylated DNA sequence, quantification of multiple mRNA species, proteins and metabolites, respectively. Such approaches can be targeted to a defined set of nutrients or to a single nutrient, allowing the analysis of global molecular species. The molecular signatures from these approaches can provide valuable insights into pathophysiological processes and yield potentially clinically relevant markers of nutrition's impact on health outcome.

Ultimate goal of human genome analysis and disease management

T. Padma, S. Vishnupriya and N. Pratibha

Osmania University has the unique distinction of establishing a separate department for Genetics for the first time in India, in the year 1966, under the leadership of Prof. O.S. Reddi. From the time of inception, the department was actively engaged in research activities in different areas such as plant genetics, human genetics, animal genetics, cytogenetics, microbial and immunogenetics. Although his initial work was related to the study of the effects of radioactive isotopes like Strontium90, Iodine131, S35 etc., on the mammalian tissues and their function, Prof. O.S. Reddy mainly concentrated on the genetic basis of monogenic and complex diseases in humans. Late Prof. J. S. Murthy studied epidemiological, anthropological, morphological parameters and evaluated the effect of inbreeding, genetic distance and genetic load on population structure. The first research activity included 3000 school children from the city of Hyderabad for the distribution of ABO and Rh blood groups, different types of colorblindness, PTC taste sensitivity, capacity of smelling sodium cyanide apart from anthropological parameters. Further investigation of a migrated isolated endogamous Muslim group called "Navayat" covering 9 generations revealed higher susceptibility to malaria and typhoid besides high incidence of myopia, ptosis, schizophrenia and α thalassemia minor due to the presence of HaemoglobinA2 and foetal haemoglobin resulting in high mortality in children.

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Population genetics (1970-1996)

The study of genetic origin of tribal groups from Andhra Pradesh and eight subsects of Brahmin caste was carried out to identify the origin and likelihood of diversity. The presence of conditional lethals in one of the sub-sects due to inbreeding was reported. Inbreeding depression in anthropometric traits was significantly higher among forward caste. Subsequently, the effects of ABO blood group incompatibility on intra uterine growth rate and neonatal status on 4076 consecutive newborns was studied. For the first-time, construction of growth curves was done, to help in the diagnosis of intra uterine growth retardation, also referred as "small for date babies" and developed a "growth quotient" (GQ) index. Further, maternal-foetal ABO blood group incompatibility had significantly conferred high risk to maternal preeclampsia and neonatal asphyxia with emphasis on the role of isoimmunization in infants of later para. Genetic affinities of some of the Himalayan tribes revealed their maternal and paternal lineages that comprised of East/Southeast Asians and Central Asian haplogroups.

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Ophthalmic genetics (1975-2017)

Congenital cataracts

A three generation Indian family with congenital autosomal dominant zonular cataract with sutural opacity was studied to map the 5th gene in collaboration with National Institutes of Health (NIH) and LV Prasad Eye Institute using microsatellite markers. The gene for the disorder was mapped to chromosome 17q11-12. Splice mutation in the beta A3/A1 crystallin gene was identified in congenital cataract (MIM ID#600881; MIMID* 123610). A 5 base pair insertion in gamma crystallin gene was identified in autosomal dominant variable zonularpulverulant cataract in a Caucasian family. Further, a mutation in *GJA8* gene (c.139G>A; D47N) was identified in autosomal dominant Zonular cataract without pulverization in 4 generations of a Muslim family from Hyderabad.

Age Related Cataract (ARC)

Novel variation (F71L) was detected in the exon-2 of CRYAA (αA-crystallin) gene in three unrelated female sporadic nuclear cataract cases which resulted in significant (35–90%) loss of chaperone-like activity (CLA) in thermal aggregation of carbonic anhydrase, βL- and γ-crystallins.

Molecular screening of *IDO* gene revealed two novel variations c.-979G>A and c.-471T>G and one known variation c.-738A>G in promotor region. Pathogenic mutation (c.422+90G→A; rs4613984) in the intron downstream to exon 4 of the IDO gene was identified in ARC for the first time.

Myopia (2000-2008)

Two large multi-generation Indian families with isolated non-syndromic myopia segregating as X linked condition was located to the locus between proximal DXS1073 and distal DXS154.

Study of polymorphic variants of putative candidate genes revealed association with f allele and b allele of *VDR*, h allele of *COL2*A1, N allele of Endostatin and Proline allele of TGF beta1 codon 10 indicating their significant role in myopia progression. Further, mutation analysis of Decorin (intron 3) gene revealed a A>G intronic variation, three exonic variations, viz: A>G at codon 311(synonymous), and two G>A variants at 3' UTR region.

Retinitispigmentosum and Enamel Hypoplasia–A new syndrome (2000)

Two first cousins in a family with a rare combination of retinitispigmentosum and enamel hypoplasia was identified for the first time, which was inherited in an autosomal recessive manner.

Congenital Non-Syndromic Hearing Impairment (NSHI) (1997-2008)

Congenital non-syndromic hearing impairment is mostly inherited as autosomal recessive condition (ARNSHI). Epidemiological studies of NSHI revealed 19.26% familial incidence and involvement of recessive genes with an estimated genetic load of 2.33 and B/A ratio of 6.96.

Mutations in *GJB2*, *GJB6* and mitochondrial genes *MT-RNR1* and *MT-TS1* revealed a)

Five different mutations in *GJB2* gene (c.IVS1+1G>A, p.W24X, c.167delT, c.235delC and p.W77X) and b) one known (m.1555A >G) and 3 novel mutations (m.1462G > A, m.1508C > T, and m.1453A > G submitted to MITOMAP Data Base) in *MT RNR1* gene. Of these p.W24X mutation in *GJB2* gene was present in high frequency (86.7%). Interestingly, 7.7% of p.W24X alleles were present as heterozygotes. In the absence of second allele, such cases were considered as compound heterozygotes/genetic compounds.

Screening of 25 families for all the above genes revealed the segregation of p.W24X mutation in *GJB2* gene in 9 families. In 2 families compound heterozygosity was observed with c.167delT and p.W24X mutation in *GJB2* gene apart from Uniparentaldisomy in a family. Further, two families showed maternal transmission of mitochondrial mutations.

Cardiac disorders (1982-2017)

Essential hypertension (EHT) (1982-2017)

Significant association of BMI, lipid profiles, habits like smoking, alcohol consumption and dietary patterns were shown to be associated with hypertension advocating the need for life style modification. Initial studies revealed an association of EHT with Hp2-2, ApoE4, and isoenzyme fractions of LDH. Molecular analysis was performed with candidate genes viz., Renin angiotensinogen aldosterone synthase (RAAS) pathway (*AGT, ACE, RENIN, CYP11B2* genes); signal transduction pathway (*GNB3, GNAS1*); endothelial dysfunction (*NOS3, END1*); genes coding for cytoskeleton proteins (*ADD1, ADD2*); genes involved in lipid and fat metabolism (*APOE, APOB, LPL, LEP, LEPr*); and Vitamin and dopamine receptor genes (*VDR,DDR)*.

Exploration of the *AGT* gene revealed a significant association of -217G>A, M235T, T174M, 15241G>A, 5855G>A, 6635G>A, 6506G>A, 13828T>C, g.11216C>T variants as susceptible alleles for EHT. Five of these novel variants vizc.-61G>A (rs312262681); c.-4+17C>T(rs312262682); c.24T>C (rs207482231); c.28A>T (rs199476082); c.*90T>C (rs207482232) were deposited in NCBI database. Further, polymorphisms in genes viz. *CYP11B2, ACE, LEP, GNB3, GNAS1,ADD1, ADD2, VDR, DDR, AP OB, and NOS3* showed significant risk for EHT.

Pregnancy Induced Hypertension (PIH) (1990-1996)

High risk for PIH was found in individuals with familial incidence, ‘A’ blood group, Hp 2-2 and P+, P++ alkaline phosphatase phenotypes in addition to decrease in fibrinogen and increased serum ceruloplasmin, lactate dehydrogenase, plasma fibrinogen, 5’ nucleotidase and alkaline phosphatase levels.

Cardiomyopathies

Mutations/SNPs in sarcomere genes that disrupt the structural framework of sarcomere were identified in Hypertrophic Cardiomyopathy (HCM), Dilated Cardiomyopathy (DCM), and Arrhythmogenic Right Ventricular Cardiomyopathy or Dysplasia (ARVC/D). A 25 bp deletion mutation in MYBPC3 gene was identified as a preclinical diagnostic

marker for sudden cardiac deaths associated with cardiomyopathy. Putative candidate genes (myopalladin, desmin and chitin) in ARVD/CL were also identified by next generation sequencing. A novel mutation in ANKRD1 gene (exon 9: D304H) was reported in DCM. PKP2 gene was found to be a hotspot for mutation in ARVD/C patients.

Long QT Syndrome (LQTS)

Research on Long QT syndrome, a congenital channelopathy, revealed genotype specific drug targets of KCNH2 and ADR-I & II receptor genes, apart from identification of other candidate genes (CAV3).

Idiopathic Pulmonary Arterial Hypertension (IPAH)

Novel candidate genes (EF1) through NGS were identified in IPAH, a devastating disorder characterized by a rise in pulmonary arterial pressure, culminating in right heart failure and death. The functional role of these genes and variants in the pathophysiology of the disorder were studied in collaboration with Cambridge and Clinton universites.

Coronary Heart Disease (CHD)

SNPs of genes involved in oxidative stress (eNOS, PhoX), Inflammation (IL-6, 8,18), MMPs (MMP1, 3, 9) and apoptosis (FAS, FASL, Caspases 3,8,9) were investigated. Polymorphisms of *eNOS* (-786T/C, VNTR4b/4a and 894G/T); *IL-6*(-174G/C), *IL-18*(-137G/C -607C/A), *MMP 1*(−1607 1G/2G); *MMP 3* (−1612 5A/6A); *MMP* (−1562 C/T); *TIMP 1*(536 C /T); extrinsic *FAS* (-670 G>A, FASL -844 T>C); *Caspase 9*(IVS12-19 G>A) genes caused significantly increased risk for CHD with variations in serum MMP levels. An association of NADPH oxidase phox P22 C242T and poly (ADP- ribose) polymerase-1 gene (PARP- 1 Val 762 Ala) polymorphisms in angiographically verified cases of CAD revealed protective effect of 242T and 762Ala alleles.

Responses to treatment with statins with respect to SLCO1B1, HMGCR and PCSK9 genes and their role in drug transport and metabolism is evaluated.

Methylenetetrahydrofolate reductase gene and apolipoprotein E gene polymorphisms were shown as risk factors for myocardial infarction in South Indian population.

Congenital Heart Diseases (CHD)

Four heterozygous sequence variants in highly conserved Helix 3 of homeodomain of NKX2.5 were identified in 55% of patients. Significant association of NKX2.5 with VSD either alone or in combination with other CHDs was reported.

Three heterozygous sequence variants in GATA4 (one in ZNF1 and two in ZNF2) were identified in 27 patients (18.18%). The first two mutations resulted in substitution and the third in deletion. These variants altered the highly conserved nucleotide sequence in Zinc Finger 1 and 2 resulting in augmented transcription of downstream genes.

Cancer genetics (1994-2017)

Breast cancer

Primarily, analysis of BRCA1 and p53 genes, identified 5 novel mutations in DNA binding region of the p53 gene (rs72661116, rs72661117, rs72661118, rs72661119, rs72661120). Fourteen novel structural mutations (missense) and forty novel synonymous mutations in mitochondrial genes(ND1, ND2, ND3, ND4, ND4L, ND5, ND6, CYTB, COI, COII, COIII, ATP6 AND ATP8) were identified of which single missense mutation in complex III, 3 in complex IV, 4 in complex V, 3 novel mutations each in rRNA genes and tRNA genes were identified with 5.33 fold higher mutation rate (179 mutations/1121 NP =0.16) in D-loop. Haplogroup M5 was found to be predominant in Indian population. Further, significant association of breast cancer with genotypes which enhance anti apoptotic function (BCL2 -938AA), reduce pro apoptosis (BAX -248GG, CASP9 -1263GG, Ex5+32GG and CASP3 -137AA), reduce metastatic suppression(BRMS1-1120TT, NME1-128TT, RRP1B 1307TT, ECAD -347GA/GA and -160AA) and promotes metastasis (SIPA1 -313GG, +545CC and +2760GG). Expression levels of BRMS1 and E-Cadherin (Metastatic suppressors) were reduced and levels of BRD4 and SIPA1 were elevated in tumor tissue as compared to adjacent normal tissue.

Chronic Myeloid Leukemia (CML)

Mutational screening of Abl tyrosine kinase domain revealed 26 exonic, and two splice site mutations. Of these, 16 were missense mutations, six were synonymous, two were insertion mutations leading to frame shift and two were termination mutations. Four mutations found in the activation loop in five patients, failed to respond to imatinib therapy. Of 47 intronic mutations, 11 mutations conferred complete drug resistance. Mutational screening of 5-9 exonic regions of p53 gene revealed 4 intronic and 9 exonic mutations. Intronic mutations (C14181T, T14201G, A13463G, and C14310T) resulted in partial and poor response which indicated that they might influence the drug response of the patient.

Significant associations with CYP3A5*3, 3/3 genotype, CYP2D6*4, GSTP1 Ile105Val, P53 codon 72 (proline), MDR1 C3435T (3435TT) with drug resistance was reported. Development and progression of CML was found to involve defective DNA damage sensing (ATM (-5144 A>T, 4138C>T)), excess or defective NHEJ DNA repair (XRCC5, XRCC6 genes) and constitutively active Jak-STAT pathway. Presence of Jak2 V617F mutation in few of the CML patients was associated with elevated Jak2 expression. Elevated Jak2 expression influenced Bcr-Abl expression. STAT3 expression was elevated in patients diagnosed in advanced phase and poor responders to imatinib treatment.

Acute Myeloid Leukemia (AML) and Acute Lymphoid Leukemia (ALL)]

FLT3/ITD and NPM1 mutations were more frequent in AML compared to ALL, whereas the frequency of FLT3-D835Y and N-RAS mutations were similar in both ALL and AML, while p53 mutations were infrequent. The AML patients with

FLT3/ITD mutation had very low complete remission(CR) rate and reduced overall survival. The risk conferring genotypes namely 3/3 of CYP3A5*3, Poor Metaboliser genotype (CYP2D6*4), M0 (GSTM1), T0 (GSTT1), Val/Val (GSTP1),TT (NQO1), GG (MDR1) and TT (MTHFR), were associated with loss of enzyme activity, and functional impairment of Phase I and Phase II xenobiotic metabolism. AML and ALL patients having XRCC3 241Met/Met or XPD 751Lys/Gln or XRCC1 194Trp/Trp or XRCC1 399Gln/Gln genotypes with reduced expression had increased disease free survival. Acute leukemia was also strongly associated with BAX -248GG, CASP9 -712 CT and CASP9 -1263AG and MDM2 -309 GG genotypes.

The enhanced/reduced expression associated with variant genotypes of ATM (TT of-5144A>T), XRCC5 (0R/0R of -201, VNTR 0R/1R/2R and AA of 2408G>A), XRCC6 (GG of-61C>G and -1310 C>G) and XRCC7 (TT of 6721G>T) gene polymorphisms lead to dysregulated error prone repair, interference with normal apoptosis and development of neoplasia.

Cancer therapy

In silico analysis of various point mutations revealed differential drug sensitivity towards ABL kinase inhibitorswhich will be of great help in deciding treatment strategies on an individual basis.

Developed novel imine stilbene analogs exhibiting anti-cancer activity by regulating the HIF1alpha-HRE directed transcriptional activity.

Immunological studies: (1975-2017)

An indirect haemoagglutination test was developed (using antigens from local isolates) for serodiagnosis of hepatic amoebiasis.

IFN-gamma over-producing allele T and low-producing allele A were found to be associated with predisposition to Hashimoto's thyroiditis and Graves disease, respectively.

Dot program revealed SNPs/levels of IL-2 and IL-5 to be associated with tuberculosis and contact subjects.

Gender-specific biomarkers were developed with respect to FOXC2-Q117Q variant apart from the role of VEGF and cytokines in TH1 and TH2 responses for lymphatic filariasis with familial aggregation.

Mucosal immunization in animal models of human diseases

Mucosal administration of recombinant cholera toxin B fused with either epitope of infectious agents or self-antigens like MMP activated the immune system/exerted the tolerogenic effects in animal models and thus can be used as a double-edged weapon for controlling infectious agents/tackling autoimmune disorders.

Rheumatoid arthritis

Genetic heterogeneity was identified with respect to age at onset and specific clinical & genetic markers (alkaline phosphatase) in Rheumatoid Arthritis, juvenile and osteoarthritis. In another study, anti CCP

antibody levels were found to be associated with high DAS28 values. Mutations in 3 exons of *PADI4* gene revealed significant association of allele "C" of rs1748033 polymorphism with rheumatoid arthritis.

Asthma

Differential expression of cytokines IL-17A, IL-22 and TGF-β was observed in asthma.

Study of other diseases/disorders

Peptic ulcers

Pepsinogen and its isozymes were characterized and correlated to its multi-gene structure for the first time. Further, the strength of ABO antibodies in peptic ulcers was investigated by developing an indigenous technique

Nephrotic syndrome

The study on primary nephrotic syndrome and steroid resistance suggested mutations in NPHS2 gene are responsible for Steroid resistant nephritic syndrome.

Epilepsy: (1990-1996)

Genetic analysis of idiopathic generalized epilepsy (IGE), Generalised tonic-chlonic seizures (GTCS) and Juvenile Myochlonic epilepsy (JME) revealed preponderance of males and genetic heterogeneity. Individuals with blood group A, group M, Hp2-2, Gc2-2, ALP P, GLO2-2 showed high risk to epilepsy. Comparison of affected and unaffected members in five families also showed high risk for same parameters.

Uterine leiomyomas

Novel variants in HMGA (intron 6: G6767 DelT) and VEGFR3 (exon 17: Q827H) are reported in uterine leiomyomas/fibroids with genetic compounds.

Cytogenetics and genetic toxicology

Studies of drug toxicity in human lymphocyte cultures using SCE, mitotic index and satellite associations in human chromosomes revealed genetic effects of drug interaction in TB patients and claustogenic effect of psychotropic drugs on human chromosomes.

Identified fragile sites associated with various conditions such as carcinogenesis, NHL, folate deficiency, aneuploidy and chromatin decondensation in humans.

The study on X chromosome inactivation and reactivation revealed variation in gene expression in different phases of development.

Differential DNA damage between precancerous and cancerous states of the cervix was identified using Single cell gel electrophoresis assay.

Future activities

The investigations conducted by the faculty and research scholars in the field of Human Genetics revealed several mutations/variants of genes associated with different diseases enlightening the scope for developing genetic diagnosis, manipulating the gene actions, discovery of new drugs, adopting preventive measures

etc. These attempts make it evident that there is an absolute need for

1) Screening of population for genetic defects

2) Making genetic counselling services mandatory in all medical centers

3) Routine sequencing of genome of normal and affected individuals

4) Making trials to edit the defective genes

5) Developing the methods of stem cell treatment needed for diseases/disorders

6) Identification of genotype-specific drug targets

7) Validation of medicinally important bioactive compounds using breast cancer and cardiomyocyte cell lines

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Research accomplishments of Institute of Genetics and Hospital for Genetic Diseases

O.S.Reddi, P.P.Reddy, M.P.J.S Anandraj, C.KusumaKumari, M.Sujatha, M.D.Sadhanani, P.Usha Rani, M.Hema Prasad, A.Venkateshwari, G.Deepika, B.VijayaLaxmi, T.Sunitha, B.Srinadh, M.L.N.Deepika, AnjanaMunshi and A.Jyothy

Institute of Genetics and Hospital for Genetic Diseases, situated at Begumpet, Hyderabad was established by Osmania University in the year 1978 as a unique research institute, first of its kind in the country to conduct multidisciplinary research in genetic disorders. The major focus of the Institute is research, service and training. Following are the accomplishments of the institute:

Inborn errors of metabolism

Institute has an ongoing programme for screening inborn errors of metabolism in mental retardation with special reference to aminoacid, carbohydrate and mucopolysaccharide metabolism. So far Institute has screened 6,000 cases suspected for metabolic disorders and 63 cases were found to be positive out of which the rare ones include:

Threoninemia- a new metabolic disorder was identified for the first time in the world. *Hydroxykynureninuria*- a defect in the tryptophan metabolism and *Prolinuria* were the first to be reported from India. *Dicarboxylic aminoaciduria*- is the second and *Valinemia* is the third to be reported from India.

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Persistent hypertyrosinemia and *hereditary tyrosinemia,* disorders of tyrosine metabolism were the rare cases reported from this Institute.

Institute also formulated Special Indian diets low in phenylalanine in collaboration with National Institute Nutrition to treat cases with Phenylketonuria.

A number of cases with Hurler's, Hunter's, Morquio's and Sanfillipo types of mucopolysaccharidoses were also investigated and counseled.

Institute was the first to start Radio Immunoassay (RIA) in the state. More than 10,000 cases of hormonal imbalances (Thyroid disorders, primary amenorrhea, primary sterility, azoospermia, bad obstetric history and diabetes mellitus) were studied.

Chromosomal disorders

Chromosome abnormalities accounted for 30.6% of the suspected cases. Institute was the first to report a large study on 1001 Down syndrome cases from India. Advanced molecular cytogenetic techniques such as Fluorescent *in-situ* hybridization (FISH) and Spectral Karyotyping (SKY) are being used to detect subtle chromosomal abnormalities and several rare cases have been identified**.**

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Congenital Anomalies

Institute has pioneered ultrasonography imaging in the state for studying congenital anomalies. So far, more than 16,000 cases have been screened. Of these, 8,000 cases were of high risk pregnancies with various congenital anomalies like neural tube defects, hydrocephalus, microcephalus, kidney abnormalities and other congenital defects. 600 families who had one or more than one child with neural tube defects were identified. Molecular studies have been carried out in neural tube defects by case-control parent triad approach on genes of folate and cobalamin pathways.

Duchenne Muscular Dystrophy

Among 60% of the DMD cases, DNA deletion was identified as the predominant causative mutation. Even before the identification of DMD gene we had initiated work on the pathogenesis of this disorder attributing to calcium dependent changes in DMD. A DST sponsored project has been implemented for the development of kit for carriers of DMD. Our findings established platelet calpain as a marker for 100% detectability of obligate carriers of DMD, independent of the causative deletion mutation. Calpain-model disease pathology was also explored in dystrophic mouse model. So far, 726 cases of Duchenne Muscular Dystrophy (DMD) have been investigated.

Hemoglobinopathies

The statistics from screening as well as hospital data points revealed a general frequency of 9-10% of beta thalassemia in the State. So far 3,810 cases of β-thalassemia and sickle cell anemia have been diagnosed with the help of molecular analysis. Our findings revealed that IVS1-5(G-C) and 619bp deletions are the most common mutations in our population.

Fragile X syndrome

Fra X A is one of the major causes of mental retardation in our population. PCR based methodologies and anti-Fra X A protein sera have been effectively used for the diagnosis of this disorder. Using Southern blot analysis in a large pedigree, mosaics of Fra X A syndrome have been identified.

Sexual Ambiguity

Six Novel mutations in exons 2, 6 and 7 of androgen receptor gene were identified in individual patients with Hypospadias and were submitted to Gene Bank (Gene Bank entry *viz*., GU373805, GU784855, GU784856, GU784857, GU784858 and GU784859).

Wilsons Disease

Studies were carried out to identify a spectrum of mutations in ATP7B gene in the regional cohort. Eleven mutations were identified out of which three were novel located in exons 15 and 18.

Premature Ovarian Failure

Mutational analysis of Inhibin α gene revealed three novel variants (734 C>A/Ala 245 Asp, 755 C>A/Pro 252 His, and 777 C>A/His 259 Gln) in Indian women with premature ovarian failure.

Recurrent Pregnancy Loss (RPL)

Studies on RPL have identified anatomic, cytogenetic, hormonal defects in 36.64% of the cases. Screening of antiphospholipid antibodies, the lupus anticoagulant (LAC) has accounted for 10.28% of the cases investigated, while beta2 glycoprotein – I dependent anticardiolipin antibodies (beta2 aCL) was tested positive in 40.24% of the women investigated indicating the importance of these auto antibodies in the etiology of RPL among idiopathic cases. Elevated plasma homocysteine levels, low red cell folate levels and C677T MTHFR gene mutations were detected.

Male Infertility

In majority of infertile males the cause is unknown. In recent years the role of microdeletions in Y chromosome is attributed to male infertility. Molecular analysis carried out in these subjects revealed microdeletions in AZF region in 15% of the cases.

Adult Onset Disorders

Diabetes: Studies on diabetes revealed the synergistic effects of genotypic interactions involved in oxidative stress and inflammation in the pathophysiology of type 2 diabetes mellitus. Our findings on diabetic neuropathy indicated that IFNγ and IL-10 genes to be significantly associated with peripheral neuropathy. The study also showed that the 'high-producer' IL-10 −1082 G/G genotype and the 'low-producer' IFNγ +874 A/A genotype to be responsible for the down regulation of immune response leading to inflammation.

Stroke: Association studies including 25 genes and their SNPs in 700 cases were carried out in ischemic stroke & its subtypes and hemorrhagic stroke. Our major revelation is the absence of prothrombin G20210A polymorphism suggesting its exclusion in the diagnostic panel for cerebral ischemia. The other finding is of monomorphic forms of PDE4D, SNP 87 and 32 and discovery of a novel SNP in PDE4D gene. The study identified intracranial large artery-subtype of ischemic stroke to be highly prevalent in the population.

Asthma: Our research unraveled pharmacogenetics of β2 adrenergic receptor considering Salbutamol as a reference β2 agonist. By studying response patterns in asthmatics we found that individuals bearing Thr164Ile polymorphism developed refractoriness to Salbutamol. We established "binding inefficiency" of Salbutamol for Thr164Ile polymorphic receptor as the underlying principle for refractoriness. We identified a compound which promiscuously targets wild and variant Thr164Ile β2 adrenergic receptor with consistent and high binding affinity using computational virtual screening experiments. Currently, our present initiatives delve with *in vitro* validation by employing binding and kinetic studies.

Cancer: Studies of cervical cancer revealed higher expression of eNOs mRNA and plasma nitrite /nitrate levels among women with precancerous lesions.

Molecular analysis of matrix metalloproteinases (MMPs) and inflammatory cytokine genes eNOs, IL4, IL6 and IL10 were found to be significantly associated with the etiology of gastric cancer. Gene polymorphism of angiogenic genes (TGF beta, VEGF, IL10) revealed the association of VEGF with breast cancer and BRCA1 and BRCA2 gene mutations with ovarian cancer.

Other adult onset disorders being studied include Cardiovascular diseases, Pre-eclampsia, Uterine fibroids, Polycystic ovarian syndrome, Osteoporosis, Pancreatitis, COPD etc.

Occupational and Environmental Hazards

Studies were undertaken as per WHO guidelines to monitor the genetic risk in agricultural and industrial workers. Vulnerable groups studied include traffic police, radiographers, cement, rubber, pharmaceutical, aluminum, mint, pesticide, nuclear fuel factory and agricultural workers. Till date, the department has screened more than 50,000 vulnerable subjects and suggested preventive measures.

Clinical Psychology& Special Education

The Institute is providing educational services for the mentally handicapped children by using innovative and improvised methods of teaching and training so that the children are helped to the maximum possible extent towards their self-dependence. Apart from providing educational services to children, the center also conducts research on the psycho-social aspects. The center was started with seven children on its roll and is presently providing educational services to 45 children aged between 4 and 16 years. Expert guidance is given to parents and teachers about behavior modification, physiotherapy and speech therapy.

II. Service

The specialized services offered by this institute gave a new dimension in improving the reproductive and child health services in the state and in decreasing the burden of genetic diseases. Institute was the first to start kidney transplantation and dialysis centre, AIDS screening center and blood transfusion centre for haemoglobinopathies.

Genetic Registry

Institute is the first to maintain a genetic registry in India. Till date 3,02,662 cases were screened for genetic disorders out of which 35,586 were diagnosed as chromosomal disorders, 21,198 as single gene disorders, and 65,478 as multifactorial disorders. Hemoglobinopathies predominated (43%) followed by Wilsons (32%), DMD (14%) and lipid disorders (11%).

Prenatal Diagnosis

A total of 3,301 HRP women attending government maternity hospital were screened for birth defects by 4D ultrasound scan, double and triple marker screen, FISH karyotype, TORCH profile and molecular evaluation. The prevalence of birth defects was found to be twice than

that of the general population and the major birth defects observed were central nervous system anomalies followed by renal defects.

Antenatal, Neonatal & Newborn Screening

Institute is performing Antenatal and Neonatal Screening for high risk pregnancies and sick neonates for predominant genetic disorders including Congenital hypothyroidism and Congenital adrenal hyperplasia.

Population Screening

To bring about awareness for identification and prevention of genetic disorders in rural population, Institute has conducted door to door survey in Mahboobnagar district of Telangana covering over 80,000 households. The Anganwadi workers and ANM's were also trained to help in early detection of genetic disorders.

Genetic Counselling

Institute has carried out genetic counseling for more than 50,000 cases and the cases are being followed to know the reproductive decisions made by individuals.

Management & therapy

Restricted diet therapy and hormonal therapy are offered to those affected with metabolic and hormonal disorders. Early intervention program for children with Down's syndrome resulted in the integrattion with normal children. Speech therapy and physiotherapy are also offered to affected children with other mental and physical disabilities.

Financial Support

Institute acknowledges generous funding from DST, WHO, UGC, DBT, DAE, CSIR, ICMR, APPCB, RVM-SSA and Govt. of AP for its establishment and extramural grants.

Fifty years of plant genetics research at the Osmania University

Tummala Papi Reddy, S.Y. Anwar, D. Manohar Rao, A.K. Sarala, Padma Balaravi, A. Roja Rani, L. Ananda Reddy, and P. B. Kavi Kishor

The Department of Genetics was established in the year 1966-67 with specializations comprising human genetics and plant genetics. Plant genetics group was headed by late Prof. G. Madhava Reddy who was instrumental in establishing the Centre for Plant Molecular Biology (CPMB) during 1991-92 with the financial support from the Department of Biotechnology, Government of India. Most of his students have been carrying the mantle on their shoulders and have contributed substantially to the growth of plant genetics and molecular biology at the Osmania University. One of his students late Prof. K. Vaidyanath was instrumental in starting the M.Sc. (Biotechnology) course during the year 2000-2001. The efforts of Plant Genetics Group at CPMB and the Department of Genetics, Osmania University, have resulted in a comprehensive and tangible research outcome in the areas of biochemical genetics, mutation breeding, plant cell and tissue culture, secondary metabolite production, genomics, isolation of genes conferring biotic and abiotic stress tolerance, and development of transgenic plants with improved agronomic attributes.

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The following are some of the major research highlights:

- Inter-tissue complementation studies established the linear sequence of gene action in anthocyanin biosynthesis of maize and cross-feeding studies identified the gene-product relationships.

- Incorporation of opaque-2 gene into Indian inbred maize lines resulted in the development of half-opaque lines with improved protein and lysine contents.

- Treatment with physical and chemical mutagens in rice, triticale, foxtail millet, safflower, castor, chickpea and pigeonpea resulted in the induction and recovery of various useful mutants with altered plant, panicle, and grain characters besides days to flowering and/or maturity.

- In elite traditional rice varieties, mutant semi-dwarfing & dwarfing genes, non-allelic to DGWG, have been identified and characterised.

- Rice, triticale and castor plants were irradiated with acute gamma rays at meiotic, gametic and anthesis stages resulted in maximization of mutation frequency and recovery of different beneficial mutants with alterations in various morphometric and physiological characters of agronomic importance.

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- In rice, induced fine grain mutants with medium slender, short slender grain dimensions having translucent endosperm showed increased head-rice recovery besides better cooking quality. Genetic analysis of short slender grain mutants revealed the presence of two major nonallelic mutant genes.

- Established inter-species and phylogenetic relationships between cultivated and wild relatives of *Oryza* based on biochemical, biometrical and induced mutation profiles.

- Electrophoretic analysis of castor F1 hybrid seedlings for Peroxidase, Esterase and GDH Isoenzymes revealed that seedlings exhibiting “hybrid bands” and decreased “specific-enzyme activity” invariably disclosed marked heterobeltiosis for seed yield.

- In 411-JI-44 castor line, three major nonallelic complementary dwarfing genes have been identified and characterized.

- Mutagenic effects and genetic toxicology of different metallic salts namely Sr, Cd, Hg, Ba, Cu, Pb and Fe, and adulterants chloral hydrate, methanol, argemone oil, and pesticide carbendazim were evaluated using different plant test systems of rice, barley and onion.

- Genetic analysis of waxy locus in glutinous rice revealed intra-cistronic recombination.

- Determined the genetic and biochemical basis of scent in aromatic rice.

- Analysed and identified rice lines with deeper protein distribution in the grain endosperm.

- Introgressed WBPH resistance gene from *Oryza officinalis* to cultivated rice and determined its segregation pattern using molecular markers.

- In sorghum genotypes, significant correlations were observed between grain mould (GM) resistance and seed hardness, phenol content and glume colour; genetic analysis of GM resistance in seven crosses revealed the presence of diverse nonallelic epistatic and complementary genes essential for genetic enhancement of sorghum varieties/hybrids.

- Established efficient protocols for callus initiation and plantlet regeneration from different explants of rice, maize, triticale, sorghum, pearl millet, finger millet, foxtail millet, kodo millet, pigeonpea, chickpea, cowpea, groundnut, castor, safflower and niger.

- Generated androclonal variation in rice.

- Deciphered the epigenetic mode of profuse-tillering somaclone in triticale.

- Established protocols for *in vitro* flowering from de-embryonated cotyledons of groundnut, safflower and niger.

- Developed efficient protocol for plant regeneration and established protoclones from calcium alginate encapsulated indica rice protoplasts.

- Established the process of regeneration from long-term (1400-day-old) callus cultures of rice.

- Induced and identified a retrotransposable element system in indica rice.

- High frequency *in vitro* propagation protocols were developed for the important medicinal plants namely *Acorus calamus*, *Vitex negundo, Excoecaria agallocha* and *Adhatoda vasika.*

- Large scale *in vitro* multiplication and field establishment of medicinal tree *Terminalia chebula* through multiple shoot induction and somatic embryogenesis have been developed.

- Elicitor driven yield enhancement of diterpene lactone andrographolides using different *in vitro* culture systems in *Andrographis paniculata* has been developed.

- Hairy root cultures of *Psoralea corylifolia, Phyllanthus amarus* and *Withania somnifera* were developed and used for *in vitro* production of bioactive isoflavonoids, amarone and with anolides, respectively.

- In peanut, proteins associated with somatic embryogenesis have been identified and characterised.

- In pigeonpea, F1 seedling leaf-callus weight showed strong positive association with heterobeltiosis for seed yield in hybrid plants, helpful for mass screening and early prediction of promising hybrids.

- Suspension cultures of *Plumbagorosea, Morindacitrifolia, Tinospora cordifolia* and *Ipomoea batatas* were established and bioactive compounds viz., plumbagin, anthraquinones, berberine and ergot alkaloids, respectively, were produced *in vitro.*

- Bioactive compounds betulinic acid and ursolic acid were isolated from *Vitex negundo*; while natansinin, an unusual antioxidant dibezoyl glycoside was isolated from *Salvinia natans*.

- Carried out distribution analysis and classification of various *Andrographis* species in the states of Andhra Pradesh and Telangana.

- Established authentic DNA barcodes for six *Andrographis* species and resolved the taxonomic ambiguity of *A. echioides*.

- Developed an effective antipsoriatic formulation from the methanolic extract of *A. nallamalyana.*

- Extracted and identified two bioactive flavonoids such as 2',5-dihydroxy-7-methoxyflavanone and 2',5-dihydroxy-7-methoxyflavone from *A. glandulosa*.

- Genotypic diversity analysis was carried out in the genus *Aloe vera* using RAPD

and ISSR makers, and established its potent anti-diabetic activity.

- Structural analysis and classification of CYP450 genes in flax, castor, *Citrus* and common bean were carried out and established their phylogenetic relationships.

- *Bacillus* phytase coding gene was expressed in *E.coli* and the recombinant phytase was found more effective as a feed supplement in poultry.

- *Pichia pastoris* expressing yeast S-adenosylmethionine synthetase gene was developed for the production of therapeutic molecule S-adenosylmethionine.

- Identified proline biosynthetic pathway genes (*P5CS* and *OAT*) in *Vigna aconitif*olia. Overexpression of these genes in tobacco, rice, and sorghum resulted in abiotic stress tolerance

- Transgenic finger millet, rice and tomato expressing vacuolar proton pyrophosphatase, osmotin-like protein, chitinase, sodium-proton antiporter like protein, and APETALA37 coding genes ameliorated the biotic and abiotic stress conditions.

- Isolated and validated arsenic resistant genes from marine bacterial species.

- Identified sodium and potassium porters in rice and sorghum genomes. A genome-wide scanning of *Sorghum bicolour* resulted in the identification of 25 heat shock factor (Hsf transcription factor) genes and determined their tissue specific expression profiles. A higher plant stress protein database has been developed.

- Lignin biosynthetic pathway genes were cloned from subabul and validated for their functionality in tobacco.

- Transgenic indica rice lines exhibiting resistance to brown planthopper (BPH), green leafhopper (GLH) and whitebacked planthopper (WBPH) were developed by overexpressing mannose-specific lectins of *Allium sativum* agglutinin (*ASAL*) and *Galanthus nivalis* agglutinin (*GNA*).

- Pyramided rice lines containing *ASAL* and *GNA,* proved more effective in reducing insect survival, fecundity, feeding ability besides delayed development of insects as compared to the parental transgenics.

- Stem borer resistant transgenic parental lines, involved in hybrid rice, were produced by transferring modified *Cry1Ab*/*Cry1Ac* genes from *Bacillus thuringiensis*.

- Semilooper resistant transgenic castor plants were produced through *Agrobacterium*-mediated genetic transformation method by transferring *cryI Ab* gene.

- Expression of *Brassica juncea* Nonexpressor of pathogenesis-related genes 1 (*BjNPR1)*/ rice endo-chitinase (*Chi l1*) gene in the rice conferred enhanced resistance to rice blast, sheath blight and bacterial leaf blight diseases.

- A synthetic gene (*Cry1Ac-ASAL*) encoding the fusion-protein having 488 amino acids, comprising DI and DII domains from Cry1Ac and ASAL, was developed. Very low concentration (0.025 µg/g) of fusion-protein was sufficient to cause 100% mortality in *Pectinophora gossypiella* and *H. armigera* insects, respectively.

- Developed transgenic cotton (NC-601) lines expressing mannose-specific *Allium sativum* leaf agglutinin (*ASAL*) encoding gene which exhibited potent entomotoxic effects against jassid and whitefly insects.

- Different antifungal proteins have been purified and chartecterised from *Bacillus subtilis* and *Sorghum bicolor*

- Transgenic finger millet and pearl millet plants expressing *pin* (antifungal protein encoding gene of prawn) showed blast resistance and downy mildew resistance, respectively.

- Homozygous pearl millet transgenic lines of ICMP451-*BjNPR1* and hybrid ICMH451-*BjNPR1* exhibited resistance to three strains of downy mildew pathogen.

- Transgenic ICMP451-*BjNPR1* pearl millet plants infected with *S. graminicola*, displayed differential expression of systemic acquired resistance pathway genes, and contributed to the transgene-mediated resistance against downy mildew.

- Gene (*PcSrp*) encoding a serine-rich protein was isolated from *Porteresia coarctata*. Its over-expression in yeast and finger millet conferred high-level tolerance to 250 mM NaCl stress owing to ion homeostasis.

- Different promoters of rice, viz., OSIPA, P12, RP6 and M2, associated with the development of panicle, have been evaluated to analyze their tissue-specific expression pattern using transgenic approach. Two promoters, viz., OSIPA and PP12, exhibited pollen-specific expressions in rice and *Arabidopsis*.

- Developed the transgenic male sterile system in rice using the *argE* and *BnCysP1* cytotoxic genes driven by OSIPA and P12 promoters.

- A novel promoter of hybrid proline-rich protein encoding gene *(CcHyPRP)* was isolated from the pigeonpea and characterized for its ability to drive gene expression under different abiotic stress conditions. The pigeonpea *Cc*HyPRP promoter exhibited higher levels of expression under different stress conditions.

- Full-length cDNAs encoding hybrid-proline-rich protein (CcHyPRP), cyclophilin (CcCYP), cold and drought regulatory protein (CcCDR), metallothionein type 1 protein (CcMT1) and cyclin-dependent kinase subunit (CcCDK) were isolated from *Cajanus cajan* subtraction libraries. Functional validation of these genes in yeast, *Arabidopsis thaliana* and rice bestowed tolerance to multiple abiotic stress conditions.

- Genomes of *Oryza sativa* elite indica cultivar RP Bio-226, castor wilt pathogen *Fusarium oxysporum ricini*, *Bacillus pumilus* isolated from *Mesomosphus* sp, *Enterobacter* sp isolated from decaying wood, *Sacharomyces cerevisiae* strains, NCIM3186 and NCIM3207 differing in bioethanol production, rice endophytic bacteria, *Ralsonia piketii*, *Sphingopyxis granuli* and *Pseudomonas aeruginosa* were sequenced and characterized.

- *De novo* assembly of the leaf transcriptome of *Andrographis paniculata* facilitated the identification of 83,800 clustered transcripts and key enzymes involved in various pathways of secondary metabolism including terpenoid biosynthesis.

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Challenges and opportunities in fungal world

C. Manoharachary

Fungi are achlorophyllous and eukaryotic living organisms possessing mainly chitinous cell wall and absorptive nutrition. The specific characters possessed by fungi enabled them to raise themselves to the level of a separate kingdom-The Fungi. Thus far, about one lakh fungal species have been recorded of which about 29,000 are reported from India. Present estimates indicate the existence of 1.5 to 5.1 million fungi and the fungal world includes molds, yeasts, mushrooms, ascomycetes, puff balls, jelly fungi, earth stars, and bird's nest fungi besides several microscopic fungi colonizing diverse habitats. However, much of the hidden fungal wealth needs to be explored in view of their important role in agriculture, agrochemical production, enzymes, industry, waste recycling, biotransformation, medicine, production of compounds of pharmaceutical value and other relevant fields. Fungi, despite being very important and for being treated as curiosities by many, have been forgotten while formulating conservation policies. Only 5-7% fungi are culturable while the majority 93% could not be cultured.

Relationship between biodiversity of fungi and ecosystem functions is an issue of paramount importance in the face of global climate change and alteration of ecosystem processes owing to extensive human activity.

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Since the mid 1990s, various fungi growing in diverse extreme environments have been discovered. The fungal extremophiles such as thermophiles, psychrophiles, alkalophiles, acidophiles, halophiles, keratinophiles, osmotolerants, anaerobes etc. are industrially important as they are richer source of metabolites compared to mesophiles. As such, it is very much required to document the functional role of different fungal extremophiles.

Many tropical filamentous fungi have assumed importance in the conversion of simple carbohydrates into cellular products. Breakdown of complex organic materials into simpler hydrocarbons, fermentation products (ethanol), antibiotic production (Penicillin, Griseofulvin, Cephalosporin), Immunity suppressants (cyclosporin used in organ transplantation), industial enzyme production (cellulase, lipase), alkaloids, metabolites like taxol, biopulping, dye industry, food industry and several others. Presently, ~16 billion dollars worth of biotechnological products of fungal origin are available in the global market.

Spectacular progress has been made by India towards ensuring food security buoyed by an unprecedented production of 264 million tons of food grains and 285 million tons of horticultural commodities during 2013-2014, and the steady growth in food production from the limited available land is required to ensure food and nutritional security of the whopping

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population of 1.5 billion people by 2030. Threats due to chronic as well as emerging plant diseases is a big challenge for the agricultural production and the losses due to diseases need to be minimised by appropriate plant disease control measures. Fungi have played an important role as biocontrol agents (*Trichoderma*), insecticides (*Beauvaria*), mycoherbicides (*Colletotrichum*), hyperparasites and in several other forms to control plant diseases in an eco-friendly manner. There is a need for an in-depth study of the intricacies of host-pathogen-environment interactions in order to develop efficient disease management strategies and developing crop varieties bestowed with multiple disease resistance. Disease diagnostic services ought to be provided at the farm level for the spot prescription of suitable remedial measures.

Edible mushrooms are considered more nutritious than many other vegetables and its nutritive value is almost equivalent to milk. Edible mushrooms are rich in protein (32%) and possess essential amino acids, more fibre, less carbohydrates, vitamins, unsaturated fatty acids, minerals etc. Around 2000 mushrooms have been found to be edible and 60 of them have attained commercial status. Mushrooms contain alkaloids, exhibit anti-diabetic, anti-cancer and immunomodulatory properties. *Morchella esculenta* (Guchi), *Agaricus bisporus* (white button mushroom), *Pleurotus* spp (oyster mushroom) and *Volvariella* (paddy straw mushroom) are available as edible mushrooms on industrial scale with a multi-billion dollar market. In China, the caterpillar fungus (*Cordyceps sinensis*) is often used as a traditional medicine. Moreover, there are several micro- and macro-fungi which play a vital role in medicine.

Fungi are known to be symbionts, phosphorous solubilizers and plant growth promoters, thereby contributing to the sustainable agriculture, forestry and horticulture. Mycorrhiza — the plant root and fungus association of 70-80% plants — plays a key role in mobilizing phosphorus efficiently and widens the absorptive area of roots, thus contributing to enhanced plant growth, yield besides increased soil fertility, soil stability and disease resistance. Further, the fungi which are hidden underneath the ecological niches need to be explored, identified, cultured, conserved and utilized for human welfare.

Microbiology: Challenges and future prospects

L. Venkateswar Rao and Gopal Reddy

The Department of Microbiology at Osmania University was established in the year 1974, which is the brain child of Prof. H. Polasa, a microbial geneticist then faculty member at the Dept. of Genetics. The research activity in the department mainly focused on isolation and improvement of industrially important microbes, production of value added products such as bioethanol, xylitol, lactic acid and microbial enzymes using economically viable substrates/biomass, and development of plant growth promoting microbes and probiotics.

The long span of four hundred and fifty years of microbiology has brought amazing insight into the biology of microorganisms and has also brought with it new challenges, which have both positive and negative effects upon the society. Diseases like AIDS, Bird's flu and SARS seem to appear without a trace and have challenged the basic understanding of microbial diseases. On the other hand, new discoveries have opened a door for understanding how a cell works at the most fundamental level and newly discovered bacteria stretch the already overwhelming picture of microbial diversity. Microbial ecology is providing new clues to the roles of microorganisms in the environment.

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Biofilms are recognized as the dominant form of organization of microbial communities. A vast number (95%) of microbes are not amenable for culturing and can be studied and characterized with next generation genomic tools. The understanding of microbial evolution has advanced with the use of newly available molecular biology tools and has provided new perspectives on the relationships among microorganisms. Microorganisms play more positive roles than simply causing infectious diseases. The majority of microbes are seen as rulers of the world because of their essential and important beneficial activities. Recent developments facilitated the production of therapeutic recombinant proteins such as insulin, interferon etc., at industrial scale. Diverse microbes are being used in the manufacturing of various pharmaceutical and food products including probiotics. For controlling malnutrition, several microbes are being developed and used for the production of vitamins as well as single cell proteins. Microbes have served as convenient experimental tools to understand life processes and facilitated the advancement of genetic engineering techniques. Biofuels like bioethanol and biodiesel are being manufactured using new raw materials like lignocellulosics, algae and other biomass material which has the potential to substitute non-renewable fossil fuels.

Occurrence of microbial drug resistance is of serious concern and is considered as a

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bigger threat to mankind than cancer. If antibiotics lose effectiveness, key surgical procedures-including organ transplantation could become too dangerous to perform. About 700,000 people around the world die due to infections with drug resistant microbes, and if no measures are taken, it has been estimated that such infections will kill 10 million people a year by 2050. Now, the WHO has come up with a list of 12 antibiotic resistant bacteria that pose greatest threat to human health. The most important six infectious diseases that may haunt the humanity are Tuberculosis, Gonorrhea, Typhoid, Pneumonia, Syphilis and Diphtheria. Therefore, it is important to steer research into discovery/development of new antibiotics or vaccines to control these diseases.

Microbiologists are isolating and developing large number of microbes which increase soil fertility and plant growth promotion. The concept of microbial biofertilizers and biopesticides is changing the scenario of agriculture and impact on human health. There is lot of scope to exploit new microbes for this application in future. Though we have several vaccines available for prevention of many diseases, some of these vaccines are crude and contain unnecessary components. Therefore newer vaccines are being developed which have specific components to elicit antibodies and for possible multivalent vaccine development to decrease the number of injections/applications. Today microbiologists are very much required in top organizations like NASA for identification of any life form in their missions such as the recent Mars curiosity mission and many more.

Agricultural research with global vision and local action

T. Mohapatra

As the largest private enterprise (~130 million farm families) in India, agriculture contributes nearly 14% of the national GDP and engages 58% of the workforce. Hence growth in agriculture and allied sectors remains a 'necessary condition' for inclusive growth. Historically, the decade of 1960s marked a turning point for Indian agriculture. It was during this decade that our import of foodgrains touched the peak; some landmark initiatives taken to strengthen agricultural research, education and development; Dr Borlaug visited the country for the first time; 'miracle seeds' of wheat were introduced from Mexico and a blue print was drawn for the Green Revolution in India with liberal support from the Government. The success of concerted efforts triggered a chain reaction towards establishment of new institutions, creation of infrastructure and human resource as part of the capacity building. As a result, from Green Revolution, Indian agriculture marched towards a Rainbow revolution with rapid growth in horticulture, livestock and fisheries sectors. India has moved from an era of chronic food shortages during 1960s to food self-sufficiency and even food exports by 1990s.

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While the annual food grain production has increased from 50 mmt in 1950-51 to an estimated 263 mmt presently from near static cultivable area of 140mha ±2 mha, the horticultural production has increased from 25 mmt to 262 mmt over the same period. The present annual production of milk over 128 mmt, 66 billion eggs and 8.7 mmt fish have improved food and nutritional security. The agricultural GDP growth during 10^{th} and 11^{th} plan has been 2.4 and 3.6 percent, respectively and in the current year, it is estimated at 4.6 per cent. Today, India is not only a leading producer but also a leading exporter of several agricultural commodities. The agricultural exports during 2012-13 were US$ 41 billion against imports of US$ 20 billion and in 2013-14 exports are likely to cross US$ 45 billion. Undeniably, science and technology led developments remain key drivers of growth in Indian agriculture.

Rising national population, projected to be 1.5 billion by 2050, and per capita income are pushing up the food demand, which needs to be met through enhanced productivity per unit area, input and time. Moreover, dietary patterns are also shifting from low price calorie food towards high price calorie foods. The trend in demand at national level indicates that by the year 2026-27, it is likely to rise by 1.3% per year for cereals, 3.0% for pulses, 3.5% for edible oil, 3.3% for vegetables, and 4-6% for fruits and livestock products over base year 2011-12.

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With globalization in place, Indian agriculture is developing day by day. However, the overarching concerns some of which are natural while others are manmade. Some of these include small and fragmented land holdings, climate change, nutritional and livelihood security, poverty alleviation, profitability, gender equity, ecology and environment, and competitiveness in terms of cost and quality will continue to be major issues before the NARS. Priority issues that call for attention include availability of water and its quality, soil health, genetic resource conservation, insulating farm production against increasing biotic and abiotic stresses, managing climate change, diversification, post-harvest management, enhancing input-use efficiency, energy management, increasing preparedness to match rapidly evolving trade regime, reducing knowledge lag, and congenial policy environment. Further, today's world is looking at combating malnutrition and thus along with food security, nutritional security issues do attract attention.

Notwithstanding the challenges, it has also been realized that India's food security depends not only on producing cereal crops, but also diversifying the food basket to meet the demands of an ever growing population as well as changing consumer preference towards processed and value added products. In the changing context the need for Second Green Revolution is being expressed for enabling a change in production that is necessary to meet and sustain the growing demands.

Challenges for public sector research, therefore, is to increase the long-term productivity of agriculture and food industry, while maintaining and enhancing the natural resource base. The National Agricultural Research Systems (NARS), spearheaded by ICAR, is reorienting the priorities towards enhancing farm productivity, agricultural diversification and value addition to each commodity in direct synchrony with the market. To achieve this objective, deployment of new and latest research and technologies available globally has become imperative. In all, the role of agricultural research and education remains as the foundation for primary and secondary produce in agri-sector *per se*.

The technological and knowledge empowerment of the farmers is imperative. Innovative initiative, *'Farmer FIRST'* to improve technology dissemination is contemplated. The programme will have enhanced farmers-scientists interface for technology development and application with the primary objective to take up technology development based on feedback with the participation of various stakeholders, specially farmers**.** *Student READY* (Rural Entrepreneurship and Awareness Development Yojana) is another novel programme that aims at entrepreneurship development among youth. It combines both Rural Agricultural Work Experience (RAWE) and Experimental Learning courses to provide students with the grass-root level experience and entrepreneurship skills. The challenge that lies ahead is how to make agriculture and rural professions intellectually stimulating and economically rewarding to enable to attract and sustain rural youth in agriculture and allied

sectors. With this pretext, *ARYA* (Attracting and Retaining Youth in Agriculture) program has been implemented by the ICAR to build capacity of rural youth through special programmes and projects. Further, several measures have been taken up by the Government of India to improve the farm conditions to help facilitate enhanced agricultural production such as Prime Minister's *Krishi Sinchai Yojana*, Soil Health Card Scheme, Neem coated urea, *etc*. Further, initiatives such as *Fasal Bima Yojana* help the farmers during climatic adversities. Introduction of e-NAM (national agriculture market) and minimum support pricing of agricultural commodities help in marketing the agri-produce to also ensure farmer's income.

Attaining global competitiveness, excellence in upstream research and producing first rate human resource requires adequate and competent scientific manpower. Higher investments in agricultural R&D as well as HRD are envisaged in the coming years. Though all factors are important, basic solution and basic ground for other factors to play their role is provided by technology. Success of any technology is in commensurate with enabling conditions, policies and economic environment. Overall, the country has sown seeds for science-led inclusive agricultural growth that will lead to an all-round development of a resilient, globally competitive and profitable agriculture.

Meeting food and nutritional security: Challenges for the 21st century

B. Venkateswarlu

India has made significant strides in food production since independence. From about 51 million tonnes in 1951, the country has reached a production level of 270 million tonnes by 2016. This is an unparalleled success not seen in many parts of the world. In several commodities, India is either number one or in the 1st five ranks in global production. We are largely self-sufficient in rice, wheat, vegetables, fruits, milk, fish, eggs and meat and even export these commodities to many countries. Although we are lagging behind in edible oils and pulses, the country is making serious efforts in enhancing production of these commodities as well. This significant success in food production has been described in the form of green, yellow, blue and white revolutions.

This success came largely through the use of irrigation, high yielding varieties, chemical fertilizers and pesticides. High biomass and grain production year after year and sometimes through three crops from the same piece of land has led to depletion of soil organic carbon and deficiency of micro nutrients. This decline in soil fertility is now posing a major challenge in further enhancing food production in the country.

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With decrease in cattle population, the source of organic manure has also declined. Another important input in modern agriculture is water. India is one of the few countries blessed with high rainfall and fertile soils. Thanks to the vision of Pandit Jawaharlal Nehru, India has made significant investments on irrigation development immediately after independence which continues even today. Nearly 50 per cent of the cultivated area is under irrigation. However, the water use efficiency in these irrigation projects has been declining due to poor command area planning and failure of the regulatory mechanisms in water use. As a result, more and more irrigated area is coming under ground water irrigation. Millions of farmers have made huge investments on tube wells and pump sets. Today tube wells account for nearly 70 per cent of the irrigation in the country. This poses a major challenge for the country as the ground water levels in different parts of the country are continuously falling and in many states it is resulting in fluoride, nitrate and arsenic contamination.

Genetic enhancement of crops through hybridization and selection has also contributed significantly for enhancing food production in several crops. In crops like rice, wheat and maize, the productivity levels rose almost three times since independence, mainly due to the breeding of varieties responsive to fertilizers and irrigation. However, of late the yield increments through breeding have slowed

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down. In oilseeds and pulses particularly, the country could not break the low yield syndrome due to lack of genetic breakthroughs. The GM technology has offered some hope in pushing the yield frontiers, but public opposition to GM crops has slowed down its application in food crops.

Another major challenge unique to Indian agriculture is the declining holdings. The per capita land availability is only 0.2 ha. Small and marginal farmers account for 85 per cent of the total farmers. Continuous fragmentation of holdings is leading to a situation where marginal farmer cannot eke out a living for himself and his family even under good weather conditions. Small holdings do not permit application of new technologies like mechanization. It is no surprise, therefore that 60 per cent of the farmers in India prefer to move out of agriculture if alternatives are available. Lack of timely credit, remunerative prices for the produce, post-harvest losses and lack of adequate warehousing are other associated problems faced by farmers in realising adequate returns. This is pushing farmers in several parts of the country in to growing indebtedness and increased distress.

Climate change is yet another challenge faced by farmers today. Due to increased emission of green house gases, the average temperatures are rising and rainfall distribution is becoming more and more erratic. We are witnessing delays in the on set of monsoon, long mid season breaks and heavy rainfall events in a short period leading to floods and water logging. Every one degree rise in temperature results in loss of nearly 5 million tonnes of wheat. The water requirement for irrigation is set to rise significantly due to global warming. In the medium term (2015-2039), 4.5 to 9 per cent loss in food grain production is projected in the country due to global warming. Agriculture contributes to nearly 15 per cent of the GDP; a 9 per cent decline in production translates to nearly 1.6 per cent of the GDP. Globally, weather based crop insurance protects farmers from such losses, but in India the penetration of weather insurance still is quite low.

With rising incomes and growing middle class the demand profile of agricultural commodities is rapidly changing in the country. In future the demand for cereals like rice and wheat may stagnate or decline but the demand for fruits, vegetables, milk, eggs, meat and fish is likely to rise sharply. This calls for a major shift in cropping pattern and crop diversification. Commercial and horticulture crops require more water and therefore using the limited water more efficiently through micro irrigation becomes essential in future. There is hardly any scope for increasing cultivated area in the country. For four to five decades, the net sown area in India has remained stagnant at 141 m. ha. With economic development, lot of land may go out of agriculture for high ways, industrial development and urban growth etc. Therefore India has to produce more and more from less and less land and water in future.

To meet the foregoing challenges in agriculture production and productivity, the following key strategies are suggested.

1. Programmes that help maintenance of soil health.

2. Efficient use of water-both in irrigated and rainfed agriculture.

3. Enhancing productivity through breaking yield barriers by investing on agricultural research including GM technology.

4. Crop diversification into horticulture, dairy and allied enterprises.

5. Investments on post-harvest processing and value addition to minimize losses and add to farmers income.

6. Efficient use of water through the adoption of all modern irrigation methods and water conservation in rainfed areas.

7. Need based farm mechanisation.

8. Protecting farmers from natural disasters through robust insurance system.

9. Application of new and emerging technologies like bio sensors, nano technology, bio informatics and information technology in product development and technology transfer.

10. Placing the farmer at the central point in agricultural development planning both at the centre and states.

Induced mutations and food security- prospective progress

Suprasanna Penna

Introduction

Agriculture, began almost 10,000 years ago as a human endeavour, took the first steps of conserving, sowing and manipulating the seeds of crop plants that formed part of their livelihood. Agriculture then flourished only in some parts of the world. Evolution and selection seems to have fostered new traits, either through natural or artificial selection, for crops to survive or to be better to suit human needs. This is an example of perfect balance between human culture, agricultural activity and ecosystem. Being genetically distinct, wild species have become the chief sources of genetic makeup for the domesticated crops through hybridization and selection, and thus hundreds of new crop varieties have formed the foundation of the world's food supply. The various ancestral wild species as treasures of genetic variation seem to have been bred into cultivated crops. Thus, agricultural development has always been on the move towards increasing crop productivity through exploiting natural resources. Relying on the principles of genetics, plant breeding has been practiced in the past several decades and has utilized the 'genetic variability' available in the primary gene pool of crop plants and in related species.

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Genetic variability, the 'genetic reservoir' has been the mainstay of all crop improvement strategies aimed at developing highly productive crop varieties. It needs to be tapped continuously to develop highly productive, stress resistant and better plant type varieties.

Global food security continues to be the centre stage issue to sustain the food production and to meet the demands of ever-growing human population. The world population is expected to reach 10 billion by 2050. The climatic change has mounted the pressure on both food production and food security. There is a need to find sustainable solutions to enable plant breeders to develop highly productive crops by using conventional techniques and modern tools. Among the different strategies, induced mutations has played a great role in increasing world food security, contributing to the significant increase in crop production.

Induced mutations

Since the discovery that X-rays had mutagenic properties (Muller 1928; Stadler 1928), interest in the use of physical (ionising) radiations and chemical mutagens to induce genetic variation has promoted research which contributed a great deal to applied mutagenesis. Physical and chemical mutagens cause DNA damage. Living cells can respond quickly to DNA damage and, in turn, initiate different

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mechanisms either by killing the damaged cell or by repairing the DNA lesions.The consequences of these processes are directly linked to the recovery of induced mutations. Compared to very low frequency occurrence of spontaneous mutations which arise due to errors during DNA replication or repair, mutations can be induced at higher frequency by exposing seed/plants/cells to various mutagens; thus, making use of induced mutations as an important choice in crop improvement.

The application of induced mutations has played a significant role in the improvement of crop plants and a large number of improved mutant varieties have been released for commercial cultivation in different crop plants (Kharkwal and Shu 2009; Jain and Suprasanna 2011). Mutation breeding is advantageous as it results in the alteration of one or a few traits in an otherwise promising cultivar without significantly changing the genetic setting. Mutagenesis techniques have also been integrated with molecular biology technologies such as molecular marker techniques and high-throughput mutation screening techniques, thereby improvising its application more powerful and effective in crop breeding (Shu 2009). Since the discovery that mutations can be artificially induced, experimental mutagenesis has seen rapid and progressive developments.

Mutations can be induced by using physical (X-rays, Gamma rays, Alpha particles, Fast neutrons, UV and Cosmic rays), chemical (sodium azide, ethyl methanesulphonate, methyl methanesulphonate, hydroxylamine and N-methyl-N-nitrosourea) as well as biological agents (Bradshaw, 2016). Gamma irradiation results in small deletions (1-10 bp) while neutrons cause 300 bp to 12 kbp deletions and chemical mutagens result in point mutations mainly G/C-to-A/T transitions (Morita et al., 2009). Ion beams have linear energy transfer (LET) ranging from 22.5 keV μm^{-1} to 4000 keV μm^{-1} compared to γ-rays and X-rays ranging 0.2–2 keV μm^{1}. Heavy-ion beam irradiation is considered a good tool for mutation breeding because at relatively low doses it induces mutations at a high rate and only a small number of genes are expected to be disrupted in the mutant genomes (Hirano et al., 2015).

The International Atomic Energy Agency (FAOIAEA), Vienna, Austria, maintains the mutant variety database (MVD) to provide comprehensive information on induced mutations suitable for breeding programmes and genetic analysis. MVD also catalogues updated information on crop mutant varieties, mutagens used and characters improved. Since 1960, several mutant varieties have been officially released in worldwide across different countries, among which the top six countries are China, India, the former USSR, the Netherlands, Japan and the USA. As of 2014, there is an estimate of 3,218 mutant varieties registered with the FAO-IAEA database (IAEA 2017; http://mvgs.iaea.org). Among the different plant species, rice mutant varieties share nearly 25 % (820 varieties) and of these around 35 % are developed alone by China. In India, several mutant cultivars of crops, belonging to 56 plant species, have been approved and/or released. The largest number of mutant cultivars have been

produced in ornamentals, followed by cereals, legumes and oilseeds. Trait-wise, 57 % of the mutants possess better agronomic and botanical traits; 18 % show increased yield and yield-contributing traits, 10 % have better quality and nutritional content, 6 % have superior biotic stress resistance and 4 % possess abiotic stress tolerance (http://mvgs.iaea.org). The mutant cultivars have been cultivated globally making some countries food self-sufficient and raise their economic growth (Kharkwal and Shu 2009). Mutation breeding has also significantly contributed to the increased production of rice, groundnut, chickpea, mungbean, urdbean, and castor in the Indian sub-continent (Kharkwal and Shu 2009) and the success of mutant varieties has become evident from the large quantities of breeder seed production of several mutant varieties at the national level. Global status of officially released mutant varieties in top ten countries, and development of mutant varieties – Indian scenario are presented in Fig.1 and 2 respectively.

It is also equally important that crop wise mutant repository be developed for the collection, conservation and distribution of mutants of important crops ensuring access to plant breeders and geneticists around the world. Moreover, such a collection can help maintain crop germplasm diversity. Mutant genes have also played a vital role since their successful introduction into commercial crop varieties to significantly enhance the quality and agronomic attributes of crop plants. Quality protein maize (QPM) varieties having two-fold lysine and tryptophan over normal varieties showed positive growth effect on humans and animals. Mutants of cassava showing different sizes of starch grains have had high economic potential for the industrial use of starch and influence on cooking quality. Rice giant embryo mutants were found to have an increase in the protein contents, vitamin B1, vitamin B2, vitamin E, essential amino acids, and mineral elements (Zhang et al. 2007). Wheat stem rust caused by the fungus Ug99 has threatened wheat cultivation and efforts made by FAO-IAEA global initiative to eradicate this deadly disease have resulted in the development of 13 putative resistant mutant lines. The first Ug99- resistant wheat mutant variety 'EldoNgano 1' has completed successful field evaluation for resistance in Kenya. These are some of the successful examples of application of induced mutagenesis in agriculture.

Genetic analysis

Mutational genetic analysis of plant traits has contributed greatly to linking the function and gene associated with the trait (Maluszynski and Szarejko 2012). Mutagenesis in several plant species has generated huge collection of mutants which proved valuable for basic developmental processes, for example Arabidopsis (Redei et al. 1984, Meinke 1995). Induced mutants in advanced breeding lines or in local germplasm can be crucial in developing novel germplasm suitable for local needs and environment. One of the best examples is the semi-dwarf (*sd*) character which played the most important role in the Green Revolution and modern crop breeding programmes. The

mutated *sd1* locus as the "mystique" gene (Rutger 1992) is responsible not only for short, stiff straw but also makes the rice plant insensitive to photoperiod and more responsive to fertilizer. In indica types 'Taichung Native 1', the first rice variety with the Dee- Geo-Woo-Gen (DGWG) gene led to the release of high-yielding variety 'IR8' at the International Rice Research Institute (IRRI). The success of DGWG gene based varieties such as IR8 and Taichung (Native) 1 has made breeders to depend excessively on these two rice cultivars for dwarf trait. Because of the concerns of genetic narrowness and possible outbreak, many efforts were made to broaden the genetic base through the use of mutants induced by the chemical mutagens (Reddy et al. 1975; Reddy and Padma, 1976).

Genomics interventions

The genomics tools have advanced our understanding of the nature of induced genetic variation. Mutation techniques using ethyl methanesulphonate, T-DNA insertion, transposon tagging and ionizing radiation have provided key information on the nature of mutations which has been useful to explore mutant gene structure, function, spatial and temporal expression and genetic regulation. EMS-based chemical mutagenesis mostly results in point mutations, while ionizing radiation induces physical deletions in the genome. Both the approaches of forward and reverse genetics have been used in gene function analysi). TILLING technology has been useful for screening EMS induced mutations in mutagenized populations and also with mutant populations developed through gamma and fast neutron irradiation (Till et al., 2007). Further to this, a new dimension to TILLING has come up with the advent of high throughput next-generation sequencing and the technique is known as TbyS (TILLING by Sequencing) to speed up TILLING workflows (Tsai et al., 2011). Computational tools and databases (CODDLE for prediction of most suitable gene regions for TILLING analysis; SIFT (Sorting Intolerant from Tolerant) and I-Mutant3.0 for prediction of mutation effect on protein stability) have been made available for mutation screening and the prediction of effects of mutation (Slota et al., 2017).

The available high throughput genomics platforms include techniques of cDNA-amplified fragment length polymorphism (AFLP), single strand conformational polymorphism (SSCP), serial analysis of gene expression (SAGE), microarray, differential display, TILLING and high resolution melt (HRM) analysis. The next-generation sequencing and exon capture method have become available for mutation discovery in a more efficient and cost-effective manner (King et al., 2015). Assessment of mutation density in single individuals with or without the use of a reference genome is often difficult in the absence of a reference genome. In this regard, RESCAN (Restriction Enzyme Sequence Comparative ANalysis) has been developed which uses a set of single restriction enzyme digestion and solid phase reversible immobilization-based size selection of restriction fragments (Manson-Miller et al., 2012).

Conclusions

Food security is becoming a challenge in the face of increasing population pressure and dwindling of natural land and water resources. Sustainable solutions will have to be innovated to augment efforts of crop improvement. Induced mutagenesis of crop plants (mutation breeding) has made a significant impact with the development of new mutant varieties. Several of these mutant varieties are in use in the developing and developed world, and have made huge economic benefit. Genomics advances and accessibility to crop genomes will add new dimensions into analyzing mutational events and mutant traits. The development and maintenance of plant mutant repositories could offer an excellent platform for basic and applied research in crop improvement besides for gene mapping and functional genomics based research.

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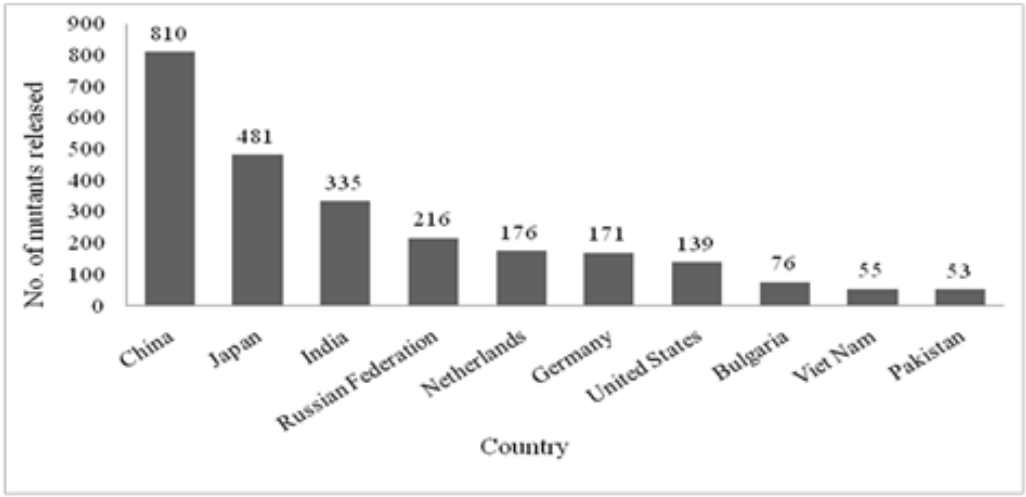

Fig. 1. Global status of officially released mutant varieties in top ten countries

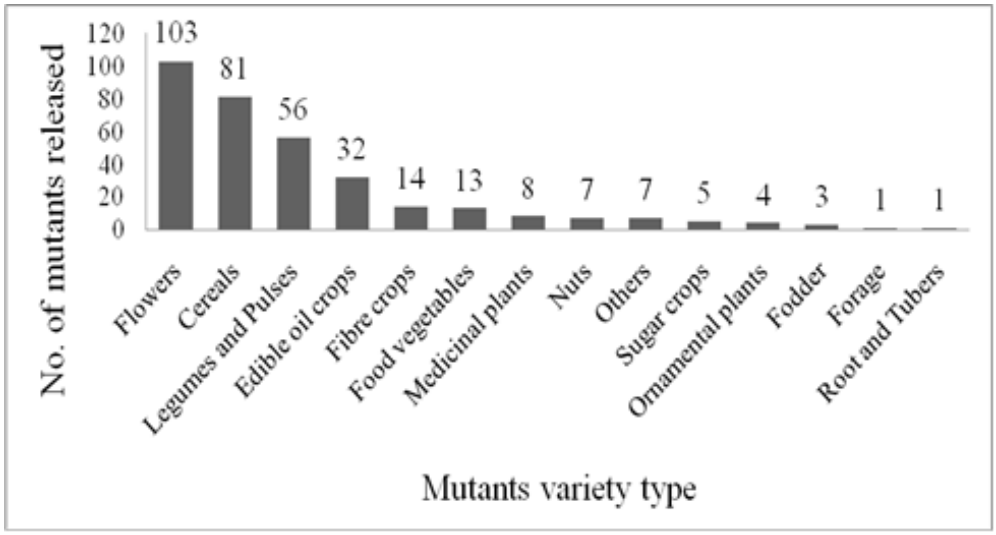

Fig. 2. Development of mutant varieties – Indian scenario

Soil health to human and animal health through breeding biofortified cultivars and balanced nutrient management for nutrition revolution in India

Suhas P Wani and Mahalingam Govindaraj

Key words: Soil health, multi-nutrient deficiencies, Anemia, bioavailability, biofortification, pearl millet, micronutrient malnutrition.

Summary

India has larger prevalence of micronutrient malnutrition as 50% of children and women are suffering from one or more essential micronutrient deficiency. There is an urgent need for the country to address this issue of malnutrition holistically through addressing the issue of soil health to animal and human health. Widespread multi-nutrient deficiencies in soil are resulting in nutrient deficient food leads to malnutrition. Feeding the children with supplements to address the issue is good to fix the issue quickly. However, in long-term, to find a sustainable solution, we need to adopt holistic approach. Along with demonstrated soil health management, biofortification research at ICRISAT is focused on improving grain Fe and Zn density. Our approach is to provide a "proof of concept" to address the issue of malnutrition through soil health management and biofortification of staple food crops.

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To make impact, soil health mapping, balanced soil nutrient for increasing crop yields and quality are proposed. Government of India has taken up soil health mapping and issuing soil health cards to all the farmers. Further, integration of biofortified cultivars of crops like millets in the states and country strategy, would help to achieve future targets of biofortified cultivars to reach one billion people by 2030. Market is a key driver for long-term adoption of biofortified cultivars by farmers and consumers, and a recent initiative on Smart-foods on millets and pulses by ICRISAT is expected to enhance this uptake process in collaboration with food industries. Holistic approach starting with identifying the soil nutrient deficiencies, meeting the crop demands through balanced soil nutrient management and using biofortified cultivars, can have increased micronutrient uptake capacity as well as capacity to have nutrient dense grains and fodder by increased nutrient-use efficiency and would significantly contribute to improved nutrition by increasing the daily micronutrient intakes as evidenced by bioavailability studies in millets.

Nutrition revolution in India is need of the hour?

The ever increasing population and to match with food production in India is a

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biggest challenge. The nutrient requirements of the people are also on the rise. On the other side, increased depletion of soil nutrients particularly micronutrients, due to high yielding mono-cropping is observed. The widespread deficiencies of iron and zinc leading to numerous adverse health consequences, are now increasingly being recognized as serious public health problems, affecting more than a billion people worldwide (Darnton-Hill and Mkparu, 2015). Whereas in India, government supported program showed reduction in malnutrition over the decades, however, there is slow progress as National Family Health Survey (NFHS, 2016) revealed unacceptably high prevalence of anaemia, under-weight and stunting among children under 5 years. More than 50% of children and women in 20 states in India are being reported anaemic. The fact is that fine cereals constitutes major Indian diets and these are relatively lower in essential minerals (iron, zinc and Vitamin A) and does not effectively address the malnutrition issue. For instance, pearl millet, is an important staple food in semi-arid regions in the country, but over the decades, its consumption as a proportion of the total cereals, has significantly reduced, primarily due to minimum support price and subsidized rice and wheat through PDS, available in ready-to-cook forms. Today, diversity of food crops becomes narrow as dominated by few crops with the high-level investment and marketing by multi-national government and corporates and all these crops were highly water-spending. Hence, millets disappeared from our food plate which is the cheapest source of energy, micronutrients and protein among all cereals and pulses. Therefore, on the cost effectiveness and sustainability perspective, cropping system-based dietary diversification and crop biofortification have been suggested to improved human and animal nutrition. Biofortification is defined as breeding crops to increase their nutritional level to have measurable impact on human health. Both CGIAR and Indian research institutes are making progress in developing and testing of biofortified cultivars in rice, wheat, sorghum and pearl millet. This paper will focus on pearl millet as biofortification research in this crop has made good progress on cultivar pipelines and its adoption in India.

Are Indian soils healthy enough to produce healthy food?

Studies conducted by ICRISAT as well as several research institutions in India have shown that most Indian soils are suffering from widespread deficiencies of multiple nutrients (Wani *et al.* 2015, 2013, 2011; Sahrawat *et al.* 2010; Chander *et al.* 2014). Detailed soil mapping work of farmers' fields undertaken by ICRISAT in Karnataka and several states in India showed that most farmers fields were deficient in zinc, boron, Sulphur along with phosphorus and nitrogen (Wani *et al*. 2015). Balanced nutrient management in farmers' fields have clearly demonstrated that farmers' crop productivity was increased by 20 to 70 % over the farmers' practice in Karnataka, Andhra Pradesh, Rajasthan, Madhya Pradesh, Chattisgarh, Gujarat, Telangana, Tamil Nadu, Maharashtra, Uttar Pradesh and Odisha (Wani and Chander, 2016). We can infer that, in most developing countries in Asia and Africa, most soils are

degraded in terms of nutrient depletion and are not healthy soils to produce healthy foods at present.

Base lines and breeding targets for pearl millet

Pearl millet as such is a high-iron crop with fairly high zinc content as well. However, not all available cultivars have high-iron and zinc content. For instance, the average of Indian commercial cultivars so far released has 42 ppm content (Rai *et al*., 2016). But pearl millet has large variability for iron and zinc i.e. 300-600% more than that of rice and wheat. This indicates that the pearl millet is a major target crop for iron biofortification. Unlike other crops, pearl millet foods are prepared using wholegrain flour thus no significant nutrient loss in the grain as such. The global baseline for iron in wholegrain pearl millet irrespective of cultivars (hybrid or OPVs) is set at 47 ppm and targets at 77 ppm (+30 ppm). These targets are set by considering biofortified cultivars are expected to lessen iron deficiencies by providing 30% to 80% of woman's and children daily needs, depending on the nutrient and the amount of the biofortified food consumed regularly (HarvestPlus, www.harvetsplus.org). In addition to that, HarvestPlus developed the Biofortification Priority Index (BPI) to identify staple food crop and target country for higher impact in reducing micronutrient deficiencies (Asare-Marfo *et al*., 2013), which includes iron pearl millet, zinc rice, and zinc wheat for India. Therefore, exploration of biofortified cultivars in India is highly important at the research and development fronts complementing existing programs to address malnutrition.

Cultivar development strategy and its progress

The first-wave of progress in breeding high-iron hybrid in colloboration with national partners is highly impresive as advanced hybrids showed more than 70-90 % of iron target increments and about 80-90% of grain yield compared to high yielding commercial checks. This yield gap exists because of few options of seed parents with high iron level, suggesting accelerated efforts to diversification of seed parents. Therefore, to fulfill the long-term objective and continued supplies of breeding material, ICRSIAT continue to mainstream breeding for iron and zinc in pearl millet in Africa and Asia programs. CGIAR centers made full commitments to mainstreaming breeding for mineral and vitamin traits into conventional food crop development programs at the Second Global Conference on Biofortification in Kigali, Rwanda (www.cgiar.org/consortium-news, 2014). For country-level, public-private sector need to increase the use of biofortified lines and germplasm from ICRISAT, and commit to micronutrient deployment in their breeding programs.

Biofortified Breeding pipelines

Pearl millet biofortification breeding at ICRISAT is gradually shifting from discovery to product development (lines/hybrids). ICRISAT in association with national partners, developed and identified a high-iron variety 'Dhanashakti' that has highest level of iron content (71 mg/Kg grain) in any pearl millet cultivar produced so far and released in the country. The same

variety also contained 40 ppm Zinc. This marks the first high-iron biofortified cultivar of any crop variety officially released and already adopted by farmers in India. Over 140,000 farming households in the country have taken up cultivation of 'Dhanashakti' (HarvestPlus, 2015). Dhanashakti was initially targeted for Maharashtra state, but it also performed equally well in other states of central and southern India. Other High-Fe hybrids have been developed with good yield potential and two of these (ICMH 1201 and ICMH 1301) have been most widely tested. ICMH 1201 has 75 ppm Fe density (similar to Dhanashakti) but has 38% more grain yields while ICMH 1301 has 74 ppm Fe density with 33% more grain yield. Further, six biofortified hybrids are advanced to AICPMIP-Biofortification Hybrid Trial for final year testing (AICPMIP, 2016). This initiative of AICPMIP is expected to have more number of hybrids with high-Fe in near future. For the first time, six seed parents (A/B pairs) deliberately bred for high-Fe (70-110 ppm), were designated as ICMA/B 1501 to 1506, with disease resistance in two diverse cytoplasm's (A_1/A_4).

Bioavailability of micronutrients

To address the malnutrition, nutritious coarse grain crops, such as pearl millet, either of its per capita consumption or iron level of grains has to be increased to get adequate nutrition by an individual. For instance, Studies in India and Benin (Kodkany et al., 2013, Tako et al., 2015) have shown that total iron and zinc absorbed from biofortified pearl millet variety were higher than those from the non-biofortified variety, implying the significant contribution that biofortification can make in addressing their deficiencies in the population consuming this nutritious cereal. For instance, consumption of 200 g of Dhanshakti can meet 80% of the Recommended Daily Allowance (RDA) of Fe in adult men and 66% of the RDA in non-pregnant and non-lactating women in India. It can also meet 65% of the RDA of Zn both in men and women. The above RDAs are based on the assumption of 5% bioavailability for Fe and 25% bioavailability for Zn content.

Suggested future directions

Biofortification, in general, has led to several success stories in many staple food crops including pearl millet for which HarvestPlus was recognized with the World Food Prize in 2016. Now it's time to the policy makers and politicians to make use of this science driven and country-based business models. Several positive attributes of pearl millet need to be tapped appropriately for drylands and possible future way forward at national and international agendas are briefly described hereunder;

- *Public-private partnership (PPP):* Seed companies have well established network in India, and dominating the pearl millet hybrid seed market in India, and thus hybrids occupy approximately 90% of the area under improved cultivars. Therefore, first-biofortified cultivar-being an OPV, less area coverage, was limited than its potential impact. To address this gap, PPP model need to be strengthened by institutional policy of nutrition commitments and special price allocation for mineral-dense seeds with

Government incentives in the markets to promote biofortified cultivars.

- *ICRISAT contribution:* ICRISAT has contributed immensely in diversifying the hybrid parents and its contribution to achieving higher genetic gain at farm level through PPP partnership. About dozen seed companies those had research and development division, capture more than 80% of the pearl millet hybrid seed market in India. Thus, the sustainability of biofortified pearl millet will depends on mainstreaming of biofortification with seed companies, state seed corporations and agricultural universities.
- *Farmer and consumer acceptance:* The biofortified cultivars have been developed using natural genetic variability in pearl millet and are not GMO products. These micronutrients have no influence on color of the grains and food taste which is key factor for consumer acceptance. With these, there is no potential threats for biofortified cultivars release and has great prospects for acceptance of these cultivars by farmers and consumers.
- *Government initiatives*: Large scale field and food product demonstrations through State agricultural universities, line departments and Krishi Vigyan Kendras (KVKs) are needed to popularize bio fortified foods, like pearl millet. Large scale production and procurements of biofortified cultivar grains for making food for anaemic populations/children through Anghanwadi (childcare centre) School feeding (mid-day meal) and PDS system needs to be promoted to address the iron and zinc deficiency.
- *Smart food*: Pearl millet is climate smart crop by itself - dryland resilient with high metabolizable energy, high gluten-free protein, and more of balanced amino acids. So, this crop has potential role to play in the smartfood initiative taken by ICRISAT which aims to build food systems where the food is good for you (highly nutritious), good for the planet (climate resilient) and good for the smallholder farmer.
- *Soil fertility map-based cropping*: Soil test-based fertilizer recommendations are needed to be promoted as per the soil requirements for sustainable intensification which will bring in not only increased production but nutritional quality as well.

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Future nutritional security

Peter Brabeck-Letmathe

Throughout history, the challenge for humanity has been to secure enough food for basic sustenance. And, for most of our past, famines and food insecurity have been the norm. It is only in the most recent period of history that we have seen a degree of success in adequately feeding the world - even if there is still a way to go. Indeed, it is only relatively recently that we can even start to think about ending hunger 'in our own lifetime', so to speak.

The future for our food security is however likely to be significantly tested by already visible demographic, resource and health trends. Researchers predict that population growth and rising incomes will, by 2030, increase the demand for food by 35%, the demand for energy by 50% and the demand for water by 40%[1]. Cities will meanwhile be the home of more than two thirds of the global population by 2050[2], an unprecedented degree of urbanization in human history, with direct consequences for both the production and delivery of food.

Moreover, there is widespread recognition today that producing enough, safe food to eat is not sufficient to guarantee food security. To date, our focus has been on agriculture, in particular on increasing agricultural productivity, and on ensuring safer, cheaper, and also more nutritious foods through industrial production.

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While this has without a doubt had a profound impact on the improved health and longer life expectancy of people living today – hence the relative success we have witnessed in feeding the world – we now know that greater focus has to be given to nutritional outcomes.

Today, one in three persons worldwide is malnourished. Every country in the world is affected, whether advanced or developing, with economic consequences rising to an estimated 11% of GDP annually in many countries[3]. There are different forms of malnutrition, with some populations or individuals suffering from several at the same time. About 2 billion suffer from micronutrient malnutrition; about 800 million are calorie deficient (insufficient quantities of food); and nearly 2 billion are overweight or obese[4], a figure most people expect to increase significantly into the future as rising wealth in many developing countries lead to changes in diet and lifestyles.

The 2015 Sustainable Development Goals, notably SDG #2, which calls for an end to hunger as well as malnutrition, provides a particularly coherent reflection of the narrative on global food security that needs to motivate us and generate action. It clearly shifts the focus beyond the alleviation of under-nutrition and the provision of food security alone to an approach that puts a central focus on malnutrition in all its forms. Indeed, when looking ahead, we will no longer speak

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about food security per se but rather about food and nutrition security or even just nutrition security. Achieving this will mean different things in different sub-populations but there are some basic elements that will be common across all population groups.

It will require a rethink of the current functioning of our existing food system. For a future that is nutrition secure, we will need the following elements: the appropriate integration of new scientific knowledge into the production of our food, a reorientation of lifestyles towards good health outcomes and a food system that uses scarce natural resources in the most efficient way.

We will see a step change in our rigorous scientific understanding about nutrition that will likely condition our approach to feeding the world going forward. Let me be more precise: the progress we are already seeing and which we will see in the next years in the life sciences will fundamentally change our understanding of nutrition and in particular how nutrition affects our health. These new scientific developments will in turn trigger a massive wave of innovation across the food producing sector and lead to a significant leap forward towards science-based personalized health nutrition. Not individualized nutrition, but personalized for similar populations of individuals. This will mean different things across different parts of the world's population: for the relatively poorer groups in the global population, this will mean sufficient healthy food, enriched with micronutrients; for the relatively richer groups, this will mean greater customization of diets.

We are already seeing a growing health consciousness, particularly across the younger generations. In part, this is the result of the rise of chronic diseases globally, notably cardiovascular disease, diabetes or cancer which can be attributed in part to a relatively small number of risk factors, mainly lifestyle (diet, exercise etc.) factors. Today, in all parts of the world except Africa, the number of deaths due to chronic diseases exceeds those due to infectious diseases[5]. This will force those responsible for the food ecosystem (and those responsible for health and social systems) in the future to look to policy and framing conditions that emphasize prediction and prevention. Individuals will also need to be appropriately supported and incentivized by all the relevant actors, including educational institutions, the media and food producers, to aspire to and be empowered to lead a healthy life.

A final point on the efficient use of resources. After all, we will not be able to ensure even the most basic nutrition security if we do not make our food system sustainable in the long term. This is particularly the case for water - let me digress a little on this. 90% of the world's water supply is used to grow the food that we eat. Water withdrawals are expected to exceed sustainable supply (natural renewal of water minus environmental flows and needs) by at least 40% in 2030[6], if current water practices are not changed. Right now we have buffers that we can use in times of drought. But these buffers – water tables of underground aquifers accumulated over

10,000 years - are now sinking and if we continue using water as we do today into the future, we will face shortfalls in global cereals in the order of about 30%[7], that is the entire production of India and the US combined. Our future nutritional security thus must factor sustainability in as a priority.

Where does all this leave us? We are in a new context today which, in my mind, will enable us to begin to construct a nutrition secure world. First, there is a timely and welcome recognition across the board that emphasis needs to be given to delivering the sustainable production of enough food for a growing and richer population as well as to providing food of the right nutritional value. The progress of scientific knowledge will increasingly enable us to better understand the science of nutrition and bring this to bear in feeding not just the richer but also the developing parts of the world appropriately. There is an accompanying and increasing awareness of the role of nutrition in economic, health and life outcomes. Finally, the issue of sustainability has become mainstream, opening up the pursuit of greater efficiencies in our use of natural resources. All these elements together give much hope for the future of nutrition security and ultimately the ability of each and every one of us to lead a long and healthy life.

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Nutraceuticals in health care

Muhammed Majeed and Appian Subramoniam

Nutrition is an essential requirement of all living organisms. Humans obtain nutrients from foods that are directly or indirectly obtained from other organisms such as plants, animals and microbes. In the long human evolutionary period, based on vast trial and error experiences and empirical knowledge at various stages of human social development and organization, different cultural groups identified many plants, animals and microbes as edibles and certain others as medicines. Materials identified as edibles are time tested for their safety for long time use within reasonable quantities. There are foods with both nutritional and medicinal values. This article focuses on such food materials, plant food in particular, for human health care and well-being.

Nutraceuticals

The term 'nutraceutical' was coined from the words 'nutrition' and 'pharmaceutical' by Dr. Stephen L. DeFelice in 1989 (Brower, 1998). He defined nutraceutical as "a food or part of food that provides medical or health benefits including the prevention or treatment of disease". Since the term was coined by Dr. DeFelice, its meaning has been modified by Health Canada as "a product isolated or purified from foods, and generally sold in medicinal forms and demonstrated to have a physiological benefit or provide protection against chronic diseases".

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If ingredients of diet or edible items have medicinal values, they are also known as medicinal foods or bioactive foods or, even, functional foods. If a functional food aids in the prevention and / or treatment of one or more diseases and/or disorders, it is a nutraceutical (Kalra 2003). Normally, functional foods are designed to allow consumers to eat enriched foods close to their natural state (Hardy, 2000). Now, nutraceutical refers to food or any product derived from food sources with medicinal values or health benefits in addition to their basic nutritional value (Subramoniam, 2016).

Food materials (ingredients of diet) with medicinal properties are medicinal foods or nutraceuticals. However, medicinal foods are not available as an over-the-counter product to consumers in USA (Brower, 1998). The FDA considers medical foods "to be formulated, to be consumed or administered internally under the supervision of a physician, and which is intended for the specific dietary management of a disease or condition for which distinctive nutritional requirements are established by medical evaluation" (Hardy, 2000). But, these demarcations are not applicable in all countries.

A dietary supplement is a product that contains nutrients derived from food products that are generally concentrated as liquids, powders, tablets, capsules, etc. If a dietary supplement contains one or more bioactive compounds that aid in the prevention and/or treatment of diseases

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or/and disorders, it is also a nutraceutical. For example, garlic extract is sold as dietary supplement to lower blood lipids.

Nutrition and nutraceuticals

In health care, first, adequate nutritious food is required to combat nutritional deficiency and malnutrition. Disorders and other medical conditions caused by nutritional deficiencies and malnutrition could be rectified with an adequate intake of balanced nutritious food, if irreversible changes have not occurred due to very severe level of nutritional deficiency early in life. This should not be confused with nutraceuticals. However, nutrients such as anti-oxidant vitamins, essential amino acids, and essential fatty acids are considered as nutraceuticals by many investigators. In health care, adequate balanced nutrition should be accompanied by appropriate amount of regular nutraceutical intake. Need-based nutraceutical consumption should be identified according to the physiological status, health status and specific medical conditions of each individual concerned.

Plant nutraceuticals

Plant foods are edible parts of plants (as such or after cooking, processing, etc.) accepted by any community through custom, habit and tradition as appropriate, desirable food or ingredient of diet. Generally, food items provide nutrients to the body without any short or long term adverse effects to health and well-being.

Plant based nutraceuticals are plant products with nutritional and medicinal values. The preference for the discovery and production of nutraceuticals over pharmaceuticals is well seen in pharmaceutical and biotech companies. One of the reasons for the same is that diet and dietary ingredients with medicinal properties are likely to be very safe. Herbal drugs which are not edible are not nutraceuticals.

Farmaceuticals refer to medically valuable compounds, produced from modified agricultural crops or animals (usually produced through biotechnological intervention). If a non-nutraceutical drug is produced in an edible plant, it is not a nutraceutical.

Ayurvedic and other traditional medicines from plants should not be considered as nutraceuticals, if they are not from edible parts of plants. Ayurveda and traditional medicinal plants should be backed by modern scientific research and technologies. For example, the presence of hepatotoxic pyrrolizidine alkaloids in certain medicinal plants used in Ayurveda and local health traditions has been reported.

Certain pharmacy and biotech companies erroneously extended the term nutraceutical even to isolated compounds from wild plants which are not edible (Kamboj, 2000). This is a dangerous trend considering human health. However, if a bio-active compound present in a food is isolated from a non-edible (but non-toxic) plant, it can be considered as a nutraceutical. Natural health products that promote health include both nutraceuticals as well as herbals and other natural products (Shahidi, 2012). Botanicals are often used as synonyms for herbal products. There is a need for a legal

distinction of plant nutraceuticals from pharmacologically active herbals or botanicals (Koch et al. 2014).

Utilization of nutraceuticals

Many diseases can be prevented and life span can be prolonged with appropriate use of nutraceuticals and healthy lifestyles. Nutraceutical can improve health and well-being and prevent diseases to a considerable extent and support economic development. Food supplements and functional foods (other than nutraceuticals) could combat malnutrition and specific nutritional deficiencies. Examples of plants with nutraceuticals are given along with their edible parts and health benefits in **Table 1**. Examples of nutraceutical compounds include epigallocatechin gallate, piperine, quercetin, curcumin, lycopene, resveratol, capsaicin, mangiferin, zingerone, gingerols, shogaol, ω-3 fatty acids, α-lipoic acid, genistin, rutin, hydroxycitrate, garcinol, pterostilbene, sesamin and thymoquinone.

Common people should understand the medicinal value of natural whole food nutraceuticals which can be consumed in its natural form. Many fruits, vegetables, grains, spices etc. contain compounds that deliver health benefits beyond their basic nutrition. Drug-nutraceutical interactions, interactions between different nutraceuticals as well as interactions between nutrients and nutraceuticals, and the effect of cooking and processing on the nutraceutical compounds and their efficacy should be determined by scientific studies. Besides, interaction of nutraceuticals with gut environment including microbes should be considered. For example, one study reports that fenugreek seeds when taken with hot water showed anti-diabetic property, whereas the same when consumed with curd did not exhibit the anti-diabetic property (Kassaian et al., 2009).

Since nutraceuticals have pharmaceutical properties, like drugs, nutraceuticals should be consumed at the effective levels or optimum amounts. These amounts have to be determined by controlled clinical trials. People with specific diseases such as diabetes, cardiovascular diseases, arthritis, osteoporosis, obesity, hyperlipidemia and liver function impairment should consume specific amounts of carefully selected nutraceuticals on a regular basis. Nutritional research should focus on the examination of foods for their protective and disease preventing roles. In many cases, a medicinal food may have preventive and/or curative roles in more than one disease or health problem. Such foods (nutraceuticals) may have more than one pharmacologically active phyto-chemical (nutraceutical). In some cases, even one isolated nutraceutical molecule could be beneficial in more than one disease and medical condition. However, in most of the cases, rational mixtures of nutraceuticals could be more beneficial.

Antioxidant nutraceuticals

Certain anti-oxidant phytochemicals exhibit health benefits including prevention of cancer, cardiovascular diseases, etc. Such anti-oxidants present in the food are also nutraceuticals. Most of the chronic diseases such as neurodegenerative diseases, arthritis, diabetes and so on carry with them a great

deal of oxidative stress. The required levels of anti-oxidants differ between infants, children, adults, elderly people, etc. Reactive oxygen species are produced in the body as well as removed from the body. Certain food contains pro-oxidants and certain other food contains anti-oxidants. In the body, the balance between pro-oxidants and anti-oxidants in relation to the physiological state of the body determines the final effects. With age and certain disease such as arthritis, neurodegenerative diseases and diabetes, the oxidative stress increases; so, elderly people and people with certain diseases require more anti-oxidant containing foods compared to healthy young growing people. Some amount of oxidants is required for normal growth and function of the body. Examples of high levels of antioxidant containing nutraceutical include green tea (epicatechin, and epigallocatechin-3-gallate), and spinach (α-lipoic acid, leutin, etc.).

Spices as nutraceuticals

Most of the spices have varying levels of antioxidant, hypolipidemic and anti-inflammatory properties. These properties are beneficial in cardiovascular function and support in preventing and/or controlling cancer and diabetes. It should be remembered that most of the spices are used in very small amounts in food preparations. High concentrations of certain spices could be toxic. When purified nutraceutical compounds from food, spices in particular, are used, the tolerable dose should be studied based on clinical trials; too high doses may not provide desired health benefits and in rare cases toxicity may develop. Long term clinical studies are needed to scientifically validate the role of different nutraceuticals in different diseases. Certain nutraceuticals are helpful to cope with the adverse effects of climatic conditions. For example, thermogenic spice, black pepper is more beneficial in cold climatic conditions.

Nutraceuticals for cardiovascular support

The major risk factors of cardiovascular diseases are hypertension, hyperlipidemia (particularly, high levels of low density lipoprotein cholesterol) and mental stress associated hormones. Anti-atherogenic/ anti-atherosclerotic, anti-hyperlipidemic and anti-inflammatory nutraceuticals given below as well as strong antioxidants provide cardiovascular support. High intake of fruits, vegetables, vitamins and minerals are recommended for prevention and treatment of cardiovascular diseases.

Anti-atherogenic / anti-atherosclerotic nutraceuticals

Important risk factors of atherosclerosis are hyperlipidemia, oxidative stress, elevated blood pressure and, to some extent, inflammation. Edible plant parts with anti-hyperlipidemic and/or anti-oxidant activity include onion, garlic, peanut, cauliflower, leaf and unripe fruit of moringa (*Moringa oleifera*), bilimpi fruit, green tea, coriander, turmeric, soybean, bottle gourd, bitter melon, Indian gooseberry, red ripe tomato (tomato contains lycopene, a powerful antioxidant), spinach, rice bran, fenugreek, ginger, cinnamon, black berry, low bush blue berry and papaya fruit. Omega-3 fatty acids (which provide health benefits by modulating inflammation, lipid metabolism

and immune function) are present in salmon, flax seed, walnuts, etc.

Anti-hyperlipidemic nutraceuticals

These include garlic, bilimpi (*Averrhoa bilimbi*), rice bran, resveratrol, β-sistosterol and ω-3 polyunsaturated fatty acids (anti-arthrosclerosis). Soluble fibres such as pectins from apples and citrus fruits, *β*-glucan from oats and barley, fibres from flax seed, etc. are known to lower low density lipoprotein cholesterol.

Anti-inflammatory nutraceuticals

Examples of anti-inflammatory nutraceutical compounds are pheophytin-a (magnesium free chlorophyll-a), curcumin, gingerols, shogaol, quercetin and linolenic acid. Most of the nutraceuticals given under, Nutraceuticals for arthritis, possess anti-inflammatory properties.

Nutraceuticals for arthritis

Since arthritis exhibits inflammation of joints, pain, oxidative stress and hyperimmune reactions (particularly in the case of rheumatoid arthritis), nutraceuticals with high levels of one or more of these properties could ameliorate the symptoms of arthritis. Antiarthritic plant foods, when consumed regularly to the optimum level, could be extremely safe without the adverse effects of currently used NSAIDs (Non-Steroidal Antiinflammatory Drugs) and immune-suppressors. Antiarthritic foods include tea leaf (*Camellia sinensis*), cinnamon, ginger, coriander seed, turmeric, black pepper, fenugreek seed, carrot and black berry (*Syzygium cumini*). Examples of pure chemical entity nutraceuticals with antiarthritic properties include chlorophyll-a and its degradation products, curcumin, epigallocatechin gallate, lycopene, mangiferin, quercetin and β-sitosterol.

Anti-obesity nutraceuticals

Nutraceuticals like hydroxycitrate from *Garcinia cambogia* fruit, pterostilbene from blue berries etc, anthocyanins from kokum (*Garcinia indica*), fruits of bitter melon (*Momordica charantia*), rhizome of nut grass (*Cyperus rotundus*), common bean (*Phaseolus vulgaris*), raw butter milk (contains conjugated linoleic acid), etc. possess anti-obesity activity.

Anti-diabetes nutraceuticals

These include fenugreek seed, ginger, coriander seed, cluster bean, bitter gourd, lady's finger (okra), gooseberry, ivy gourd, sweet potato, cucumber, almond, rim of water melon fruit and mango fruit peel (Subramoniam, 2016).

Anticarcinogenic nutraceuticals

Fruits and vegetables with vitamins A, C, E and trace elements like selenium may prevent cancer development to a large extent (Ranzato et al. 2014). Examples of anti-carcinogenic nutraceuticals include leaves and unripe fruits of drumstick tree (*Moringa oleifera*), thymoquinone from black cumin (*Nigella sativa*), curcumin (turmeric), genistein (soybean), quercetin (many fruits and vegetables), resveratrol (grapes, groundnut, etc.), limonene and *Lactobacillus acidophilus.*

Hepatoprotective nutraceuticals

These include bengal gram, sugarcane juice, gooseberry, carrot, wheat extract, mango peel (Ebeid et al. 2015), *Citrus paradisi* (naringenin), grapes (resveratrol),

ginger (zingerone), kokum (*Garcinia indica*) fruit (garcinol), limonene and piperine. High level of anti-oxidant containing food materials will protect from oxidative stress mediated toxic chemicals-induced liver damage.

Nutraceuticals for bone health or osteoporosis

Phyto-estrogens present in nutraceuticals such as soybean products (genistin and daidzein) and stem of *Cisus quadrangularis* provide bone health, particularly to postmenopausal woman. Examples of other nutraceuticals believed to be beneficial to bone health are spinach and other leafy vegetables, flax seed, inulin (naturally occurring polysaccharide) and conjugated linoleic acid (present in raw butter milk).

Conclusion

Health and well-being could be improved with appropriate use of nutraceuticals coupled with physically and mentally active life style and reduced mental stress. Each individual should identify with the help of experts of nutrition and medical doctors, appropriate nutraceuticals (combination of different foods with medicinal properties) along with required quantity to be consumed depending on the physiological status and medical conditions. Further research and clinical trials are required to fix appropriate doses and combinations of nutraceuticals to be consumed in specific individual cases.

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Table 1: Examples of commonly available plants with nutraceuticals

Botanical name	Common name	Edible parts	Major health benefits identified
Allium sativum L. (Amaryllidaceae)	Garlic	Bulbs	Anti-hyperlipidemic, anti-atherosclerotic, etc.
Apium graveolens L. (Apiaceae)	Celery	Leaf stalks (vegetable) and seeds	Antihypertensive (diuretic), anti-arthritic and skin support
Comellia sinensis (L.) Kuntze(Theaceae)	Tea	Leaves	Antioxidant, etc.
Coriandrum sativum L. (Apiaceae)	Coriander	Seeds and leaves	Anti-inflammatory, anti-diabetes, antimicrobial, etc.
Curcuma longa L. (Zingiberaceae)	Turmeric	Rhizomes	Antioxidant, cancer preventive, anti-inflammatory, etc.
Garcinia indica Choisy (Clusiaceae)	Kokum	Fruits	Hepatoprotection, anti-obesity, antioxidant, etc.
Garcinia cambogia (Gaertn) Desr. [*Garcinia gummi-gutta* (L) Roxb.] (Clusiaceae)	Kudam puli, Malabar tamarind	Fruits and fruit rinds	Anti-obesity, hypolipidaemic, anti-diabetes, anti-inflammatory, etc.
Glycine max (L.) Merr. (Fabaceae)	Soybean	Beans	Cancer preventive, bone health support, anti-atherogenic, etc.
Momordica charantia L. (Cucurbitaceae)	Bitter gourd (bitter melon)	Fruits	Anti-diabetes, etc.
Moringa oleifera Lam. (Moringaceae)	Drumstick tree	Leaves and fruits	Cardiovascular support, liver support and anticancer
Nigella sativa L. (Ranunculaceae)	Black – caraway (black cumin)	Seeds	Liver support, blood sugar support and anticancer
Phyllanthus emblica L. [syn: *Embilica officinalis* Gaertn](Phyllanthaceae)	Indian gooseberry	Fruits	Antioxidant, anti-diabetes and liver support
Piper nigrum L. (Piperaceae)	Black pepper	Fruits	Thermogenic, nutrient absorption enhancer, etc.
Punica granatum L. (Lythraceae)	Pomegranate	Fruits	Antioxidant, etc.
Solanum lycopersicum L.	Tomato	Fruits	Cardiovascular support, cancer

(Solanaceae)		(culinary vegetable)	prevention, etc.
Spinacia oleracea L.,(Amaranthaceae)	Spinach	Leaves (vegetable)	Cardiovascular support, anti-diabetes, antioxidant, etc.
Trigonella foenum-graecum L. (Fabaceae)	Fenugreek	Seeds and leaves	Blood sugar support, anti-hypercholesterolemic, etc.
Vitis vinifera L. (Vitaceae)	Grape	Fruits and seeds	Antioxidant, hepatoprotective, etc.
Zingiber officinale Roscoe (Zingiberaceae)	Ginger	Rhizomes	Digestive aid, anti-inflammatory, anti-arthritis, etc.

Developments in food preservation

Prasad S. Variyar

Foods undergo deterioration in quality post-harvest or during manufacture depending on the food type, composition and storage conditions. Preventing deterioration of food to enhance shelf life and thereby ensuring a constant supply has been one of the major challenges faced by mankind since the dawn of human civilization. This has lead to the development of several food preservation methods that ranges from the ancient and traditional to the more complex and advanced processing methods presently employed. Food preservation has become an increasingly important component of the modern food processing industry.

Food Preservation can be defined as methods of treating foods to delay its deterioration. This involves changing raw products into more stable forms that can be stored for longer periods of time thereby making it available at any time of the year in any area.

Food spoilage can be attributed to one of two major causes:

- Attack by microorganisms (including disease-causing pathogens) such as bacteria and molds.
- Oxidation that causes the destruction of essential biochemical compounds and/or the destruction of plant and animal cells.

The various food preserving methods are all designed to reduce or eliminate one or the other (or both) of these causative agents.

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Traditional preservation techniques

Among the early forms of food preservation that are still in use today, are methods such as drying, smoking, salting, freezing and fermentation. Drying is a natural technique for preventing spoilage as most disease-causing organisms require a moist environment to survive and multiply. Sun drying in the open was probably one of the earliest forms of food preservation. Modern drying techniques make use of a host of dehydrating techniques including fans and heaters in controlled environments that are especially popular for the preservation of grains such as maize and barley. Early humans probably discovered by accident that certain foods especially flesh foods and cheese exposed to smoke last longer. The antimicrobial properties of wood smoke appear to have probably aided in preventing the growth of spoilage organisms. With many alternative forms of preservation currently available, importance of smoking has now shifted to its use for adding interesting and

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distinctive flavors to foods. Curing of foods by addition of salt/sugar has been well known for centuries. Salt/sugar binds with water molecules thereby acting as a dehydrating agent while also impairing conditions under which pathogens can survive. In addition, use of salt or sugar also adds pleasant flavor to the final product. It is highly popular in the preservation of meats and fish. During freezing, pathogens that cause food spoilage are killed or do not grow very rapidly at reduced temperatures. One of the problems surrounding the use of freezing as a method of food preservation is the danger that pathogens that are deactivated (but not killed) by the process will once again become active when the frozen food thaws. Destruction of texture in meats, fish, vegetables, and fruits during slow freezing has also been observed. Early humans discovered that the spoilage of milk can be controlled in such a way as to produce a new product, cheese, made by the process of fermentation. It is a process by which naturally occurring chemical reaction activated by food microorganisms results in the formation of an edible product. Bread is another example of food product wherein fermentation of sugars by yeasts results in the formation of a product that remains edible much longer than the original raw materials.

Need for newer preservation techniques

By 2050 a projected increase in food production by 70% from the current output is imperative to feed the world population. As much as half of the food grown and harvested in underdeveloped and developing countries never gets consumed mainly due to improper handling, processing, packaging, and distribution practices. This has resulted in growing food security concerns in several places around the world. Starvation and nutritional deficiencies in vitamins, minerals, protein, and calories are still prevalent in all regions of the world. Further advancements are therefore needed to resolve the challenges of sustainably feeding the growing population. In this regard, one of the principal thrusts towards meeting future food demands lies in continued focus towards reduction of postharvest losses through improvements in food processing and packaging with a view to deliver safe, nutritious, and affordable food. Food Processing Industry serves as a vital link between the agriculture and manufacturing sectors of the economy. Strengthening this link is critical to reduce wastage of agricultural raw materials and improve the value of agricultural produce by increasing shelf-life as well as by fortifying the nutritive value of the food products thereby ensuring remunerative prices to farmers as well as affordable prices to consumers. Modern food processing has aided considerably in maintaining as well as improving food quality, safety and availability and aided in reducing food losses. It has also facilitated availability of seasonal food year round and foods for population with specific health conditions.

Current preservation techniques

Among the preservation techniques currently employed, modified atmosphere packaging (MAP) has, in recent years, assumed significance. The effectiveness of

vacuum and MAP derive mainly from the removal of oxygen, with the consequent inhibition of strictly oxidative microorganisms. Carbon dioxide is widely used in MAP foods because it has a specific antimicrobial activity, acting as a preservative. Use of heat for pasteurization to inactivate vegetative micro-organisms and sterilization for inactivating bacterial spores still remain the current major industrial scale preservation technique around the world. Techniques that restrict access of micro-organisms to products such as packaging and aseptic processing are also in focus. Application of these techniques in combination so as to minimize the extreme use of any one of them while improving food product quality has been a major trend. This forms the basis of 'hurdle technologies' that have promoted the development of new routes to food preservation. Use of mathematical models have further aided in computer-aided predictions of the effects of various preservation parameters generated on the growth and survival, of specific micro-organisms in food.

Newer and future preservation techniques

In recent years there has been an increased demand from consumers for convenient, higher quality, fresher, more natural and nutritionally healthier foods. There is thus a focus towards developing foods by using less severe or 'minimal' preservation and processing technologies by the food industry. Newer trends in food processing thus include techniques and methodologies for the manufacturing, preserving and monitoring of food that are convenient and easy to preserve. Besides, preference for safer products has also resulted in increasing demand of fresh or minimally-processed foods that are devoid of synthetic chemical preservatives. However, this may result in a reduction in shelf life and lead to a potential lowering in their microbiological safety. Thus, a major challenge has been to ensure that new and improved technologies retain, or preferably improve on the effectiveness of preservation while ensuring safety. Modern food science and technology has extended, expanded, and refined traditional preservation methods through the use of novel food and beverage processing technologies. These developments have contributed to increased nutritional quality, safety, acceptability, availability and choice of foods and beverages. New and innovative products, some with unique product attributes, have been developed through the use of new processing technologies. In this regard development of new and emerging technologies such as non-thermal physical methods of preservation assumes importance. These alternative technologies have unique characteristics and potential for applications in different categories of food products. The goal of all the new processes is to reduce the overall time and temperature exposures of the foods so that they are safe and more like fresh or freshly cooked items.

Radiation processing of food

Among the new non-thermal techniques that provide effective alternative to heat, radiation processing by ionizing radiation is a non-thermal method that brings about minimal changes in sensory qualities

thereby maintaining food quality. The process involves exposing food to a carefully controlled amount of ionizing radiation with the purpose of increasing food storage life, reducing postharvest losses and eliminating food poisoning microorganisms. Types of ionizing radiation employed include the gamma rays emitted from radionuclide (cobalt 60, cesium 137), X-rays (≤ 7.5 Mev) and the high energy (≤ 10 Mev) electrons generated by machine sources. Both gamma and X-rays are part of electromagnetic spectrum and have identical physical properties and effect on matter. SI unit for measuring radiation doses given to foods is Gray (Gy). When 1 joule of energy is deposited in 1 kg of food material by means of irradiation the amount of dose absorbed is said to be 1 Gy. In radiation processing of food the dose is generally measured in terms of kGy (1000 Gy). Radiation damages DNA of microbes and parasites. If damage is not automatically repaired the organism will be unable to replicate itself thus reducing/eliminating disease causing germs and bacteria. Radiation processing can provide an effective alternative to fumigants that are being phased out due to their adverse effects on environment and human health. The process is highly effective, non residue forming, safe to workers & environment, can be applied to pre-packed commodities, can penetrate deeper into tissues and is a cold process. Radiation processing of food has been thoroughly and extensively studied in order to ensure its toxicological, nutritional and microbiological safety. Regulation requires that every food commodity irradiated should be labeled. Label should indicate treatment given along with an international logo known as radura symbol. Several market trials have demonstrated consumer's preference towards irradiated foods when positively informed about the technology. Presently, radiation processing is practiced in sixty countries for over 100 food items. The Atomic Energy (Control of Irradiation of Food) rule 1996, the primary legislation that regulates food irradiation was amended and the notification was issued recently in June 2012. A generic class-based approval has been provided for increasing the product range for radiation processing. A gazette notification amendment for including irradiated foods in the Food Safety and Standard Authority of India was also published on 23rd August, 2016. As economies become more global, food products must meet high standards of quality and quarantine in order to move across borders. Irradiation is an important tool in the fight to prevent the spread of deleterious insects and microorganisms.

Other non-thermal preservation techniques

Application of high hydrostatic pressure (4000-6000 atmospheres) is now well-established among the non-thermal preservation techniques for inactivation of vegetative bacteria, yeasts and moulds. As bacterial spores are far more tolerant to pressure than are vegetative cells, a synergistic treatment with mild heating can inactivate spores. Possibility of using other hurdles in combination may eventually allow its use as an alternative to heat-sterilization. Ultrasonication at high enough intensities (10-1000W cm1 and < 0.1 MHz) can inactivate vegetative bacteria and reduce the heat resistance of spores.

The effect is amplified by increasing the temperature and application of a slight overpressure (i.e. a few atmospheres) and has the potential to reduce pasteurization and sterilization temperatures for pumpable liquid and semisolid foods. High intensity pulsed electric field processing employs high voltage pulses (20-80 KV/cm) for periods less than 1 second to fluid foods to achieve microbial inactivation and reduce enzymatic activities. Detrimental changes in sensory and physical properties of food are minimal. Use of high intensity short duration pulsed light for surface sterilization of food surfaces and packaging materials have shown considerable promise. Use of this technology for pasteurization of fruit juices has been recently demonstrated. Ohmic heating is an advanced terminal processing method where food material which serves as an electric resistor, is rapidly and uniformly heated. It is an effective method for fast processing and homogenous treatment. Non-thermal plasma technology is another upcoming preservation technology wherein electric discharge into air or liquid produces energetic atoms, highly reactive radicals, ozone etc. that eliminates microorganism with minimal thermally induced damage to food. The potential applications of this technology include pasteurization of liquid food products and packaging materials.

A prominent trend in recent years has been the development of functional or health-promoting foods that can reduce or prevent ailments such as heart disease, osteoporosis, cancer and diabetes. These include a) foods that have specific functionalities (functional foods) obtained by techniques such as genetic engineering, enzyme and cell immobilization, supercritical fluid extraction or those based on applying membrane technology b) fortified foods enriched with natural ingredients and c) probiotics and prebiotics. Additional research is however, needed on the bioavailability and bioactivity of newer functional food that are currently under development. With questionable safety of several chemical or synthetic preservatives as food additives there is a clear trend of substituting them with natural products (or their extracts) with multifunctional properties (antioxidant and antimicrobial, among others) such as plant essential oils and oleoresins as well as food derived bioactive natural products. Another promising area, in recent years, has been the use of fruits and vegetables as raw materials to obtain edible wrapping films and biopackaging with selective gas permeability for improving shelf life of fresh or minimally processed products as well as for slow release of food preservatives.

In summary, processing of a food includes a range of technologies and processes that can transform raw food materials and ingredients into food products that are acceptable to consumers. The primary purpose of these processes is to enhance shelf life and ensure food safety. Changes in the quality attributes of the product may either be intentional with the aim to improve nutritive quality, texture, appearance, and flavor of the product or to simply make the product different, without improving or changing its quality. Such processed foods can have positive nutrient benefits beyond those of the raw or home-

prepared product with more nutritional value than the fresh produce. At present, most of the new technologies of food preservation are at different levels of development. Future commercialization of these technologies will depend on their positive influence on food safety and the quality and the ease of implementation of these techniques at industrial level. Another important aspect will be the potential formation of unpalatable and toxic by-products during the processing that would need a thorough investigation. The advantages and disadvantages of some food preservation techniques is summarized in Table 1.

Future outlook

There is currently a real need for improved techniques, to meet the rising demands of consumers for foods that are natural and safe. Use of established techniques in new combinations or improvements derived from new and emerging technologies can aid in solving some of the problems of food preservation faced by food industry. Overcoming resistance of bacterial spores to some of the new techniques in a manner that is widely proven and accepted to be safe, can lead to immeasurably larger potential markets. A particular attraction of the newer techniques is that they act by inactivation rather than by inhibition. However, effectiveness of most of the new technologies on microbial and enzyme inactivation has not been clearly established till date. Therefore, continued research is warranted before implementing them at the industrial scale. Education and training programmes on newer technologies and their benefits can go a long way in better understanding of food processing and facilitate consumer acceptance.

India ranks 5th in the world in terms of the value of food processed and the expected growth rate is higher than the expected growth rate of the economy. This industry has really taken off, as convenience is the most important factor for the consumers. Consumers are willing to pay more as their work habits and lifestyle change. Moreover, increasing media penetration and awareness levels have increased the demand for ‘quality food’, ‘nutritional food’ and ‘healthy eating habits’. Newer technologies and product innovation have aided in food processing units being more cost competitive, while offering a better product. The industry has a significant impact on all stake holders – consumers (in terms of better quality of food), producers (in terms of profit generation) and society (in terms of generating employment and providing adequate and nutritional food). Effective use of newer techniques can thus lead to the elimination of pathogens and extend shelf life, quality and availability of food, which is the ultimate target of primary food producers, processors, distributors, and retailers.

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Table 1. Advantages and disadvantages of different food preservation techniques

Sr. No.	Process	Advantages	Disadvantages
Traditional Methods			
1.	Freezing	• Rapid, • Large materials can be handled • Low or no preservatives needed • Vitamins A, E, carotenoids, fiber, minerals, and proteins retain their value	• Freezer burn can affect texture and flavor • Vitamins B and C are lost during freezing process • Lower antioxidants in frozen fruits than in fresh fruits, expensive
2.	Canning	• Protect against microbes, bacteria, mold, and yeast • Limits food enzyme activity. • Combination with appropriate packaging effectively prevents decay. • Shelf life of 1-2 years or longer	• Time consuming • Does not taste as good as fresh food • Lower nutritional value than fresh food • Significant investment of time and equipment • Inadequate processing or poor sanitation can result in deadly *Clostridium botulinum* contamination.
3.	Pickling	• Rivals freezing, canning and drying for preventing foods from spoiling. • Adds unique flavors • Allows food to be preserved longer • Unlike canning, pickling does not require the use of a pressure canner	• Alters the taste of foods permanently • High-sodium products like pickles can cause higher blood pressure • Requires expensive jars, lids, and other canning equipment
4.	Drying	• When stored properly can keep indefinitely • Extremely lightweight and can be transported easily	• Does not taste the same as fresh food • Moisture during storage can cause mold on food. • Overly dried food can be exceptionally hard
5	Smoking	• Kills certain bacteria and slows down the growth of others. • Prevents fats from becoming rancid • Prevents mold from forming on fermented sausages. • Extends shelf life of the product • Improves flavor of smoked meat	• The process requires constant attention and costly equipment • Difficult to keep the food moist due to low moisture contents in the smoker • Smoked foods may contain carcinogens such as polycyclic

			aromatic hydrocarbons
Newer Non-thermal Methods			
1.	High hydrostatic pressure	• Enhances product safety • Extends shelf life of product • Desirable textural changes possible • Minimal effect on flavor, nutrients and pigment • Minimal textural loss in high-moisture foods • Can eliminate spores when combined with high temperature • In-container and bulk processing possible • Potential for reduction or elimination of chemical preservatives	• Equipment is cost-prohibitive • Changes in sensory quality possible • Not suitable for foods with air spaces and dry foods • Refrigeration needed for low-acid foods • Elevated temperatures and pressures required for spore inactivation
2.	Pulsed electric field	• Effective against vegetative bacteria • Relatively short processing time • Suitable for pumpable foods • Minimal impact on nutrients, flavor or pigment compounds	• Not suitable for non-liquid foods • Post-process recontamination possible • Less effective against enzymes and spores • Adverse electrolytic reactions could occur • Not currently energy efficient • Restricted to foods with low electrical conductivity • Not suitable for product that contain bubbles • Scaling up of process difficult
3.	Ultrasound	• Effective against vegetative cells • Effective against vegetative cells and spores • Reduced process times • Amenable to batch and continuous processing • Little adaptation required for existing processing plant • Energy efficient • Several equipment options • Can be combined with other unit operations	• Challenges during scaling up • Free radicals could damage product quality • Can induce undesirable textural changes • Can be damaging to eyes and can cause burns and skin cancer • Depth of penetration affected by solids and air in product • Potential problems with scaling up of plant
4.	Ultraviolet light/pulsed UV light	• Short processing time • Minimal collateral effects on foods • Low energy input	• Shadowing effect possible with complex surfaces • Has low penetration power

		• Suitable for high- and low-moisture foods • Amenable for post-package processing • Medium cost	• Ineffective against spores • Possible adverse sensory effects at high dosages • Possible adverse chemical effects • Reduced efficacy with high • microbial load • Possible resistance in some microbes • Reliability of equipment to be established
5.	Ionizing radiation	• Cold process • High penetration power • Non residue forming • Can penetrate deeper in to tissues • Suitable for sterilization (food and packages) • Suitable for non-microbiological applications (e.g. sprout inhibition) • Packaged and frozen foods can be treated • Can be scaled up • Low and medium dose has minimal effect on product quality • Suitable for low- and high-moisture foods • Diverse applications	• High capital cost • Detection of treatment difficult • All commodities may not be amenable • Lower consumer acceptance

Ethnopharmacology and Indian medicine

P. Pushpangadan*

Introduction

The history of human civilization is all about the management and utilization of the resources around him. From the very beginning of the human civilization human communities living in different agroclimatic conditions have acquired unique knowledge about their ambient biodiversity by inherent instinct, or intuition, or by accidental discovery, or by error, or empirical reasoning or even by conscious trial and experimentation. The above said process enabled him to select a variety of natural resources, more particularly the biological resources to meet his primary needs like food, nutrition, medicine, shelter, clothing and to build his ever growing material culture and civilization. Many human communities later established advanced material culture and began to live in towns and cities. But majority of the people in the third world countries continue to live in and around forests or in villages. While the advanced societies developed written languages and documented their knowledge in written records. Whereas, the traditional communities maintained their knowledge system through oral traditions.

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Traditional Medicine

The promotive, preventive and corrective approach of health prevalent in the traditional medicine (TM) of India and China are now being widely appreciated and getting increasing recognition in the world over. Besides being the mainstay of health care of over 80% of the world population, TM, particularly those of India and China is looked upon as a source for developing effective therapeutic agents to many degenerative and gerentological disabilities and metabolic disorders for which there is no cure or satisfactory management available in modern medicine. 'Rasayana' and 'Panchakarma' method of treatment of Ayurveda are the two important treatment regimes attaining greater appreciation and acceptance in this context.

The mechanisation and undue objectification of human life and health care systems of the present era have culminated to an extreme nexus between physician and patient by the interpolation of a third entirely mechanical thing, the machine, replacing the creative synthesizing role of the traditional physicians. This has resulted in the dehumanization of the medical system. In contrast to this scenario of the modern medicine, the traditional medicine attempts to embody a holistic approach i.e. viewing an individual in his totality within society and the ecological environment. It

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emphasizes the view point that ill health or disease is brought about by an imbalance or disequilibrium of man's physiological, psychological, behaviourial, ecological and spiritual environment and not just by an external pathogenic agent, be it a micro-organism or otherwise. No doubt, the modern medicine has accomplished great strides in developing many new life saving drugs. Modern health care system stressed more on the curative and to a lesser extent on the preventive aspects of diseases and very little has been done on the health promotive aspects. Problems of health have been replaced by problems of drugs and diseases. Instead of medicine for man, we have men for medicine. Modern medicine may help man to provide apparent physical health but is devoid of mental, social and spiritual health. Modern medicine is more concerned with the cure of disease but remains indifferent to health preservation. It is in this context that the relevance of the holistic approach of the traditional health care practice becomes important. There have been an ever increasing production and consumption of phytomedicines based on various traditional systems of medicine both in the developing and developed countries. A steady global market for many such herbal products is emerging.

Genesis of the subject Ethnopharmacology

Ethnopharmacology as a scientific term was first introduced at an international symposium held at San Francisco in 1967 (Efron *et al*., 1962). This was used while discussing the theme 'Traditional Psychoactive drugs' in this Symposium. But later Rivier and Bruhn (1979) made an attempt to define Ethnopharmacology as "a multidisciplinary area of research concerned with observation, description and experimental investigation of indigenous drugs and their biological activities. It was later redefined by Bruhn and Holmstedt (1983) as "The interdisciplinary scientific exploration of biologically active agents traditionally employed or observed by man". In its entirety, pharmacology embraces the knowledge of the history, source, chemical and physical properties, compounding, biochemical and physiological effects, mechanism of action, absorption, distribution, biotransformation, excretion and therapeutic and other uses of drugs. A drug is broadly defined as any substance (chemical agent) that affects life processes. Therefore, briefly, the main component of ethnopharmacology may be defined as pharmacology of drugs used in ethnomedicine. However none of the above said definitions captures the true spirit of this interdisciplinary subject. Ethno- (Gr., culture or people) pharmacology (Gr., drug) is about the intersection of medical ethnography and the biology of therapeutic action, i.e., a transdisciplinary exploration that spans the biological and social sciences. This suggests that ethnopharmacologists are professionally cross-trained – for example, in pharmacology and anthropology – or that ethnopharmacological research is the product of collaborations among individuals whose formal training includes two or more traditional disciplines. In fact, very little of what is published as ethnopharmacology meets these criteria.

Nyman (1995) has suggested that the objectives of Ethnopharmacology should focus on (1) the basic research aiming at giving rational explanation to how a traditional medicine works, and (2) the applied research aiming at developing a traditional medicine into a modern medicine (Pharmacotherapy) or to develop its original usage by modern methods (Phytotherapy).

The scientific evaluation and standardization of traditional remedies using exclusively the parameters of the modern medicine is both conceptually wrong and unethical. Evaluation of traditional remedies particularly those of the classical traditions has to be based on the theoretical and conceptual foundation of these classical systems of medicine, but may utilize the advancements made in modern scientific knowledge, tools and technology. In fact it is important to combine the best of elements of concept and practice from traditional medicines and modern medicines with the objective to improve the health care system of humankind. Such an integrated approach to study and develop holistic health care system is termed as the Ethnopharmacological approach. The concept of Ethnopharmacology research in India evolved in 1980s independently of this international initiative.

Ethnopharmacology research in India was initiated at Regional Research Laboratory (RRL), Jammu in 1985 by the then Director Dr. C.K. Atal along with his student Dr. P. Pushpangadan, the then chief coordinator of All India Co-ordinated Project on Ethnopharmacology (AICRPE) and the senior author of this communication. Dr. Atal, however left RRL in mid 80s. But Dr. Pushpangadan and his students, colleagues and a few other enthusiasts, notably Dr. A.K. Sharma, Dr. S. Rajasekharan, Dr. V.George, Dr. P.G.Latha, Dr. K. Narayanan Nair, Dr. B.G. Nagavi, Shri. P.R. Krishna Kumar etc. continued their effort to develop ethnopharmacology research. They observed that subjecting the traditional herbal remedies including the remedies of the classical systems like Ayurveda, Siddha and Unani to the parameters of modern medicine is not only foolish, but suicidal. Both these systems are conceptually quite different. The concept of disease, its etiology, manifestation and approach to treatment etc. are all viewed on a holistic basis contrary to the reductionistic approach of modern medicine. Only an integrated approach that combines the best of theory, concepts and methods of the classical systems of medicine such as Ayurveda, Siddha and Unani with the modern scientific knowledge (Phytochemistry & Pharmacology), tools and technology can bring in the desired results.

The concept and methods of Ethnopharmacology research thus developed by the authors contain experts from diverse disciplines like Ayurveda, Siddha, scholars of Sanskrit and Tamil languages (who can correctly interpret the classical texts of Ayurveda and also its theoretical basis like 'Sankhya' and 'Vaiseshika' philosophy), ethnobotany/ ethnomedicine, chemistry, pharmacognosy, pharmacology, biochemistry, molecular biology, pharmacy etc. The main objective of this approach

was to develop appropriate techniques to evaluate the traditional remedies in line with the classical concepts of Ayurvedic pharmacy and pharmacology such as the 'Rasa', 'Guna', 'Veerya', 'Vipaka' and 'Prabhava', in other words 'Samagrah Guna' of the 'Draya Guna' concept of Ayurveda. The senior author was successful in convincing Prof. M.G.K. Menon way back in 1985 who then agreed to be the Chief Patron of the newly formed National Society of Ethnopharmacology. This society was formally registered in 1986 with the senior author as its first founder president. The first ethnopharmacology laboratory started functioning at Regional Research Laboratory, Jammu under the All India Coordinated Research Project on Ethnobiology (AICRPE) funded by the Ministry of Environment and Forest, Govt. of India. However, the first full fledged Ethnopharmacology Division was started in 1992 at Tropical Botanic Garden and Research Institute (TBGRI) where the author joined in 1990 as its Director. At TBGRI the team could successfully demonstrate the integrated approach and could develop novel scientifically verified standardized herbal drugs. Some herbal drugs developed at TBGRI after filing patents were released for commercial production. The Ethnopharmacology Society in association with TBGRI and with the financial assistance of DANIDA organized the first National Conference on Ethnopharmacology in Trivandrum, Kerala from 24th to 26th May 1993. Selected papers in this conference were compiled and published as 'Glimpses of Indian Ethnopharmacology' in 1995. The second national conference of Ethnopharmacology was organized at J.S.S College of Pharmacy, Mysore in 1997 and the third at Pankaj Kasthuri Ayurveda College, Trivandrum in 2004 and the 4th at Amala Cancer Research Institute, Thrissur in 2006. In February 1999. the senior author moved from TBGRI, Trivandrum to National Botanical Research Institute (NBRI) Lucknow, a pioneer plant research institute under the umbrella of Council of Scientific and Industrial Research (CSIR). International Society of Ethnopharmacology in association with National Society of Ethnopharmacology and National Botanical Research Institute (NBRI) have organized the Vth International Congress on Ethnopharmacology in November, 1999 at NBRI, Lucknow and the VIth International Congress on Ethnopharmacology was held at Amity University, Noida.

A Satellite Symbosium on Ethnopharmacology was held at Amity Institute for Herbal and Biotech Products Development Extension Center at Kodungannoor, Thiruvananthapuram on 4th December 2012. In his presidential address, Prof. P. Pushpangadan stressed the importance of cultivation and conservation of medicinal and nutritional plants. The Third World nations of Asia are rich in Biodiversity and the indigenous knowledge particularly the traditional ethnomedical practices. Among the Asian countries, India and China are the two major stakeholders in the herbal product development and trade particularly the ethnomedical practices and phytopharmaceuticals. There are over 45,000 species of vascular plants reported from India. Of these the folk medicine

system of India use about 5000 plant species with about 25,000 formulations for treating a variety of ailments, whereas the tribal medicine involves the use of over 8000, wild plants with about 1,75,000 specific preparations/applications (AICRPE, 1998). The classical indigenous systems of Indian medicine prescribe 10,000 designated formulations. On the other hand the Traditional Chinese Medicine has 12,807 resources, including 11,146 medicinal plants, 1,581 medicinal animals, 80 medicinal minerals. China is the largest producer and supplier of herbal medicine products and technologies. Herbal medicine is an organized sector in China for which the Chinese Government extends enormous support and encouragement in the form of modernization of the Chinese traditional medicine system through integration with modern medicine and incorporation of modern S&T knowledge and tools including informatics.

Conclusion

We are thus witnessing a new paradigm in medical research with the emergence of ethnopharmacology. The complexity of ingredients and the aspect of synergistic bioactivities of TM would be well explained/demonstrated by systems biology approach that enables linking of the complex metabolic profile of a herb with biological effects – herbal metabolic fingerprints with bioactive assays and multivariate statistical analysis would provide a method to involve the whole spectrum for the medical and the pharmaceutical approach. This was essentially the concept and philosophy of the oriental systems of medicine like Ayurveda, Siddha, Unani and the Chinese Traditional Medicine. Systems biology approach thus demonstrates a shift in focus from the reductionistic approach and strategy of modern medical research to the holistic approach and strategy of TM, more particularly Ayurveda. The drug therapy that used to be mostly symptomatic, will now aim at targets that are closer to the causes of diseases. Therapeutic progress, which used to be indirect, conjectural and coincidental is about to become more directed, definitive and intentional. At the same time as researchers are discovering new knowledge, they are developing new opportunities to advance medicine in an effort to move this field rapidly forward and to seek new ways in which these advances can provide better health and quality of life to patients. Science of Chronobiology teaches us to follow nature's rhyme. Ayurveda emphasizes on this biohumoral variations during meals, across seasons and throughout one's life span. Application of this biohumoral rhyme in clinical practice is common.

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Biodiversity and climate change: Tree the saviour of future

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Biodiversity refers to the variety and totality of diverse life forms inhabiting in entire range of ecosystems on the earth. Biological systems coexist and complement each other for their survival and sustenance. The global biodiversity is estimated to be an all-time high about 30,000 years ago. This biodiversity has been declining ever since due to human-induced habitat loss, invasive species, over exploitation and further threatened by pollution and climate change. A rapid global warming recorded 251 million years ago is attributed as the major cause of Permian mass extinction, which eliminated 70% and 84% of the life forms on land and in oceans, respectively. The latest estimates indicate that more than a million species will be lost in the next 50 years, greatly reducing the world's biodiversity. The most significant cause is expected to be climate change and global warming influenced by the increasing carbon foot-print. Present requirement of ecological foot-print amounts to 18.1 billion global hectares (gha); while, the Earth's total bio-capacity is 12 billion gha and ever-increasing population further widens the gap. At this juncture, to minimize this gap, population control and the recreation of forest vegetation will be a breathing space and real time respite for the future as the forest ecosystem accounts for two-thirds of global photosynthesis.

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Trees are an integral part of human life, and a vital component of biodiversity. Forest trees in particular are renewable sources of food, fodder, fuel wood, timber and other usable non-timber products. Due to the increasing population and the human intent to progress, there has been a tremendous decline in forest cover from the earth's surface. To maintain and sustain forest vegetation, conventional approaches have been exploited in the past for propagation and improvement. However, such efforts are confronted with several innate hurdles such as slow growth, long life-span, sexual self-incompatibility and highly heterozygous nature of the trees. Due to the prevalence of high heterozygosity in tree species, a number of recessive deleterious alleles are retained within populations, resulting in high genetic load and inbreeding depression. This limits the use of traditional breeding methods such as selfing and backcrossing, and makes it difficult to fix desirable alleles in a particular genetic background. To circumvent these impediments clonal or vegetative propagation has been the choice for mass multiplication of elite germplasm of tree species. In general, the poor success with explants from mature woody trees is the main constraint in the *in vitro* propagation, as trees grow old the ability of vegetative propagules to root declines. However, most of the tree species can be propagated by vegetative means during the juvenile phase.

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Against the background of limited juvenile phase and long life-span, development of effective plant regeneration protocols for tree species has gained importance. It has also been emphasized that the juvenile characters may be preserved at the base of the older trees (ontogenetically young tissue) whereas maturation occurs at the periphery of the plant tissue that is ontogenetically older but chronologically younger. When such material (explants) for the initiation of *in vitro* culture is not available, some manipulations for reversal of aging or partial rejuvenation are helpful. In such cases conventional methods, such as hedging, severe pruning, use of root suckers, spraying with plant growth regulators and stimulating stem segments for epicormic bud flushing, are useful. Alternatively, *in vitro* culture of selected explants and epicormic buds, repeated sub-culturing, micro-grafting into juvenile root stalks, adventitious bud formation, and somatic embryogenesis will be of great help. Induction of somatic embryogenesis and their conversion to plants has been reported in a large number of tree species. Low induction frequency and quick loss of embryogenic competence are two inherent problems with somatic embryogenesis. However, reports on the induction of somatic embryogenesis from mature tree explants are not yet available in sufficient numbers. A method for the induction of somatic embryogenesis from adult tree explants would be a fundamental breakthrough.

The fruit of a slow growing economically important medicinal tree *Terminalia chebula* Retz. (Family: Combretaceae) is important raw material in tanning industry besides exhibiting diverse pharmacological activities such as anti-spasmodic, anti-HIV, anti-bacterial, anti-oxidant, dermal wound healing, anti-cancer, cardio-protective effect besides managing rheumatoid arthritis. The large scale *in vitro* propagation of this tree under the AP-Netherlands Biotechnology programme by the author's group is a token attempt towards the multiplication and preservation of this forest tree and its biodiversity at large. An efficient protocol for multiple shoot induction from cotyledonary-node explants of *Terminalia chebula* has been developed. Repeated subculture of cotyledonary-node explants to fresh media proved effective in the formation of enormous number of new shoots. About 44.33 ± 0.88 first generation shoots could be obtained from a single cotyledonary node explants after 12-14 weeks of culture. A large number of micropropagated plants were established in field conditions at the CPMB, Osmania University, as well as at different climatic locations including SAIRD, Gaddipally, Nalgonda District. The field established plants showed early flowering and fruit setting. This study is a success story of developing a rapid method for generating large number of planting stock material of the forestry and their subsequent establishment in field conditions at different locations. Employing *T. chebula* mature zygotic embryo (MZE) explants, protocols were standardized for the induction of direct and indirect pathways of somatic embryogenesis. Induction of indirect somatic embryogenesis proved effective over direct somatic embryogenesis. However, direct somatic embryogenesis is advantageous as it

curtailed the culture passage time by 4 weeks.

If the current progress in tissue culture and genetic transformation combined with biotechnological applications continues, the future may witness super tree species tailored for various special agronomic and economic characteristics. As per Chinese philosopher Lao-Tse “The world is ruled by letting things take their course. It cannot be ruled by interfering. If you try to change it you will ruin it. If you try to hold it you will lose it". Therefore at this crucial juncture it becomes urgent and mandatory for every human being to behave with responsibility as a global citizen and contribute individually by planting trees and encourage mass-tree plantation to address the erosion of biodiversity and climate change problems like carbon-foot-printing. In my opinion, the tree can be the saviour of biodiversity in particular and mother earth at large.

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Genetics, genomics and genome editing: Applications in crop breeding

Arjula R. Reddy

Mendel's Laws of Inheritance laid the foundation of Genetics about one and a half century ago. Since then, genetics, the science of heredity and variation, assumed a central position in biology connecting all the relevant disciplines. Advances in biology, biochemistry, chemistry and physics significantly contributed to the early developments in genetics. Mendel's monumental work with garden pea triggered immediate interest in plant genetics and then breeding beginning early 20th century. These include targeted experiments in controlled crosses, observed superior performance of hybrids in outpollinated populations, recombination and linkage map construction and phenotype based breeding. However, all the subsequent breeding experiments for specific traits in the next 50 years or so have not depended upon information on the concerned gene, its structure or function. Mostly phenotype and often chromosomal position was the only known information on the suspected gene. Precision of breeding improved with parallel knowledge obtained on the nature of chromosomes, their behavior during meiosis, nature of allelic variation, ability to induce mutations by physical and chemical means, biochemical and molecular analytical techniques.

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The power and depth of genetic analysis took a jump with the discovery of DNA structure, genetic code and transcription and translation. This immediately triggered wide interest in characterizing genes in relation to improved genotype-phenotype relationships and deploying them in breeding programs. The timeline and milestones of the evolution of genetics, genomics and genome editing pathway is given below:

1860-65	:	Mendel's Laws of Inheritance (foundation of Genetics)
1900	:	Rediscovery of Mendel's Laws
1905	:	**"Genetics"**
1906	:	**"Gene"**
1908	:	Observations on Heterotic effect and Hybridization
1916-30	:	Maize hybrids
1920	:	"Genome"
1930	:	Mutation breeding
1940's	:	Discovery of Maize transposons
1950's	:	**DNA structure**
1960's	:	Improved varieties, wheat, rice, **Green Revolution**
1980's	:	Gene Manipulation and Transgenics

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1990's	:	Molecular genetics, TILLING, transposon mediated mutagenesis, commercialization of transgenic crops
2000	:	Arabidopsis Genome Sequence, **Genomics and Epigenomics,** Molecular Breeding
2002,2005	:	Rice Genome Sequence
2010-	:	Gene and **Genome Editing, Epigenome Editing**

It is needless to note here that all the food and feed demands of the world populations were met by conventional plant breeding based on the principles of genetics. However, the ever rising human population (reaching 9 billions by 2050), requires almost 70 % more food grains over the present levels. This has to be achieved using less crop land, less water, less fertilizers and pesticides and under the threat of climate change. Plant breeding has been enriched by advances made in plant molecular biology and genetics in terms of identifying and molecular characterization of genes, their precise mapping, functional role and regulatory circuits that govern their expression. Spectacular advances made in gene cloning and gene transfer coupled with ability to transform select pants lead to gene modification and thus the birth of Genetically Modified Crops. Transgenic technology and the products from such biotechnologies across many plant species, particularly commercial crops like cotton, spread rapidly across the globe. For instance, a whopping 80% of cotton crop land was soon occupied by GM cotton in USA and India. However only a few traits, such as herbicide tolerance, insect resistance, modified oils in select crops were targeted.

Parallel rapid advances in DNA sequencing and computational biology coupled with sophisticated genetics led to the birth of genomics in 1990s. Though the term 'Genomics' was coined in 1986 and 'Genome' 50 years before, rapid progress in omics technologies has set only in late 90s. By the beginning of the twenty first century, Whole Genome Sequencing efforts came to a reality and Human genome and Arabidopsis genome sequence drafts were released in the year 2000. This is followed by rice in 2002 and 2005. Soon after, Whole Genome Sequences of several crops were released; grape in 2007, sorghum-2009, maize- 2009, soybean 2010, Apple2010, strawberry-2011, potato 2011, cabbage-2011,cassava-2012, foxtail millet-2012, banana-2012, chickpea-2013, cotton-2012, 2013, pegion pea 2014, sugarcane 2015 and so on. More than 100 plant genomes were sequenced by end of 2015 and the number is increasing steadily.

Deep sequence information and knowledge from the genomes, transcriptomes, expression profiles of target genes on a large scale, and new information from epigenetic studies enabled the breeders to improve crop varieties in an efficient and cost effective manner. Spectacular developments in HTP DNA sequencing technologies and tools rapidly opened up diverse crop genomes

spanning across several important genera. The scope of genetics as well as plant breeding was dramatically widened by the availability of sequence information that provided a deep insight into the ordered arrangement of genes and also their epigenetic states, which were not revealed by classical genetics. This has ushered in and strengthened the molecular breeding programs in an unprecedented manner. Marker generation, tagging and QTL region characterization experiments were extensively used to analyze relationship between candidate genes and phenotypes. Map-based cloning of candidate genes followed by functional evaluation was linearly integrated into gene discovery and deployment into breeding programs. Earlier generation markers such as RFLP, AFLP, RAPD, ISSRs, SSRs and other non specific markers were replaced by more informative SNPs. High density marker maps were prepared for many agronomic traits across major crops. Automated HTP Sequencing technologies helped researchers to expand the scope and scale of sequencing of populations of a large number of crop plants. Genomics provided unprecedented access to a range of genetic variation and offered tools to measure gene expression directly in a global manner with very high precision and accuracy. Selective application of these tools and technologies has greatly impacted crop breeding. Particularly, comparative genomics approaches facilitated a systematic comparison of structure and function of orthologous genes at diverse loci across the sequenced crop genome, such as grass genomes. Thus, generating deep knowledge of variation in gene function and their networks greatly facilitated studies on phylogenetic relationships among them. Another result of genomic analysis is the uncovering of novel alleles, unknown alleles related with novel function, in the wild relatives of major crop species. The Omics approaches have lead to great opportunities to address questions on crop domestication and evolution because of availability of many layers of critical knowledge. Genomic analysis powered by rapid, affordable and powerful deep sequencing of whole genomes has uncovered hitherto unknown information on gene and chromosome organization, behavior and evolution. For instance, while genetic analyses has explained giant chromosome in Drosophila more than half a century ago, genomics revealed nanochromosomes, 16000 of them, in the nucleus of Oxytricha.

Genome Sequence of model plants and crops greatly helped in unraveling the function of many, but not all, genes. Soon, a major initiative such as ENCODE project in plants may begin to understand the function, interactions and networks of all genes in a plant genome. As a result, the prediction of phenotype from genotype becomes a reality. Such an approach of systems-level integration of gene function into complex networks unraveled genetic control of complex traits such as flowering time *vis a vis* response to day-length. Genomics approaches enabled us to understand evolutionary genetic processes, such as gene duplications, deletions, other chromosomal interchanges that indicate footprints of domestication process.

The newly introduced genome sequencing technologies, called Next Generation Sequencing (NGS) technology was used to generate millions of novel allelic variations, SNPs, which can be used as genome wide markers to identify agronomically important genes. This greatly facilitated introgression breeding and also other types of crop breeding. Huge genome wide SNP discovery programs became a reality for major crop genomes, This approach provided yet another advantage in the identification of functional insertions or deletions of genes and different numbers of short DNA sequence motifs within SSRs. Such informative markers have been successfully used for constructing of high resolution genetic, molecular genetic, and physical maps, which are of great use in identifying the genes or QTLs controlling agronomic traits. Molecular breeding coupled with deep sequence data lead the era of Genomic Selection and Association Genetics.

Vast sequence data generated by NGS and whole genome sequencing and re-sequencing obtained from genomes and transcriptomes, coupled with the expression profiles under different physiological conditions, will help to identify the genes associated with different traits. Such experiments on abiotic and biotic stress induced expression of huge number of genes gave critical information on relevant genes controlling such an expression. Regulatory loci that govern the stress specific expression of one or a bunch of genes have been identified by using such technologies in several crops for different traits. Distributions of allelic variations at these loci in the genomes of related species enable us to predict and confirm the role of such genes in determining resistance or susceptibility to the given stress. Identification of candidate gene in one crop genome will enable us to identify the ortholog in other target species and transfer such genes across other species, both related and otherwise. Recent projects such as 3000 genome sequencing will provide enormous valuable data on genetic variation, linkage disequilibrium, novel alleles, gene duplications, deletions and chromosomal interchanges and other structural genetic variations among the genomes of populations, varieties, species and related genera. Thus the big data enables breeders to perform effective genomic Selection. GWAS is increasingly used in major food crops as well as commercial crops. Eventually, this genome sequencing and resequencing approach needs to be extended to unsequenced crop genomes for exploitation of genetic variation existing in those under-researched crops, such as millets.

A relatively new but revolutionary technology, Gene Editing or Genome Editing, provides great opportunities for clean gene manipulation, gene integration and gene replacement. Genome editing essentially can be used to precisely introduce mutation within a gene at a specific nucleotide or a region, creation of novel alleles across the genome without leaving any leftover DNA or RNA or Protein of foreign origin. Thus the products of this method are not strictly transgenic as they do not carry any nonspecific DNA and absolutely indistinguishable molecularly, genetically and cytogenetically from their counterparts occurring in nature. However,

the process of editing does involve transgenic method and also use chimeric constructs, but the product, usually deletion lines, will not have any transgene or and foreign DNA fragment. Any locus on the chromosomes of any plant genome can be the target and modified in a variety of ways. Genome editing is a Game Changer Technology in the field of genetics and biology. Genome editing approach opens up unprecedented opportunities and also a few challenges for crop improvement at significantly lower cost, much lower than transgenic approach, to modify or introduce new genes.

Genome editing is, strictly speaking, not a standalone technology, but normally integrated into plant genetics and breeding programs. Particularly, genome editing, often assisted by NGS and whole genome sequencing and re-sequencing, lead to a set of different breeding technologies called as NEW BREEDING TECHNOLOGIES (NBT). These are diverse, powerful, simple, cost effective and applicable to a diverse array of crops such as food crops, feed crops, root crops, perennials etc. to improve desirable agronomic traits. The genome editing assisted NBT versions include Rreverse breeding, Cisgenic, Intragenics, ODM (oligonucltide DNA mutagenesis), RdDM (RNA dependant DNA Methylation), GEgrafts (root stocks), and Synthetic genes. It is widely believed that these technologies will be routinely used in the near future in crop improvement and the products will be in market once the Country Specific Regulatory Regimes are through with relevant modifications in their ACTs and rules governing the GE varieties and hybrids. It is only 150 years long journey (path of Genetics) that began with genes (factors then in 1865) empirically related to phenotype and now reached to the level of relating a single nucleotide to a specific phenotype.

Note: *The author followed a narrative approach in the above article tracking the growth of Genetics during the last 100 years which incidentally coincides with the 100th Anniversary of OSMANIA UNIVERSITY from where the author earned all the academic degrees.*

Biotechnological approaches for crop improvement

Ramesh V Sonti

The green revolution has helped our country achieve self-sufficiency in food production. However, yields have plateaued in recent years. The indiscriminate use of fertilizers and pesticides has led to serious environmental issues, development of resistance in pests and declining soil fertility. The availability of water for agriculture is decreasing as ground water levels have depleted and there is increasing demand for water for residential and industrial purposes. Prime agricultural land is being converted for residential and industrial purposes. Also, it appears that climate change is underway and is leading to more severe episodes of droughts and floods. Therefore, in the future, we will have to produce more on lesser available land with fewer inputs and our agriculture will have to be climate resilient.

The need of the hour is to breed newer varieties of crops that are high yielding and which are more resistant to pests, diseases and abiotic stresses. In this regard, biotechnological approaches offer great opportunities for achieving this objective. There are two major biotechnological approaches for crop improvement. These are called "Transgenesis" and "Marker Assisted Selection (MAS)".

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Transgenesis involves the isolation of DNA molecules containing the desired sequence of genetic information in a test tube and the introduction of this sequence into plant cells in such a manner that it is stably inherited and passed onto subsequent generations. The introduction of exogenous genetic material is often done through the agency of an intermediate bacterial strain called Agrobacterium which is proficient at transferring DNA into plant cells. Transgenic crops are also called GM (genetically Modified) crops. Marker assisted selection (MAS) is a very effective tool for crop improvement that involves use of variations in DNA sequences (called molecular markers) as flagposts to make selections of varieties that have new and advantageous combinations of genes. MAS is a variation of traditional plant breeding. It makes the process of developing plant varieties much more efficient and reduces the time required for development of such varieties. Each of these technologies have their own unique advantages and disadvantages.

The advantage of GM technology is that it allows the introduction of any genetic material into plant cells irrespective of whether it is derived from another plant, animal or microbial cell or is a synthetic molecule. The major disadvantage of GM technology is that, due to issues of biosafety, there are very elaborate, time consuming and costly regulatory processes that have to be cleared before the "GM"

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crop can be commercialized. This delays the process of commercialization of the GM crop. Furthermore, inspite of these elaborate protocols for assessing biosafety, lingering concerns persist in the public mind and affect acceptability of GM crops. The development of insect resistant GM cotton is a recent example of an application of GM technology that has been widely deployed in India and abroad.

The major advantage of MAS is that, as a variation of traditional plant breeding, there are no biosafety regulations that have to be considered before the MAS derived plant is released for commercial cultivation. This speeds up the process of commercialization of the newly developed plant variety. A major disadvantage of MAS is that the genes that can be introduced into a variety are limited to those that are within the crossable gene pool of the crop of interest. An additional disadvantage of MAS is that it is not as precise a tool and a number of other genes, besides the gene of interest, are transferred into the newly developed plant variety during the process of breeding. These co-transferred genes can, in certain cases, have a deleterious effect on crop performance. Inspite of these disadvantages, a number of plant varieties developed through MAS have been successfully released for commercial cultivation in recent years. The development of rice varieties that are resistant to the serious bacterial blight disease is a notable example of plant varieties developed through MAS that have been released for commercial cultivation in India.

Recent developments: Both GM and MAS technologies have been in use now for almost two decades. During recent years, new developments in genomics and post-genomics technologies are helping to further advance these applications. The major outcome of these new developments is that the advantages associated with MAS and GM technologies are being maximized and the disadvantages are being minimized.

The effectiveness of MAS is dependent on the number of molecular markers that are available for use in the crop of interest. The greater the number of markers, the more effective is the applicability of this tool for crop improvement. Recent advances in genome sciences (called next generation sequencing [NGS] methodologies) have greatly increased the number of crops for which molecular markers are available. Even for crops in which molecular markers had been previously available, the application of NGS technologies has greatly increased the numbers and types of molecular markers that are available. Furthermore, newer platforms have been developed that allow a large number of molecular markers to be scored in a relatively short time. The net effect of these technological changes is that they can greatly increase the efficiency with crop varieties with desired agronomic characters can be developed using MAS.

As indicated earlier, one of the disadvantages of MAS is that it can be used only for improvements of traits for which variation exists in the ‘crossable’ gene pool of the crop of interest. In order to

circumvent this difficulty, scientists have tried to marry the well known practise of mutation breeding with recent developments in NGS technologies to create new variation in the crop gene pool and develop molecular markers that will allow the newly developed variants to be used for crop improvement using MAS. An interesting recent example of this methodology is the development of a salt tolerant variant of a Japanese rice cultivar. This rice cultivar had been grown in areas of Japan that had been affected by salt water ingress caused by the tsunami which was triggered by the 2011 earthquake. Mutagenesis was used to develop a salt tolerant variant of the rice cultivar and NGS technology was used to develop a molecular marker that was used in MAS to develop a new salt tolerant variety that could be grown in soils that had been rendered saline by the tsunami.

A new and revolutionary technology called genome editing is being applied to develop new crop varieties with advantageous traits through introduction of precise genetic changes. Although it comes under the broad ambit of GM technologies, the advantage of genome editing is that no new gene is introduced into the newly developed crop variety. Moreover, the changes made in genome edited plants are akin to those in varieties developed through traditional plant breeding. Thus, although it comes under the category of GM technologies, genome editing should not evoke the safety concerns associated with GM technologies. Thus, crop varieties developed through genome editing should reach markets faster so that farmers and consumers can benefit from the new technology.

In conclusion, it is a great pleasure for me to contribute to this commemorative volume. The Department of genetics and the Centre for Plant Molecular Biology, Osmania University have made very significant contributions in the areas of plant biotechnology. I wish them continued success in the future. It is a matter of great happiness that Osmania University is celebrating the 100^{th} year of its establishment. Many great scholars have taught and conducted research in this august institution. In the second century of its existence, I wish the university all success as it marches forward with renewed vigour in the noble task of imparting knowledge to newer generations of students.

Genome editing and crop improvement

P. Ananda Kumar

Plant molecular biology has revolutionized agriculture by facilitating introduction of foreign genes into crop species and expressing novel traits such as pest resistance, disease resistance, quality improvement etc. Transgenic plants are usually developed relying upon the genetic transformation techniques mediated by *Agrobacterium tumefaciens*, particle bombardment, protoplast uptake of DNA etc., The transgene integration mediated by these techniques takes place at random sites in the plant genome. Development of techniques that mediate transfer and integration of foreign genes at specific pre-determined locations obviates many problems associated with existing methods of gene transfer. Introduction of foreign genes via gene targeting based on the technique of homologous recombination offers many advantages such as precision gene integration, single copy transgene insertion and high expression of the transgenes. The earliest attempts to carry out genome editing in plants exploited the phenomenon of homologous recombination and non-homologous end-joining. This requires nucleases that can create specific double-stranded break (DSB) at desired location in the genome.

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Zinc Finger Nucleases (ZFNs)

The development of Zinc Finger Nuclease (ZFN)-mediated gene targeting provided molecular biologists with the ability to site-specifically modify plant genomes via homology-directed repair of a targeted genomic double-stranded break (DSB). ZFNs can be used to induce DSBs in specific DNA sequences and thereby promote site-specific homologous recombination and targeted genomic manipulation. A site-specific zinc-finger endonuclease has been successfully employed to induce site-specific mutations by non-homologous end joining in *Arabidopsis* in 2005. Subsequently ZFNs were used to modify endogenous loci in plants of the crop species *Zea mays*. Insertional disruption of one target locus, *IPK1*, results in both herbicide tolerance and the expected alteration of the inositol phosphate profile in developing seeds. Herbicide-resistance mutations were introduced into *SuR* loci by ZFN-mediated gene targeting at frequencies exceeding 2% of transformed cells for mutations as far as 1.3 kilobases from the ZFN cleavage site.

Transcription Activator-Like Effector Nucleases (TALENs)

Transcription activator-like effectors (TALE) proteins were identified in plant pathogens of the *Xanthomonas* genus. These bacterial effectors are DNA binding proteins that recognize specific DNA sequences of host gene promoters and modulate their

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expression. These proteins are made up of repeats of DNA binding domains of 33-35 amino acids length. Each repeat recognizes a single base pair which is determined by two hypervariable residues typically found at positions 12 and 13 of the repeat, known as the repeat-variable di-residues (RVDs). The corresponding length of DNA sequence that is to be recognized dictates the number of repeats present in the TALE. The amino acid in 13th position directs the recognition of the DNA base and amino acid at 12th position aids in stabilization of the repeat structure. TALE repeat code was deciphered and engineered TALE repeat arrays with novel specificities were constructed. Since each repeat is specific to a single base, by combining number of repeats specific to a sequence and coupling it with a nuclease domain, any part of the genome can be cleaved. TALENs are rapidly becoming a tool of choice for genome engineering due to different advantages. TALENs could be designed to target almost any part of DNA and length of DNA that could be used is also greater than that of ZFNs leading to lesser off targets and greater specificity. Two FokI nuclease domains are fused together to create a single chain TALEN thereby decreasing the size and simplifying the design as well as construction of TALEN for the desired site. Homologous recombination (HR) pathway for DNA repair is generally preferred for genome editing instead of Non-Homologous End Joining method (NHEJ). One way of increasing the frequency of HR repair is to induce nicks instead of double stranded breaks. Following the deciphering of DNA binding code of TALE, it has been rapidly adopted for genome targeting in different eukaryotes including plants. The first successful application of TALENs for genome modification conferred resistance against blast disease in rice. An effector-binding element in the promoter region of OsSWEET14 gene was targeted. This region is required by the effectors of *Xanthomanos oryzae* to manipulate the gene expression and divert the cellular resources for its use. By deleting this region the effectors were not able to induce the expression of OsSWEET gene, conferring resistance against the bacteria. TALENs have been since used successfully to demonstrate their efficacy for genome editing in different plant species

Clustered Regularly Interspaced Short Palindromic Repeat (CRISPR)

A recent and novel mode of inducing double stranded breaks in DNA and thereby its application for genome editing was derived from the bacterial immune system. Clustered regularly interspaced short palindromic repeats and CRISPR-associated systems (Cas) impart adaptive immunity against foreign DNA like plasmids, bacteriophages and viruses through RNA interference like mechanism in bacteria. The CRISPR system constitutes, two RNA components that include a short complimentary stretch of nucleotides to the DNA that is to be recognized called as CRISPR RNA (crRNA) and a transactivating RNA (tsRNA) that is required to initiate a ribonucleoprotein complex with Cas9 nuclease, the protein component. Cas9 is a monomeric DNA nuclease that is made up of two nuclease domain, similar to HNH and RuvC nucleases and the nuclease is directed by crRNA and tsRNA to the intended target DNA sequence. The HNH

nuclease like domain cleaves the complementary DNA strand that is recognized by the crRNA while the RuvC nuclease like domain cleaves the non-complimentary strand resulting in a blunt cut in the target DNA. CRISPR system includes spacers, which are transcribed and processed into crRNA. This crRNA combines with tsRNA and guide the Cas9 nuclease to cleave the homologous double stranded DNA called as protospacers. Virtually any DNA sequence can be targeted by simply altering the sequence of crRNA and it could be combined with tsRNA into a single guide RNA (gRNA). This led to simplifying the system into two components and making it easy to adopt it for genome editing. The application of CRISPR for genome editing in plants was first established in Arabidopsis and tobacco. Thereafter, many groups demonstrated the applications of CRISPRs for genome editing.

Future Perspectives

The use of genome editing technologies has opened new avenues for crop improvement. Conventional breeding relies on the availability of allelic differences existing in the nature and is limited by the availability of the same. The relative ease with which the genome editing technologies are used for creating mutations in the DNA of interest can be used for accelerated breeding for novel traits. Altering the phytic acid content and increasing the nutritional quality in barley, imparting disease resistance against powdery mildew in wheat, conferring herbicide resistance to rice are some of the examples that exemplify the applications of genome editing technologies. Although, the potential applications of genome editing technologies are immense so are the associated challenges. The major technical challenge is decreasing the off target modifications in the DNA. Apart from this, efficient delivery methods and optimal expression of nucleases in plants are also needed for increasing the efficiency and their wide application.

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Legume genomics: A perspective

Mahendar Thudi, Rachit Saxena, Manish K Pandey and Rajeev K Varshney

Abstract

Legumes such as chickpea, pigeonpea and groundnut are among the most important crops grown in Asia and Sub-Saharan Africa. India is the major grower as well as consumer of all these legume crops. In fact, India is also the biggest importer of chickpea and pigeonpea. The productivity of these three legumes has been stagnant and unacceptably low for decades as they are grown in marginal environments. Cereals have been the major beneficiary of utilizing genomics approaches in breeding and the above mentioned legumes have started to catch up very recently with cereals and other crops in terms of genomic interventions in their breeding. For instance, last ten years have witnessed significant progress in the area of development and deployment of genomic tools in crop improvement programs. Better genotypes with enhanced levels of resistance to biotic and abiotic stress as well as higher yields have been designed and developed in all three legume crops. Advances in sequencing and phenotyping technologies are expected to see the optimization and deployment of some modern genomics-assisted breeding approaches such as genomic selection, early generation screening, genome editing etc. We believe that by integrating genomics in breeding, better seeds can be developed and those seeds coupled with appropriate agronomy and management practices can provide better produce in the farmer's fields.

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Introduction

Legumes belong to the family Leguminosae, with edible legumes being placed in the subfamily Papilionoideae. They play a vital role for food security and human health especially in developing countries besides maintaining soil health through biological nitrogen fixation. Legumes are often cultivated in a wide range of environments and soils. Based on cropping season, food legumes are broadly classified as (i) cool-season food legumes, comprised of chickpea (*Cicer arietinum*), pea (*Pisum sativum*), broad bean (*Vicia faba*) and lentil (*Lens culinaris*), (ii) temperate-season food legumes include common bean (*Phaseolus vulgaris*), runner bean (*Phaseolus multiflorus*), lima bean (*Phaseolus lunatus*), and hyacinth bean (*Lablab purpureus*), and (iii) warm-season food legumes include pigeonpea (*Cajanus cajan*), mung bean (*Vigna radiata*), black gram (*Vigna mungo*), adzuki bean (*Vigna angularis)*, cowpea (*Vigna unguiculata*), velvet bean (*Mucuna pruriens*) etc. Soybean (*Glycine max*) and groundnut (*Arachis hypogaea*), in most countries, are classified under oil seed crops as they are cultivated primarily for oil extraction.

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Proteinacious legumes along with cereals play vital role in supplying nutritious diets to the vegetarian families around the globe. However, as compared to cereals, the extent of progress made in research and yield enhancement in legumes is far below than the expectation. This is basically due to the fact that cereals were considered as staple food and as a result the nutritious food was ignored in the past. Moreover, global population is expected to reach 8.5 billion by 2030. Therefore the world food production must rise by 50 percent by 2030 to meet the ever increasing demand. Enhancing legume production in the same proportion seems to be a daunting task as legumes are frequently exposed to several abiotic and biotic stresses, and there is less public funding support and limited private sector attention for R&D of legumes (Varshney *et al.* 2016a). On the other hand, many legumes have enormous genetic potential to overcome the yield stagnation and can be transformed in to climate-smart varieties.

Achievements

In terms of research innovations, a number of success stories have become possible in cereals starting from Green Revolution in the second half of 20th century to the modern genomics-assisted breeding products such as Swarna-Sub1 (Septiningsih *et al.* 2009) in early 21st century. Realizing the importance of legumes, a few concerted efforts were initiated recently and reasonable progress has been made. In recent years, legume genomics has been focused on the development of resources such as molecular markers, genetic maps, transcriptomes etc. (Varshney *et al.* 2016). These resources have been used in enhancing our understanding on genetic control of various economically important traits and deploy them through genomics assisted breeding (GAB) (Pazhamala *et al.* 2016). With the advantage of next generation sequencing (NGS) the legume research is now catching up the pace with limited available resources. As a result of affordable NGS and available genomic resources, in the last decade major legume species have been sequenced and draft genome sequences have been assembled. For instance soybean (Schmutz *et al.* 2010), pigeonpea (Varshney *et al.* 2012), chickpea (Varshney *et al.* 2013a), mung bean (Kang et al. 2014), common bean (Schmutz *et al.* 2014), adzuki bean (Kang *et al.* 2015; Yang et al. 2015), groundnut (Bertioli *et al.* 2016, Chen *et al.* 2016), etc. are now equipped with the draft genome information. Accordingly, now there is a need to deploy the genome sequence information for crop improvement programs in respective legume species. In this direction, some efforts have been initiated in selected crops at different research organizations and universities.

ICRISAT, in collaboration with several partners, both at national and international levels, has been successful in developing and deploying genomic resources for enhancing the productivity of three most important legumes, *viz.,* chickpea, pigeonpea and groundnut, in arid and semiarid regions of the world (Varshney 2016). Besides unravelling the draft genomes in three legumes, several germplasm lines have also been

resequenced (Thudi *et al.* 2016a, b; Kumar *et al*. 2016). The generated genomics information has also been used in developing some superior lines/varieties. Using marker-assisted backcrossing (MABC) approach in chickpea, several improved lines for drought tolerance (Varshney *et al.* 2013b), *Fusarium* wilt and *Ascochyta* blight resistance have been developed (Varshney *et al.* 2014a). Three improved lines have been promoted for advanced varietal trials (AVT) from initial varietal trials (IVT) under All India Coordinated Research Project (AICRP) on chickpea. Similar efforts are also being carried out at Indian Agricultural Research Institute (IARI, New Delhi), Indian Institute of Pulse Research (IIPR, Kanpur) for developing drought tolerant lines in chickpea. In case of groundnut, several improved lines with enhanced resistance to foliar diseases like rust and late leaf-spot have been developed (Varshney *et al.* 2014b). Some of these lines have shown higher yields in multi-location trials conducted in India (Janila *et al.* 2016a). Similarly, using marker-assisted backcrossing, several lines with high Oleic acid/Linoleic acid ratio have been developed in groundnut (Janila *et al.* 2016b). Purity testing kits were developed for ensuring the purity of F_1 hybrids and parental lines, which is most important to realize the full production potential of pigeonpea. Furthermore, by using genomic-segment-introgression from wild species (*C. cajanifolius*, *C. acutifolius*, *C. scaraboides,* etc), some promising lines with enhanced resistance to sterility mosaic disease and higher yield have been developed in pigeonpea and are included in multi-location trials under AICRP-Pigeonpea in India.

Outlook

As mentioned above, the importance, bottlenecks in R&D, and recent developments in grain legumes, the time has come now to give due credit and support the legume research community as well as the farmers. Presently, this is visible in various developmental activities to enhance the legume production (Varshney *et al.* 2016). Hence, it is imperative to continue to invest in research with a long-term vision. There is a need to enhance the genetic gains made in legume breeding by focusing on factors like selection intensity, selection accuracy, genetic variance in the germplasm/breeding lines, heritability of the trait, besides management etc. Modernization of breeding by adopting genomic tools is the first step to enhance legume productivity in a systematic manner. Accordingly, research objectives should be redefined in consultation with the stakeholders. In short-term goals, genomics research should move in the direction of importing of easy assessable tools for making quick and accurate decisions for breeding. In the long-term, genomic selection approach should be deployed in other legumes as it has been done in the case of chickpea (Roorkiwal *et al.* 2016) and pea (Tayeh *et al.* 2015). On the other hand, early generation selection for desirable traits will reduce the time, efforts and resources invested in the development of improved lines/varieties (Varshney 2016). Most of the legume species are self-pollinating crops and thus suffer from low-level genetic diversity of

cultivated gene pools. Modern approaches such as multi-parent advanced-generation-intercross (MAGIC) populations and nested-association mapping (NAM) populations should be adopted for optimal utilization of genetic diversity. Moreover, efforts should also be directed towards utilization of genetic variation and useful traits available in many related wild species using introgression lines (ILs), backcross-inbred lines (BILs), chromosome-segment-substitution lines (CSSLs), etc. We visualize that in near future the use of NGS, early-generation screening, GS, genome editing, coupled with other advances, will revolutionize legume-breeding strategies which might pave way for the realization of their potential yield.

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Current status of genomics and genomic resources in select group of oilseed crops

M. Sujatha[1] and T. Papi Reddy[2]

Introduction

Recent advances in biotechnology have facilitated genetic improvement of major crops through transgenics and molecular marker-assisted breeding; however the commercial success has been restricted to a few crops like rice, cotton, canola, soybean, maize, etc. The last decade has witnessed a major change towards genomics and next generation sequencing (NGS) to have an understanding at the molecular level of the systems biology and functional biology. While genetics focuses on single genes and their interaction, genomics involves the study of the entire set of genes known as the genome which enables the study of the genotype and its relationship with the phenotype especially for complex traits. The NGS technologies as well as proteomics and metabolomics are useful to understand how the changes in the genotype lead to differences in the final phenotype. This article discusses the advances being made thus far in genomic technologies and resources, methods employed and the promise that these technologies hold for genetic enhancement of five oilseed crops, viz., sunflower, safflower, sesame, castor and jatropha.

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Sunflower

Sunflower (*Helianthus annuus* L.) belongs to the family Asteraceae with diploid chromosome number 2n=34. The sunflower genome database (https://sunflowergenome.org/) provides a reference genome for sunflower, and a number of other genomic resources, including high density genetic and physical maps, as well as transcriptome and sequence data for a diverse array of wild and cultivated genotypes. The sunflower genome is fairly large and complex with 3.5 to 3.6 billion bases, and is slightly larger than the human genome. A hybrid approach was employed for assembly of the sunflower genome, which combines whole-genome shotgun (WGS) sequencing and further enhanced by the whole genome profiling method of Keygene, Inc., thereby providing unique sequence-based markers for every 2-6 kb across the genome (Kane *et al*., 2011). The first complete mitochondrial genome sequence for sunflower was presented by Grassa *et al.* (2016) and serves as a prelude for characterization of the sterile cytoplasm variation in sunflower. The genomic, transcriptomic and proteomic tools were used for identification of candidate gene(s) during senescence, abiotic stresses (chilling, salinity, drought) and biotic stresses (*Sclerotinia sclerotiorum*, powdery mildew). Integrated analysis of transcriptional and metabolic profiles

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allowed the identification of distinct metabolic pathways leading to discovery of robust candidate genes and key metabolic pathways involved in the outbreak of the early senescence process in sunflower (Moschen *et al*., 2016). Transcriptional profiling of sunflower plants grown under low temperatures revealed an extensive down-regulation of gene expression associated with chilling sensitivity (Hewezi *et al*., 2006). Likewise, differentially expressed proteins and genes during drought (Fulda *et al*., 2011) and salt stress (Messaitfa *et al*., 2014) were identified employing the proteomics and transcriptomics approaches. Metabolomics studies revealed the mechanisms underlying genetic sources of resistance for necrotrophic interaction between *S. sclerotiorum* and sunflower (Peluffo *et al*., 2010).

Safflower

Safflower (*Carthamus tinctorius)*, belongs to Asteraceae with diploid chromosome number of 2n=24. The haploid genome size of safflower was estimated to be about 1.4 Gb. Bowers *et al*. (2016) produced a draft genome assembly of *C. tinctorius* covering 866 million bp (~two-thirds) of the genome after sequencing a single, short insert library to ~21 × depth. Sequence reads from the RILs of a cross between safflower (*C. tinctorius* L.) and its wild progenitor (*C. palaestinus* Eig) were mapped to this genome assembly to facilitate identification of 2,008,196 genetically located SNPs in 1178 unique positions. The complete chloroplast genome of safflower was reported to be 153,675 bp, which harboured 127 annotated genes, including 89 protein coding genes, 30 tRNA genes and 8 rRNA genes (Lu *et al*., 2016). The *de novo* transcriptome investigation of the unique transcripts provided candidate gene resources for studying oleosin-coding genes and for investigating genes related to flavonoid biosynthesis and metabolism in safflower (Li *et al*., 2012). Expression analysis of chalcone synthase, chalcone isomerase and anthocyanidin synthase, which are involved in safflower yellow pigment biosynthesis, was carried out by Liu *et al*. (2015). Cao *et al*. (2013) profiled the high oleic (HO) genotype S-317 of safflower for miRNA which resulted in the identification of 13 differentially expressed miRNAs between the HO and HL safflower genotypes. Thippeswamy *et al*. (2013) following subtractive hybridization identified safflower cultivar A-1 as a relatively drought tolerant genotype.

Sesame

Sesame (*Sesamum indicum* L.) is an annual herb belonging to family Pedaliaceae with diploid chromosome number of 2n =26. The Sesame Genome Working Group (SGWG) of China was formed with the objective to provide a fine map of *S. indicum* and coordinate the global genomic and functional genomic studies (http://www.sesamum.org). To facilitate functional and comparative genomic studies in sesame, a comprehensive database designated as Sinbase of the *S. indicum* genome was designed which includes genomic (369Mbp), genetic and comparative genomic data from sesame (Wang *et al*., 2015). Sinbase includes sequences of assembled sesame

pseudomolecular chromosomes, protein-coding genes (27,148), transposable elements (372,167) and non-coding RNAs (1,748) (http://ocri-genomics.org/Sinbase/). The chloroplast (cp) genome of *S. indicum* (GenBank acc no. JN637766) with 153,324 bp, having a pair of inverted repeat (IR) regions containing 25,141 bp each, was reported by Yi and Kim (2012). Specific length amplified fragment sequencing (SLAF-seq) was employed for large-scale *de novo* SNP discovery and genotyping to obtain sufficient markers to construct a high-density genetic map of sesame (Zhang *et al*., 2013). Transcriptome analysis of resistant and susceptible sesame varieties, viz., 'Yuzhi 11' and Rongxian black sesame (RXBS), inoculated with *Fusarium oxysporum* f. sp. *sesami* (Fos) pathogen, indicated that 'phenylpropanoid biosynthesis' plays a key role in sesame resistance following *Fos* inoculation (Wei *et al*., 2016). RNA-seq analysis was performed to identify differentially expressed genes during waterlogging stress (Wang *et al*., 2016), characterization of *AP2/ERF* genes and expression profiling of DREB subfamily and *hsf* genes under drought stress (Dossa *et al*., 2016).

Castor and Jatropha

Castor (*R. communis*) is a diploid species (2n= 20) which belongs to the monotypic genus *Ricinus* and family Euphorbiacea. Morphologically, the *Jatropha curcas* (2n=22) resembles *Ricinus* and represents a potentially valuable source of germplasm as they possess very interesting characteristics, such as drought resistance, photoperiod insensitivity, resistance to *Fusarial* wilt and castor semilooper besides desirable oil quality. The draft genomes for both castor and Jatropha are 320 Mb and 320.5 Mb, containing 31237 and 27172 predicted genes, respectively (Chan *et al*., 2010; Sato *et al*., 2011). Organelle genome sequencing, assembly and annotation in castor was carried out by Rivarola *et al*. (2011). The complete nucleotide sequence of *J. curcas* chloroplast genome (cpDNA) was determined by pyrosequencing and gaps filled by Sanger sequencing (Asif *et al*., 2010). Tan *et al*. (2016) analysed the transcript profiles in different sex types of castor during development from apical buds to inflorescences. Chandrasekaran *et al*. (2014) identified ABA-mediated regulatory changes towards storage filling in developing castor seeds through differential gene expression analysis using Illumina RNA-Sequencing technology. Differentially expressed genes under the influence of light demonstrated the photosynthetic efficiency of capsule walls and seed coat of castor (Zhang *et al*., 2016). Hu *et al*. (2016) studied the differences in plant productivity between a high-stalk variety and a dwarf variety combining proteomics with agronomic and physiological analyses. High-throughput sequencing of digital-gene-expression profiles (DGEs) displayed diverse expression patterns for understanding the function of *AP2/ERF* gene (Xu *et al*., 2013).

It is evident from the available information that insightful studies have been made to develop genomic resources and NGS technologies which might pave way for achieving quantum leaps in improving different oil seed crops.

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Future biological research: A genomics perspective

Kandasamy Ulaganathan

With the sequencing of first bacterial genome, *Hemophilus influenza* in 1995(Fleischmann *et al*., 1995) followed by human (Lander *et al*., 2001; Venter *et al.,* 2001), *Arabidopsis* and rice genomes (Goff *et al.*, 2002), research in Biology has entered the high throughput genomics era. These and subsequent sequencing of many bacterial species and a few eukaryotes for the first time helped to understand what makes a bacteria, fungi, plant, animal and human in terms of number of genes and their functions.

Human genome project served as the catalyst for development of technologies like automated DNA sequencing, microarray based transcript profiling, next generation sequencing, whole transcriptome sequencing, small RNA sequencing and developments of parallel bioinformatics methods for high throughput analysis and interpretation of genomic data.

One of the greatest developments in this regard is the development of holistic approaches in biology which was lacking until then and biology used to be a reductionist Science where the focus was on one gene/protein/metabolite at a time.

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Microarrays are one such holistic methods, which for the first time revealed the dimension of traits in terms of number of genes associated and number of genes expressed at a given location and time. Microarrays enabled scaling up of experiments from one gene at a time to study of all genes of an organism in a single experiment under identical conditions. Actually microarrays identify the transcripts and measure their quantity at organism or trait level indirectly by hybridizing them to genes or oligonucleotides representing them. This wonderful technology is now replaced by RNAseq analysis, a direct method of identification and quantification of transcripts by completely sequencing the transcriptomes. RNAseq analysis not only identifies transcripts and quantifies them but also profile the transcript diversity in the form of mRNA variability, small and non-coding RNA species and RNA-DNA differences.

The early part of the genomic era focused on understanding organisms at species level by inter species comparison of genomes. For example how much relationship exists between different kingdoms; how much relationship is there among/within various species. Although we understood a lot about different organisms at species level, which is not sufficient for improving them as individuals of each species show extensive variation. At that time it was not economically possible to apply genomic methods at

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individual level, so the research was focused on developing reference genomes in each species and use the reference genome to map the variations among members of the species. As the fast changing technological advancements in sequencing in the form of next generation sequencing resulted in reducing the cost of sequencing, it is high time genomic research is focused on intra species i.e. inter individual comparisons. Isolated efforts have been made in this regard by some groups but there is no organized effort by various scientific groups in this regard. The national and International funding agencies and research planners should make efforts to orient the genomic research in this direction.

Our group at the Centre for Plant Molecular Biology, Osmania University is making one such effort to develop genomic resources for understanding the elite indica rice cultivar RP Bio-226. We sequenced the nuclear, mitochondrial and chloroplast genomes of this cultivar first (Reddy and Ulaganathan, 2015; 2016) and are in the process of profiling mRNA, long non-coding RNA and micro RNAs of this cultivar in response to nitrogen nutrition (Reddy and Ulaganathan, 2016; 2017). We have profiled alternate splicing and RNA editing of nuclear and organellar transcripts for understanding the differences in RNA and DNA. Further, we have profiled the endophytic bacteria colonizing this cultivar and sequenced four of the endophytes colonizing this cultivar (Latha *et al.*, 2017a, b). Developing genomic resources for individual genotypes of various species will help us understand them by comparing to other individuals differing in the trait of interest. In future, the genomic research will be not only focussing on understanding individual genotypes of species but also on studying intra-individual temporal and spatial variation in gene expression, and correlate them with the genotype of the individual. Sweeping changes have started to arrive in plant and animal breeding research in which sequencing of whole genomes and transcriptomes of large mapping populations is performed. Laboratory work based genotyping is being replaced by computational genotyping due to the availability of genome sequence of the mapping populations which will speed up the process of breeding (Gao *et al.*, 2013; Li *et al.*, 2015).

Recent high throughput genomic research work in multiple organisms have shown that there is a substantial difference between the genome of an organism and its transcriptome which is due to alternate splicing, alternate promoters, alternate poly A sites, microRNAs, long non-coding RNAs and editing of messenger RNA, micro RNA and their binding sites, and long non-coding RNA and their binding sites. For example, it has been found that close to 100 million sites are edited at RNA level in humans which shows that apart from genome, methylation based epigenetic regulation, RNA –DNA differences play crucial role in determining the eukaryotic complexity and differences among individuals of a species (Ulbricht and Emeson, 2014).

The developments in next generation sequencing technology is changing the way the high throughput genomic research is

done. In the pre-NGS era, researchers used to spend close to 90 % of the time in generating data and spend about 10 % of their time in analyzing and interpreting the data using computational tools. In the NGS era, due to the cost reduction and simplicity, huge data is generated every day on each organism / trait and are made available for free, thanks to the insistence of Scientific Journals. So, in future, a researcher starting a research in any organism or trait actually starts with voluminous raw genomic data available for free that can be analyzed using bioinformatics tools and predictions can be made before starting lab work to confirm the prediction. In addition to starting with the huge data already available, researchers can generate huge genomic data in very short time i.e. within months. Moreover, this data generation has moved out of the researcher's lab to industry to whom raw data generation is out sourced. Hence, the role of researcher will be restricted to planning the work by doing analysis of already available data, outsourcing additional data generation and substantial time will be spent on analyzing the generated data and interpreting them.

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The changing face of plant biology: Future perspectives

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Plants are an important group of living organisms and are the major sources of food, fodder, energy and medicine. Plants mitigate the problems of pollution and ameliorate carbon foot-print. Plant science research has advanced from mere morphology of the system to the more intricate molecular mechanisms of different life's phenomena. This has been possible due to the advancements in many technologies, including optics and electronics. The primary aim of this article is to identify how technologies have transformed plant sciences and help us to address the myriad challenges in plant science research during the next few years.

Structural elucidation of DNA and how it is transcribed into RNA and later translated into important molecules such as proteins to perform diverse functions in a plant's life are certainly the key discoveries. Such great molecular discoveries would not have been unraveled without the advancement in technologies like x-ray diffraction and others. The discovery of complex photosynthetic mechanisms, primary and secondary metabolic pathways, and plant development needed the use of labelled isotopes.

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Postulation of chemiosmotic hypothesis by Mitchell facilitated the understanding of the generation of ATP during oxidative phosphorylation in mitochondria and during light reaction in chloroplasts. Identification of TaqDNA polymerase and its use in PCR technology has revolutionized many aspects of molecular biology. From Maxam and Gilbert's technique of manual DNA sequencing, we moved to automated DNA or next generation sequencing (NGS) and RNA seq technologies using different platforms which have helped us to a large extent in the exploration of genomic information. Whole plant genomes are being sequenced alongside organellar genomes in a day and subsequently annotated. This massive information is central for our understanding of plant biology and crop plant productivity. Breakthroughs in PCR and cloning technologies have certainly aided plant biologists to isolate genes and to make constructs using Gateway and other vectors. Despite this, plant biologist still face daunting tasks to clone individual genes due to the existence of big gene families and their close sequence homologies. RNA interference (RNAi) and CRISPR-Cas9 technologies are being used to manipulate genes or edit the crop plant genomes that are paving the way to develop designer plants. High-throughput quantitative real time-PCR (qRT-PCR) and Fluidigm's microfluidic expression of genes at the transcription level have increased our breadth and depth of understanding about their tissue-specific expressions. But

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such technologies are being replaced by micro arrays or tilling arrays. Further, fluorescence-activated cell sorting and affinity-purifying ribosome-associated RNAs using translatome-based methods are being exploited widely. Application of robotic systems in protein-protein interaction studies especially in the yeast two-hybrid systems has become wide spread. Many labs have been utilizing microfluidic chip for high-throughput analysis of protein or molecular interactions by utilizing plasmon resonance energy imaging. Wide-spread use of mass spectrometry technologies for peptide finger printing and amino acid sequencing of different peptides is a reality now. Technologies such as synchrotron microfocus, nano gravimetry and atomic force microscopy have enabled us to prepare miniscule crystals of proteins which is otherwise not possible. Artificial neural networks are now being deployed in tissue imaging. Near Infra-Red Fourier Transform Raman Spectroscopy has been found to have many applications in plant biology today including taxonomy in a non-destructive way. Several biosensor technologies are being utilized in agriculture and food industry to detect the infections.

Technologies such as T-DNA insertion lines mostly in model plants has enabled the use of reverse genetics and the understanding of altered plant phenotypes. Creation of high-throughput platforms for phenotyping of crops using robotic-assisted imaging and computer vision-assisted analytical tools are helping to measure plant-centric traits such as growth and architecture. Targeted induced local lesions in genomes (TILLING) has become a valuable tool to the plant geneticists for development of mutations in plants. Oligonucleotide-directed mutagenesis is increasing the speed and precision with which biological functions of cells can be dramatically changed. Approaches to develop quantitative trait locus (QTL) mapping has been successfully utilized in select crop plants for enhancing their productivity. However, association mapping studies are greatly helping the plant biologists in improving plant productivity. The discovery of fluorescent proteins and their tagging to the genes has been a great boon to probe the cellular location of the proteins. Forster resonance energy transfer (FRET) technology is being used frequently now that can help analyzing the phosphorylation state of a protein domain.

Types of technologies that are needed for the future of plant biology

The existing molecular techniques coupled with spectroscopy and microscopy and computer software tools have been helping us to a great extent to understand the plant traits better. However, many techniques that are being used in yeast, animal or human biology are not being adapted/deployed in plant science research. For instance, still we do not have techniques where either single or multiple genes can be replaced at will in a specific tissue or organ of a plant. Also, no tools are available for large scale genomic engineering. Much work has been carried out to prove totipotency of plant cells, but still we do not have technologies to generate plants from any given tissue or cells *in vitro*. The concept of totipotency has been evading us and we wonder if it is

ever possible to generate any plant organ or a tissue from a given plant cell type. We need to develop technologies that help us to grow only pollen grains or only mesophyll cells at will in isolation to understand them better. We also do not have techniques today where crystal structures of large number of plant proteins, visualizing their three-dimensional structures and also tissue localizations of diverse proteins. Further, it would be desirable to create technologies where imaging of crop plants is possible so as to enable us to understand their field performance. Ever since the discovery of a hand-held microscope by van Leeuwenhoek, dramatic improvements have taken place in developing methods for better resolution of cell and tissue images. Besides confocal laser microscopy, different types of electron microscopes like TEM and SEM, atomic force microscopy, photoactivated localization microscopy (PALM), stochastic optical reconstruction microscopy (STORM) are being utilized with remarkable high resolution and precision both in time and space. While 3D imaging of live cells and tissues is possible to obtain high resolution images, efforts are underway now to prepare 4D images in order to overcome the limitations of 3D imaging. Both optical tomography and array tomography are being exploited to find out the molecular architecture of tissues in three dimensions especially large plant specimens.

Electronics and bioinformatics

The discovery of chips used in making modern computers is revolutionizing the world of plant biology. Without such computers, it would not have been possible to store massive molecular data generated over the years from the genome sequencing projects world over. However, we still need to develop super computers or cyber infrastructure that can handle gigabytes or terabytes of data sets, better tools that can help us to annotate genes and proteins in a shorter time with high accuracy. Existing tools or algorithms of bioinformatics are not good enough to annotate and mine the data from databases, and hence there is a need to develop novel approaches/ways and analyze the big data to extract the meaningful biological information from them.

Synthetic biology

The regulatory gene and protein networks are certainly helping to understand different life's processes. However, it is a long way before we create a crop plant that is sustainable in the wake of climate change. Artificial chromosomes are being developed now but we need to understand about the type of synthetic genes to be inserted into the chromosomes and how to switch on and off these genes temporally and spatially.

Areas that need to be addressed

Following are some of the problems that plant biologists are not able to solve at the moment but like to address them in future without destroying the environment. For the ever-growing population, there is a need to improve both quantity and quality of our food grain production, keeping in view of the limited land and water resources available, in the wake of global warming and with minimal environmental impact. At the same time, plant

biodiversity should be preserved and utilized to achieve this goal. We still do not have a comprehensive understanding of crop epigenetic processes that can aid us to grow crops in varied environments. Despite a long-history of plant genetics, genotype-to-phenotype association mapping is still limited due to their immense genomic space and confounding effects of environmental factors. Marker-assisted selection especially single nucleotide polymorphic (SNP) markers and their genome-wide association with metabolic traits should provide novel insights about the metabolic pathways essential for plant growth and development. Unravelling the complex network structure and identifying its key components will provide effective targets for engineering crops adaptable to changing climate. It is critical for us to cross the estimated yield barriers and to identify barriers that prevent us from achieving higher productivity in crop plants. It is vital for plant biologists to think about amelioration of global warming, reduction of carbon foot-print and improvement in urban environment. Therefore, we need to convert C_3 plants into C_4 or CAM, optimize photosynthetic efficiency and make them more climate resilient with improved yields. Associated with photosynthesis, we also have a problem of energy crisis. We need to get sustainable bioenergy resources from algae and higher plants that can capture CO_2 better in arid, semi-arid and temperate regions and produce more biofuels per unit area and time. Another aspect that we need to focus is conversion of non-symbiotic crops into symbiotic that can fix atmospheric nitrogen effectively. Mycorrhizal associations have been limited so far to few plants, but we need to make these associations possible in all the food crops and improve food grain production and ecosystem health.

Besides short rotation seasonal crops, we have horticultural crops that take few years to bear flowers and fruits. Hence, it is essential to reduce this gap, but without compromising yields and the phenotypic characters. The role of millions of short RNAs in crop productivity is not completely known especially under multiple environmental stress and disease conditions which needs to be addressed in future. We also need to use plant wealth and their bioactive compounds for the well-being of humans and animals. Different complex biosynthetic pathways, and enzymes associated with medicinally important biocompound production need to be addressed in order to enhance their accumulation. To solve some of these challenges that we face today, and to achieve the aforesaid goals, it is vital for us to develop newer technologies in future and deploy them optimally.

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Indian seed industry – Opportunities and challenges

P. Sateesh Kumar

Indian agriculture is one of the most diversified in the world and supports a 1.27 billion culturally diversified population living in the country. The Indian seed industry plays a vital role in supporting Indian agriculture to meet the needs of the fast growing and economically advancing population. Seed is the most vital component of agriculture and it is directly responsible for the efficacy and effectiveness of other inputs used in agriculture. It is estimated that the contribution of quality seed to the total agricultural production is about 15 – 20% and along with other inputs it contributes between 25-40%.

The Indian seed industry, at present, is estimated to be doing an annual turnover of about Rs. 20,000 crores (~ USD 3 billion), whereas the global seed business is estimated to be at Rs. 3 lakh crores (USD 50 billion). However, the compound annual growth rate (CAGR) of Indian seed sector is 10% as compared to global CAGR of 3%.

Apart from opportunities for the growth of the domestic seed sector, India has the potential to be a global regional hub for seed production, especially looking at the agro climatic congeniality that exist for quality seed production in several of Indian states, especially Telangana, AP, Gujarat, Maharashtra and Karnataka.

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India has the potential to meet the seed demands of various countries in the regions of South Asia, South East Asia and Africa which have overlapping agro climatic conditions with India.

The new policy on Seed Development, 1988 followed by the liberalization reforms in 1991, laid the foundation for the development of a vibrant seed industry in India. This was followed by National seed policy in 2002. An enabling public sector, rapid growth of hybrid seed segment, entry of multinationals, phenomenal rise of homegrown seed companies, rapid adoption of high value improved hybrid seeds and introduction of transgenic traits like Bt Cotton can all be considered as clear outcomes reflecting the impact of the progressive policy decisions.

All the above developments took place within the framework of the Seeds Act 1966, which governs the seed trade and overall seed industry in India. However seed industry is also influenced by various other acts and legislations like Seed Control order 1983, Plant variety protection and Farmers rights act, 2002, Biodiversity Act 2002, etc. The Seed Bill 2004 is yet to be legislated and has been devised to bring in a systematic process for quality assurance in Indian seed industry. Indian seed industry is poised to grow in the future based on the strong foundation laid during the past 3 decades with significant contribution from both private and public sector.

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The key drivers for growth of Indian seed industry in future are as follows.

- Diverse agro-climatic conditions comprising tropical, sub-tropical & temperate climates at different levels of humidity and temperatures, providing congenial atmosphere to develop improved seeds for all important food grains, commercial crops and vegetables.
- Extensive national agricultural research system comprising ICAR and SAUs and an equally vibrant private sector R&D and technology development system contributing to skilled and trained manpower in plant breeding, seed technology, agronomy, biotechnology, engineering, information technology, etc. including postgraduates and Ph.D.s.
- Supportive Government policy and regulatory environment for creation of a vibrant seed sector and a huge unmet demand for quality seed.

However the seed industry has to navigate through several challenges to achieve its potential and the following are the key challenges.

- Increasing labour costs and challenges of labour availability due to urban migration.
- Tussle between market mechanisms for determination of seed price and Government regulation.
- Delay in rollout of quality standard testing mechanisms for improving competitiveness of Indian seed exports.
- Slow pace of farm mechanization.
- High entry barriers for access of advanced GM/GE technologies and traits for small and medium seed companies.

With an excellent opportunity to grow by catering to the need of domestic markets, apart from opportunities beyond our borders, the Indian seed industry will grow at an exponential rate if the challenges are addressed collaboratively by all stakeholders. The following would be key drivers of growth of the Indian seed industry in the near future.

- Increase in seed replacement rates for high yielding varieties.
- Adoption of superior agronomic practices, farm mechanization, precision farming and modern irrigation techniques will be vital engines for overall improvement of farm productivity.
- High growth oriented vegetable seed industry integrated with food processing value chains.
- Increased adoption of corn and rice hybrids will be the key growth areas, with introgression of new traits by both breeding and molecular marker based tools.
- Increased adoption of GM traits and technology.
- Biological inoculants and growth promoter fortified seeds.

In spite of challenges confronting the seed industry, the potential for growth and possibilities for realization of the potential look promising for Indian seed industry.

Public-private partnership in agricultural biotechnology

Gurdev S. Khush*

Scientific advances in plant breeding led to "green revolution" regarded as the most important agricultural achievement of humankind. This revolution targeted staple cereal crops particularly rice and wheat with staggering results. Food grain production in India doubled in a short span of 25 years between 1970 and 1995. The credit for this achievement goes to Indian scientists and policy makers. While we should be proud of these achievements, we should not become complacent. Our population is increasing at the rate of 1.9% per year and we are adding 19 to 20 million new mouths to feed every year. Moreover, as the living standards of our people improve, they shift from low value to high value foods such as eggs, milk and meat. To meet this demand, more cereals are needed as livestock feed. It takes 2, 4 and 8 kilograms of grain to produce 1 kg of poultry, pork and beef, respectively. This increase in demand for livestock products implies increased demand for cereal grains as livestock feed. According to various estimates, we will have to increase food grain production by 50% in 2030 when our population is likely to stabilize.

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Compounding this food grain production scenario is the realization that additional food grains will have to be produced from less land, with less water, less labor and less chemicals without degrading the fragile resource base. Agricultural research and technological improvements will continue to be a pre-requisite for increasing crop productivity. Major emphasis will continue to be on development of crop varieties with higher yield potential, durable resistance to diseases and insect, tolerance to abiotic stresses, and more nutritious grains. Time tested methods of classical breeding such as hybridization and selection, ideotype breeding and hybrid variety development will continue to be used but tools of biotechnology will play increasingly important role in crop improvement. Amongst the frontier technologies for crop improvement, molecular marker aided selection and genetic engineering have captured the imagination of crop scientists and policy makers alike. Construction of dense molecular genetic maps of major food crops has ushered in the era of molecular markers which are being employed for moving genes form one varietal background to the other and for pyramiding several genes for the same trait such as disease and insect resistance through molecular marker aided selection (MAS). Genetic engineering or recombinant DNA technology has offered exciting opportunities to introduce cloned genes from unrelated sources into crop varieties for increasing yield potential,

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disease and insect resistance, tolerance to abiotic stresses and for introducing novel grain quality traits.

The immediate potential benefits from the use of biotechnology tools include; (1) increased food supply for consumption, (2) increased farm input for cash, (3) reduced cost per unit of output, (4) employment generation for food processing , (5) growth of non-farm local economies , and (6) poverty alleviation, particularly for rural poor.

Status of biotechnology in developing countries

Biotechnology research is currently being carried out in private as well as public organizations broadly divided into five categories.

1. Large global private sector companies such as Monsanto, Syngenta, Bayer, and Du Pont, etc.

2. Public sector research organizations in national agricultural research systems (NARS) including universities.

3. The International Agricultural Research Centers (IARCs) of the Consultative Group on International agricultural Research (CGIAR).

4. Public research organizations including universities in industrialized countries.

5. Various other international initiatives funded by donors and non-profit foundations of industrialized countries.

There is little doubt that globally, the private sector is the major player in biotechnology research. According to one estimate, the major life science companies invested some US$2.6 billion in agricultural research and development in 1998. Only a small proportion of this private R&D is directed at developing countries, most of this occurring through direct investment by the global life science companies through alliances between local and global companies.

The public sector finances around 90% of total agricultural research in developing countries. Compared to about 50% in industrialized countries.

There is huge diversity among NARS in developing countries with respect to their capacity in agricultural biotechnology R and D. Byerlie and Fischer have divided the developing country NARS into three groups according to their biotechnology research capacity.

- Type 1 NARS have strong capacity in molecular biology to develop new tools and products for their own specific needs. India, China, Mexico and Brazil are in this category.

- Type 2 NARS have considerable capacity to borrow and apply molecular tools e.g. molecular markers and transformation. Thailand, Philippines, Indonesia,

Colombia, Argentina and Kenya fall into this category.

- Type 3 NARS have a very fragile capacity to borrow and apply molecular tools developed elsewhere. Several NARS in Asia (Laos, Cambodia, and Myanmar) and most in Africa fall into his category.

Type 1 and 2 NARS have instituted a regulatory framework for the testing of transgenic crops and for protecting intellectual property (IP). Most type 3 NARS have no regulatory framework in place even to import and test transgenic products.

Accessing proprietary technologies

Several mechanisms for accessing proprietary technologies by the public sector from the private sector and sometimes other public sector organizations are available. These include business and legal options to gain access to proprietary technologies such as confidential agreements, material transfer agreements, licensing, purchase, and joint ventures. Up to now, there is limited experience in developing countries with these various types of agreements. Some of the options are as follows:

Unilaterally accessing technologies

One option for the public sector is to unilaterally access a tool or technology, especially those technologies that can be easily copied such as a specific gene from a transgenic variety without seeking permission of the owner. This is legal if the patent for the technology has not been lodged in the country where the technology is to be used and if the product is not exported to a country, where there is a protection on the invention. This is most likely to be the case with type 3 NARS. However, many critical tools and products of biotechnology have been widely patented in many countries especially in type 1 and type 2 NARS.

A recent review of the proprietary technologies for golden rice illustrates the patterns of protection. There were 44 potential patents related to this rice in USA but the number of patents in different relevant countries varies form none to 11. All type 1 NARS would face restriction, but there is no clear relationship between the number of potential patents and importance of rice and strength of public sector research programs. For example, no patents have been taken out or filed in Thailand, a type 2 NAR, while patents have been taken out or filed for several of the technology components in countries with little capacity in biotechnology (e.g. in some African countries).

Purchasing the technology

Proprietary technologies can be bought by the public sector for use in developing countries. For example, a consortium of public-sector institutes in Asia led by the International Rice Research Institute (IRRI) purchased the right to *Bt* gene owned by Planttech, a Japanese company. The consortium then decides whether to make the materials public property or allow others to use the technology, subject to

royalty payment. There are over 50 instances where Latin American NARS have purchased proprietary biotechnology tools and products.

A variant of this approach would be to contract with the private sector, through competitive bidding, to develop a specific tool, but with public sector retaining ownership of the product. This is most appropriate where the expertise exists in the private sector to adapt a product to a specific situation with considerable certainty.

Material transfer and licensing agreements

Material transfer agreements (MTAs) are often used to define conditions for the transfer of research materials and tools for use in research only, leaving the need to develop a license for commercial use of final technologies to a later stage. Public research organizations favor MTAs that define "front-end decision" about priorities and resource contributions. Upfront costs are minimal and risks are reduced because the negotiation for the use value occurs after the values of the product, if any, is known. However, this practice can also weaken the negotiation position of licensing for the use phase, since the greater the success of the research the greater the value of the technology and therefore the greater the expectation of the return by the owner. In some cases, the flow of research products to users has slowed after considerable investment in product development because of the failure to reach agreement about the commercialization and royalty sharing.

Opportunities for public-private partnership

There is no denying the act that public sector is in a unique position to play a key role in biotechnology R and D in developing countries, but working alone public sector will make a slow progress. Therefore, public-private partnership is highly desirable for the developing countries to harness the benefits of biotechnology. There is no greater incentive for collaboration between the public sector in agricultural research than the enormous challenge posed by global food security. A large investment of the private sector in biotechnology has clearly demonstrated the need for and significant advantage associated with collaboration between the public and private sector in agriculture.

The public sector organizations invest in agricultural research to maximize societal benefits and private firms need to earn profits in order to give good returns to their shareholders. Both public and private sectors have complementary assets, which are a magnet for collaboration. Public sector assets include germplasm, evaluation networks, expertise in breeding, familiarity with local growing conditions and access to seed delivery system, relationships with extension organizations and in case of International Agricultural Research Centers, reputation and goodwill they enjoy with NARS. Global life science companies have assets in the form of biotechnology tools, genes, promoters, markers, technical knowhow, financial resources, and skills in dealing with regularity agencies.

The goal of partnerships is not to transform public sector institutions into private companies. The private sector is unlikely to replace the role of the public sector in research or in facilitating broad applications of biotechnology in developing countries. Rather the role of the public sector will remain vital, as the private sector is unlikely to deliver biotechnology applications for many crops grown by the poor farmers and orphan crops and to address all biotic and abiotic production constraints important in developing countries. It is the responsibility of public sector to fill these gaps. Moreover, the public sector will continue to provide a critical role in addressing broad policy issues, and guiding programs that optimize public benefits from technological innovations in agriculture.

Some examples of public private sector partnerships

There are several successful examples of public-private partnerships that have facilitated access to biotechnology and development of improved crop varieties for developing countries. Such partnerships have been brokered by nonprofit organizations with a mandate to help the transfer of technologies to developing countries.

Components of such partnerships include: (1) outright donation of technology by private firms to national public research institutions, (2) institution capacity building in biotechnology tools, regulatory procedures and IPR, and (3) information and knowledge sharing. In some partnerships, donors of technology also benefit.

Collaboration for resistance to insects in corn

Potentially novel strains of *Bacillus thuringiensis* (BT) were characterized by the Agricultural Genetic Engineering Institute (AGERI) in Egypt in collaboration with US-based Pioneer Hi_Bred company. *Bt* gene isolated from these strains was introduced into locally adapted varieties of corn to develop insect resistance in those varieties. The collaboration involved training of AGERI scientists for characterizing BT and maize transformation, while Pioneer was granted access to evaluate novel BT proteins and genes patented by AGERI. The project was brokered and supported by the Agricultural Biotechnology Support Program (ABSP) of the US Agency for International Development (USAID) based at the Michigan State University, USA. A particularly significant aspect of the collaboration was that the ownership of IPR related to these Bt strains belonged to public sector (AGERI) and was made available to Pioneer under the term of a contractual agreement. AGERI is pursuing commercialization of BT maize varieties in Egypt while Pioneer used the license in USA.

In Indonesia, ABSP supported collaboration between ICI seeds (now Syngenta) and the Central Research Institute for Food Crops (CRIFC). The focus of the project was development of tropical maize varieties resistant to Asian corn borer. It included training of CRIFC scientist in the use of

transformation technologies. The experience of ABSP highlighted the challenges faced by public-private sector partnerships. The most significant constraint encountered was related to IPR, due both to lack of awareness and management capacity in public institutions, as well as differences in the extent of IPR protection provided by national laws. Despite capacity building efforts to address this issue, due to absence of IPR protection, the CRIFC/ICI project ran into difficulties at the stage of negotiating technology transfer agreement and the project between CRIFC and ICI could not be implemented. Many of the public sector research institutions in developing country NARS especially in types 2 and 3 NARS are not well versed in negotiating with public sector. Moreover, companies are not used to slow bureaucratic process and government requirements. Type I NARS have developed sufficient capacity in handling IPR and Type 2 and 3 NARs should enhance their capacity in this vital area if they have to benefit from public-private partnership.

Papaya biotechnology network

The importance of papaya in developing countries in terms of daily consumption is next only to bananas in Southeast Asia. Unfortunately, papaya is affected by several diseases and pests, the most important and widespread of which is ringspot virus (PRSV), which drastically reduces papaya yields and has a devastating effect upon the livelihood of subsistence farmers.

International Service for the Acquisition of Agri-Biotech Applications (ISAAA) developed and brokered a project with support from both the public and private sectors to develop ringspot resistant papayas. Monsanto and scientists of the University of Hawaii are now collaborating with the network to develop PRSV-resistant papaya, while the former Zeneca Plant Science (now Syngenta) and the University of Nottingham are sharing their technology and expertise to develop delayed ripening papaya. The network includes national scientists from Indonesia, Malaysia, Philippines, Thailand and Vietnam. The program seeks to enhance income, food production, nutrition and productivity for resource poor farmers. As a part of the project, scientists from the five countries have been trained in transformation technology, biosafety, food safety and IPR management through workshops, courses and internships. Malaysia has made good progress in terms of the development of delayed ripening papaya and is conducting its first contained field trial. Thailand has already developed and field-tested several promising PRSV-resistant papayas. However, bureaucratic processes and stringent government requirements for biotechnology work, especially for field testing, have consistently delayed progress of the network. Other problems include a lack of skilled personnel and national capacity and chronic inadequacy in public sector research funding in developing county partners.

Virus resistant sweet potato in Kenya

Sweet potato is an important food security crop in Africa especially during the maize crop failure. It yields higher amounts of food energy and micronutrients per unit area than any other crop. The production of sweet potato is however constrained by a number of factors, in particular the disease, caused by sweet potato feathery mottle virus (SPFMV). It may cause up to 80% yield loss in susceptible varieties in many parts of Africa.

In 1991, ISAAA developed and financially brokered a research partnership for developing SPFMV resistant sweet potato through biotechnological approaches. The initial partnership involved the Kenya Agricultural Research Institute (KARI), Monsanto, USAID's ABSP and the Mid American Consortium. Monsanto donated through a royalty free license, virus resistance technology for application to sweet potato. Through this partnership, genetically modified (GM) SPFMV-resistant sweet potatoes have been developed using Kenyan varieties. Besides, several Kenyan scientists have been trained both in the USA and in Kenya on various aspects of transformation, the establishment of biosafety structures, preparation and submission of biosafety permit application, laboratory and field evaluation of GM crops, IPR protection and technology transfer mechanisms. The GM sweet potatoes are now being tested on station trials in four KARI centers in Kenya.

Super sorghum

Sorghum is the dietary staple for more than half billion people. It is the sixth most widely planted crop in the world grown on 40 million hectares and currently produces 60 million tons grain each year. It is the staple food in many African countries. It is low in protein quality due to its low content of essential amino acids such as lysine. The reliance on sorghum as dietary staple results in problems associated with malnutrition especially in children. In view of its importance in meeting nutritional needs of millions of people and limitations of breeding to develop nutritionally fortified varieties using conventional methods, modern genetic engineering techniques have to be utilized to develop biofortified sorghum cultivars that are high yielding, rich in essential amino acids and acceptable to farmers and consumers. Africa Bofortified Sorghum (ABS) project aims to accomplish that. Project consortium is a needs driven, Africa initiative and it brings together nine globally respected institutions.

Africa Agricultural Technology Foundation (AATF) is the lead agency. Included in the consortium are public institutions as well as a private company. ICRISAT a CGIAR institute is providing germplasm and transformation technology. Pioneer DuPont has donated intellectual property rights, materials and expertise for creating sorghum with improved nutritional value for human consumption. The initial donation is transgenic biofortified sorghum that contains 50% more lysine compared to traditional sorghum. Lysine is an amino acid and a key component of protein.

Golden rice humanitarian board

Golden rice is an excellent example of the potentials and hurdles of public private partnership. At least 400 million of the world's population has vitamin A deficiency and of that, 100 million are children. Every year, at least half a million children go partially or totally blind because of vitamin A deficiency and are at increased risk of respiratory diseases and diarrhea. Rice grains do not contain betacarotene, the precursor of vitamin A. Therefore, poor people who derive vast majority of their caloric requirements suffer from vitamin A deficiency. A research team led by Swiss Scientist, Ingo Potrykus, developed GM rice by introducing three genes; two from a plant (daffodil) and one from a bacterium (*Erwinia uredovara*) which produces betacarotene . Due to the presence of betacarotene, the grains are yellowish in color hence the name "golden rice". Dr. Potrykus wanted to transfer the golden rice materials to developing countries for further breeding to introduce the trait in local varieties consumed by the poor people. However, Potrykus team had to take care of IP used in the development of golden rice. A survey uncovered 70 patents belonging to 32 different companies and universities embedded in golden rice. This clearly presented a major challenge to inventors who wanted their invention to reach poor farmers free of charge and without restrictions. After lengthy negotiations, arrangements were made to enable the delivery of this technology for humanitarian purposes. First, the inventors assigned all their rights to a company called Greenovation that licensed to Zeneca (now Syngenta) all rights to golden rice related inventions. Syngenta arranged for further technology licenses to be granted for humanitarian use in connection with Syngenta's Humanitarian license terms. Syngenta had to secure rights from several companies such as Bayer, Mogen, Novartis, Monsanto, Zeneca and a Japanese company. All of these licenses are for defined humanitarian use. Syngenta then granted back a license with rights to sublicense for humanitarian use to the inventors that retained all commercial rights. Syngenta also agreed to license further improvements and share regulatory data as well. The rights are transferred to developing countries, and institutions that assist them such as IRRI by inventors through a sublicense with or without right to sublicense. A sublicense with the right to sublicense has been granted to IRRI. No materials may be passed to researchers/institutions that have not executed a valid license. Humanitarian use has been defined as use in developing countries (according to FAO definition), by resource poor farmers who make less than US$10,000 per year, leaving the company free to explore commercial prospects for the technology. To date licenses have been given to six major rice growing countries namely Philippines, India, China, Bangladesh, Vietnam and Indonesia. It represents an excellent example of a public-private partnership.

A major hurdle remains before this rice will reach subsistence farmers. The trait needs to be transferred to many locally adapted rice varieties in rice growing countries. A careful needs assessment and analysis of pros and cons of alternative measures, bioavailability, food safety, biosafety and

environmental and economic assessments followed by field trials are needed. A golden rice humanitarian board has been set up to provide advice and support throughout this process.

Rice functional genomics

Rice is the most important food crop for half the world's population. In Asia, the yield gains in rice have been crucial in keeping with growing population. Since 1962, population in Asia has more than doubled from 1.6 to 3.7 billion. Rice production has grown by 170%, whereas the land area planted to rice increased only marginally (21%) during the same period. The increased production efficiency has reduced the price of rice to less than 50% in real terms over the past three decades. Continuing increase in population coupled with decreasing arable land, water and other resources for sustaining agriculture make it especially important to maximize rice production. Tapping into the genetic potential of rice gene pool is the most feasible strategy for developing rice varieties for increased productivity. The availability of diverse genetic resources and knowledge is fundamental to any successful plant improvement program. Yet, this is also the most contentious issue confronting public research institutes at a time when private sector is increasing investment in crop research that has been done largely by public sector. This issue is particularly sensitive with rice.

On the one hand, the private investment can bring about innovations. On the other hand, a shift in the balance of public and private investment in rice research has also raised concerns that some proprietary technologies might become unavailable to those who cannot afford them. Such concerns must be considered because gene identification, validation and application are occurring at an ever-accelerating pace. The question is can the model of free access to genes; germplasm and knowledge exist and contribute under an increasingly protective environment that exercises intellectual property rights.

The public rice genome-sequencing project (IRGSP) was initiated in 1998 under the leadership of Japan Rice Genome Research Program (RGRP). Eight other countries: China, Taiwan (China), India, Korea, Thailand, France, USA, and Brazil have participated in the project. The completion of the sequencing project was announced in December 2004. Two private companies, Syngenta and Monsanto, as well as public Beijing Genomics Institute (BGI) contributed their genome sequence data that facilitated and expedited the completion of the project.

The completely sequenced and freely accessible rice genome promises an enormous pool of genes and genetic markers for improvement of rice and other cereals through marker aided selection and genetic transformation. However, to exploit this information will require detailed genetic and phenotypic analysis to identify and understand function of each of more than 60,000 rice gene sequences. Both public and private resources are needed to exploit the potential offered by genomics. Diverse resources held by rice growing countries and IRRI are crucial for success, and these include mutants,

germplasm, near-isogenic lines, population for gene mapping and elite breeding lines for diverse rice growing conditions. The private sector has greater capacity in molecular skills, tool ownership and most importantly, access to capital markets to undertake detailed molecular analysis that employs new sequencing and bioinformatics tools and large databases.

In order to enhance public-private collaboration, IRRI proposed formation of an International Working Group on Rice Functional Genomics in 1999. It was agreed that the following activities are of high priority: (1) create an information node to deposit and disseminate information on rice functional genomics, (2) build a public platform to promote access to genetic stocks and phenotypic information, (3) develop databases on phenotypes and mutants with linkage to sequencing laboratories, and (4) initiate partnership to develop resources for microarray analysis.

The pattern of rights envisioned is that genetic resources for functional genomics will be made available to the public and private sectors under a material transfer agreement (MTA). This agreement permits recipients to obtain patents on genes discovered with material, but requires them to make available rights under those patents at a reasonable royalty for application in commercial markets of developing world and at zero royalty for application in noncommercial subsistence farming. In addition to ensuring the possibility of use in the developing world, it is essential that data and materials are freely available for research. Hence, the MTA has provisions permitting free use for research purposes of any of the patents, as well as provisions ensuring that recipients cannot obtain any form of intellectual property on the genetic stocks *per se*. The information gained from research with such genetic resources must be provided back to the public; albeit after an appropriate delay to allow patenting. Public institutions engaged in developing and studying these genetic resources must agree among themselves to supply materials and to exchange all information developed and maintained in a common database. They must also follow the same rules as those imposed on the private sector through MTA.

The experience of last four years shows that this is a workable model. The International Working Group on Rice Functional Genomics was converted into International Consortium on Rice Functional Genomic (IRFGC) on the basis of discussions among participants at International Conference on the Status of Plant and Animal Genomic Research II in San Diego in January 2003.

Conclusions

As the foregoing discussion shows both the public and private, organizations have important roles to play in harnessing the benefits of biotechnology and emerging field of genomics. Collaboration between the two sectors is even more crucial for addressing the problems of food security and poverty alleviation in developing countries. As the examples of public-private collaboration cited in this paper show, large life science companies such as Monsanto, Syngenta, Pioneer are willing to

donate their proprietary technologies (genes, promoter, process and sequences) for humanitarian causes. Choosing which materials and tools to use in the lab is an important juncture where increased knowledge about IP can help avoid later proprietary claims to innovation. Public intellectual property resource for agriculture (PIPRA) (www.pipra.org) based at the University of California has a database related to patents and patent application owned by members and can be easily accessed through an on-line interface.

In addition, the formation of global public-private alliances and international agreements will be critical to ensure that the current explosion in genomics knowledge can be tapped to solve the problems of poor producers and consumers. The public sector has critical assets in the form of germplasm and associated biological knowledge important in new science of genomics. However, to fully exploit these assets, public sector must develop a capacity in IP management, strengthen biosafety protocols and upgrade business skills. Most public-private alliances to-date have been based on free access to proprietary technologies for non-competing markets. Market segmentation is likely to be a key element in public-private negotiations in the future. To ensure that public sector organizations in poor developing countries have access to proprietary technologies, multinational life science companies should have enlightened patent policy like that of Danforth Plant Science Center, Saint Louis, USA. It states; “Any licensing agreements from discoveries made at the center shall diligently and in good faith negotiate the terms of the exclusive worldwide license, making provision for preserving the availability of the intellectual property for meeting the needs of developing countries”.

Opportunities and challenges for contribution of aquaculture to food and nutritional security

Vijay Gupta Modadugu*

The world is concerned with food security by year 2050 when global population is expected to cross 9 billion and food production has to be doubled to meet the demand. In India, the present population of 1.2 billion is expected to reach 1.6 billion by 2050. The fisheries planners/ administrators and scientists are concerned whether fish which is rich in protein, essential fatty acids, vitamins, minerals and as a component of food basket would be able to meet the demands of increasing population combined with increased consumption as a result of better understanding of health benefits of consuming fish as compared to other terrestrial based meat products and the increasing affluence leading to higher purchasing power**.** Thirty seven percent of global production of fish is traded internationally making fisheries sector as one of the most globalised and dynamic food industry, with its value exceeding the value of international trade in other agriculture products combined.

Fish provides over 4.5 billion people with at least 15% of the animal protein. In India, per capita consumption of fish has been estimated at around 9 kg per annum as against global average of 20 kg per annum. Though present fish consumption is low, it is on the increase in view of the realization of its health benefits. Global food fish production reached 167 million tons, with aquaculture contributing 74 million metric tons. In India, fish production reached 10.8 million tons with 4.5 million tons contributed by aquaculture or farming of fish. Consumption and demand for fish is increasing globally and estimates made by various agencies on the demand to year 2030 have put the need for an additional 30-40 million tons. In India, the government has set a target of reaching a production of 15 million tons by 2020, as against present production of 10.8 million tons. This would necessitate doubling our aquaculture production from about 4.5 million tons now to about 8.7 million tons in the next 3-4 years, as there is little potential for increasing production from capture fisheries – both marine and inland. While the marine capture fisheries sector is suffering from over capacity in fishing, inland sector is suffering in addition to over-exploitation, from pollution of rivers, diversion of waters for irrigation, etc. Added to this, the looming climate change will impact both marine and inland fisheries. Because of the above, emphasis is being laid on increasing production through aquaculture.

In the aquaculture sector, there is high potential for increasing production. In the

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last three decades, global aquaculture production has increased by 12 times, with an average annual growth of about 8%, turning out to be the fastest growing food sector. The scenario is same in India and has potential for further growth as our resources have been under-utilized so far.

Asia is the cradle of global aquaculture production with over 90% contribution to global production. China, the top producer of aquaculture produced 43.5 million tons in 2013 while India produced only 4.1 million tons, or one tenth of what China is producing indicating opportunities for increasing production through intensification of existing facilities and utilization of un-exploited aquatic resources. The estimated increase in production of 30-40 million tons to meet global demand by 2030 has to come from Asia. China the major aquaculture producer and also a major consumer is expected to be a net importer of fish in the future due to very high domestic consumption. This leaves an opportunity for India, the number two producer in the world to increase production from unutilized and under utilized resources, both for domestic consumption and export. This would lead to creation of additional employment – especially among unemployed rural youth.

In addition to contributing to food basket, aquaculture has been providing livelihood to over 15 million people in India. Our export of aquatic products has crossed US$ 5.5 billion and there is much scope for increasing this value to over US$ 10 billion in the next few years.

India is bestowed with vast aquatic resources: a coastline of 8,118 km, 2.25 million ha of ponds and tanks, 1.3 million ha of beels and derelict waters, 2.09 million ha of lakes and reservoirs, 0.12 million ha of irrigation canals and channels and 2.3 million ha of paddy fields some of which are suitable for fish culture, and about 1.2 million ha of brackish waters suitable for farming of fish and shrimp. The research institutions and fisheries universities have come up with a number of technologies that can be taken up for farming fish at subsistence level or at commercial level. Technologies are available for farming of fish even in seasonal ponds/tanks which retain water for 3-6 months only with productions of 2-3 tons per hectare. Farming of multi-species or polyculture in perennial freshwaters with productions of 5- 10 tons per hectare is possible now. We have also made much progress in farming of shrimp in brackish waters – which are mostly exported and a beginning has been made in farming of fish in brackish waters. In addition to these water resources, farming of fish in enclosures (cages) in reservoirs and tanks has been initiated in some of the states and has very high potential for taking up this activity on a large scale which will result not only in increased production, but also create employment among landless rural poor.

One area that has shown promising for small-scale rural farmers is integration of aquaculture with crops, horticulture, agro-forestry, livestock etc. Integration of aquaculture with crop farming and livestock raising is resulting in increased incomes to households, diversification of

crops, less risk and environmental friendly as it results in less or no use of pesticides and weedicides in rice farming. Further integration resulted in decrease in rice production costs and increased rice production.

One area that is getting attention in recent times is culture based capture fisheries – stocking of fingerlings (baby fish) in open waters and harvesting them at regular intervals. We have vast areas under reservoirs, tanks, flood plains, ox-bow lakes, etc., fish productions from which are very low. Stocking of these natural water bodies with fingerlings and managing them on a scientific basis is paying dividends. Added to this, cage and pen culture in these natural water bodies has been found to be quite lucrative and when done properly could result in creating employment/livelihoods among landless population. For example, Telangana state has taken up a program of renovating 46,351 tanks under its "Mission Kakatiya" for irrigation and other purposes. This program offers an excellent opportunity for incorporating aquaculture in to these tanks in addition to for whatever purpose they are being renovated, which would result in increased availability of fish and creating livelihoods in rural areas.

Issues/Challenges: While the opportunities are high for increasing aquaculture production to meet the growing demand, creating employment among rural poor and increase export earnings, at the same time there are a number of challenges that need to be addressed by scientists, development agencies and policy makers, for sustainably increasing aquaculture production and its contribution to food and nutritional security of our population.

Our productions, the number of species or types of fish we farm and exports of aquatic products, as compared to many other countries in the region are very low for various reasons. While we have done comparatively well in the case of freshwater and brackish water aquaculture, being the second largest producer of freshwater aquaculture in the world, we are still in the primary stages of development of mariculture. We need to develop seed production and culture technologies for a large number of marine commercial species and in the case of species where seed production technologies have been developed such as Cobia (*Rachycentroncanadum*), Sea bass (*Latescalcarifer*), Silver pompano (*Trachinotusblochii*), etc., we have to upscale the technologies to a commercial production level.

An area where India has not done much and needs to do more is diversification of species in our farming system. We have been mostly depending on few species of fish, mostly carp species – that too, Catla (*Catlacatla*), Rohu (*Labeorohita*) and Mrigal (*Cirrhinusmrigala*), forgetting many other species of minor carps and other species that we have. In the absence of diversification of native species, exotics are being introduced in to the country posing threats to biodiversity.

Seed quality and certification is an area which needs more attention. Many studies have indicated that our hatchery bred stocks are worse than the wild stocks due

to years of inbreeding in hatcheries. Enormous increases in crop and livestock yields we are seeing today are because of improved varieties/breeds the sectors are using. Aquaculture is way behind agriculture and livestock in terms of production and use of improved strains. Globally, less than 10% of production comes from improved varieties of fish and shell fish. In India, Rohu has been genetically improved for over 8 generations with growth improvement by 18% per generation as compared to other stocks of Rohu. In the absence of strategies for the dissemination of this improved variety, we were not able to take advantage of this research output which would have doubled our production of Rohu fish. In recent years, government is encouraging farming of an improved strain of tilapia – GIFT tilapia which is suitable for small-scale subsistence farming and also intensive farming on a commercial scale.

While the demand for fish is increasing, the resource base – land and water is declining, which would mean we have to go for intensive systems to optimize land and water use for which technologies are available. This intensification as is to be expected will lead to higher fish health problems and hence investments in fish health management research will be needed.

The other challenge is the fish feeds. Feeds constitute about 50-60% of total fish production costs. Already there is shortage of raw materials for feed formulation with increasing prices and this is going to be accentuated in the future as the aquaculture sector has to compete with other sectors for feed ingredients. One of the concerns of the aquaculture feed sector is that the fishmeal and fish oil production which is finite will not be able to meet the future demands of the sector. To me, this is not a big problem as fishmeal and fish oil could be replaced with plant substitutes as has been demonstrated by the Salmon aquaculture industry in Norway.

Globally over 80% of aquaculture production comes from small-scale farmers and India is no different. In our enthusiasm, we should not forget to take care of the needs and survival of these small-scale farmers who are the backbone of aquaculture industry. They need technologies and technical knowledge, bargaining power for input supply and marketing of outputs. A beginning is being made in the formation of Fish Farmer Producer Organisations (FFPOs) which need to be encouraged and supported by government and non-government agencies.

I have mentioned earlier that our aquaculture productions as compared to those of other countries in the region are way behind. One of the reasons for this is weak linkages between research and development. While a number of technologies, methods, modules have been developed or being developed in our research institutions, state agriculture and fisheries universities and colleges often do not see the light of the day in terms of commercialization due to weak extension services. The need is for good collaboration and cooperation between research

institutions, development agencies and the farming sector.

In the past, the fisheries sector in India has not received the Government attention it deserves. Only in recent times the sector is receiving the attention of government through higher allocation of funds, etc. through the “Mission Blue Revolution”.

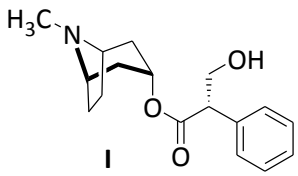
As the sector is contributing to food and nutritional security, employment generation and foreign exchange earnings, it is high time that the government creates a separate Ministry of Fisheries, as is being demanded by all involved in the sector, to take advantage of the potential the sector offers and provide the necessary policy and institutional support the sector needs. While agriculture income is tax free and receives subsidies (such as free power, free water, etc.) aquaculture income is being taxed and does not receive the subsidies the agriculture sector receives. Keeping in view the importance of the sector, the government should consider treating aquaculture on par with agriculture for taxation and subsidies.

The government in its plans for increasing animal protein production to meet the demand should take note of the fact that production of animal protein through aquaculture is a better option compared to land based animal productions systems such as beef, pork or poultry in terms of feed conversion efficiency (production of meat/protein per kg of feed used), water use efficiency (amount of water required to produce a kg of meat/protein) and green gas emissions. In all these cases, aquaculture has proved to be a much better option.

Chiral pharmacology and natural product chemistry

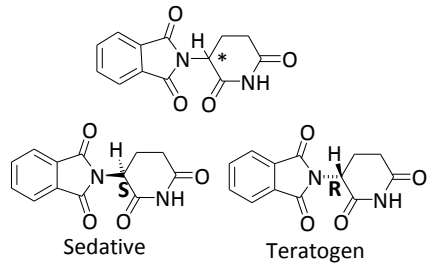
Vasantha Mittapelli[1] and P.S.N. Reddy*[2]

The discovery of Arthur R Cushny (1866-1926) that (-)-adrenaline is twice the potency of (+)-adrenaline (I) as vasoconstrictor and is 12-15 times more potent on sympathetic vessels has revealed the biological relationship of optically isomeric substances.



I

The story of thalidomide (II), a drug used as a sedative by women in their early pregnancy and the havoc it caused, confirmed that enantiomers of a molecule may have different biological properties often exhibiting conflicting pharmacological response. For example, the S-isomer of thalidomide is a sedative whereas the R-isomer was proved to be a teratogen causing phocomelia in new born children.



II

There are several drug molecules whose enantiomers exhibits radically different bioactivity (affectivity, toxicity, taste etc.) in the body and a few common examples are mentioned below to illustrate the point (Table-1).

The affinity of a drug for a specific receptor and its intrinsic activity are related to its chemical structure and minor changes in the molecular structure leads to major changes in pharmacological properties. Receptors of drugs, taste, bio-pharmaceuticals, agro-chemicals etc., are chiral and the natural ligand to a receptor is often specific to only one enantiomer. Thus, drug-receptor interactions are stereo selective. This observation led to the development of more structured drug regulations; control over drug use and development; and the importance of chiral isomer came into existence in pharmaceutical industries. In order to avoid the adverse effects of another isomer, US Food and Drug Administration (FDA) recently recommends the assessments of each enantiomer activity

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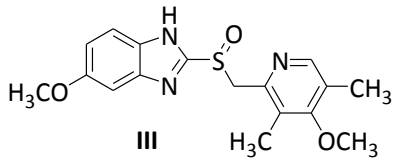
for racemic drugs in body and promotes the development of new chiral drugs as single enantiomers. Single enantiomer drug sales show a continuous growth worldwide and many of the top selling drugs are marketed as single enantiomers.

Some drug companies have patented and developed a racemic drug, with the intention of patenting and developing a single enantiomer later. When the patent on the racemate expires, the company can undercut generic competition by launching the single-enantiomer. AstraZeneca, for instance, has developed esomeprazole (III, Nexium), a single enantiomer version of its $6 billion anti-ulcer drug omeprazole (IV, Prilosec), which came off patent in 2002.



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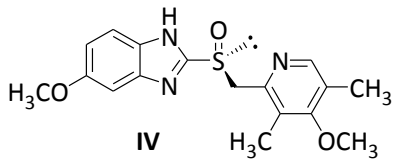


IV

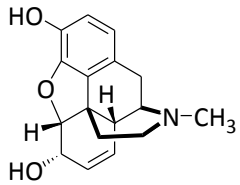
This value of single enantiomer drugs has spurred rapid development in research and development of several chiral technologies such as

- asymmetric synthesis
- chiral separation techniques and analytical assays
- chiral stationary phases
- chiral selectors for GC, LC and CE
- chiral switches
- chiral drug synthesis using enzymatic, bio and organo-metallic catalysts
- chiral chemistry in natural product synthesis

The pharmaceutical industry in India ranks 3rd in the world in terms of volume and 14th in terms of value though, a few questions surface in this context.

- Our country's contribution to chiral drug technology?
- The role of our pharmaceutical industry and universities in the development of chiral technologies?
- Future efforts to create a *niche* in chiral drug industry?

The future lies in the pursuit of natural product chemistry. Natural products represent a source of remarkable chemical diversity for drug discovery. Impressive numbers of drugs have been isolated and derived from natural resources, for instance morphine (V), aspidospermidine (VI), aminoglutethimide (VII), doxapram (VIII) vinblastine (IX), artimisinin (X), taxol (XI) and cyclosporine (XII) are a few chiral natural products which proved invaluable as drugs. Approximately, 80 % of the population still uses drugs exclusively from natural source, 35 % of drugs contain 'principles' (key structure elements) from natural products, but less than 5 lakh higher plant species underwent biological pharmacological screening. Each plant has potentially 10,000 different constituents.



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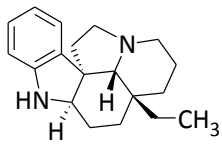

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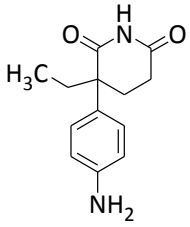

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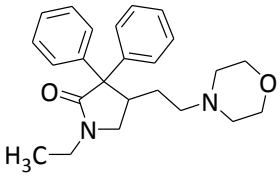

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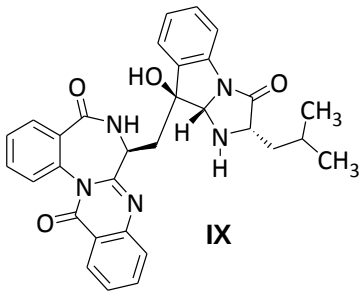

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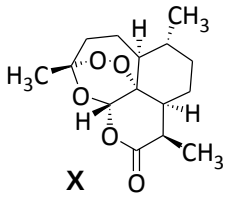

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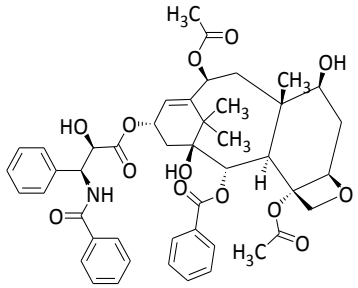

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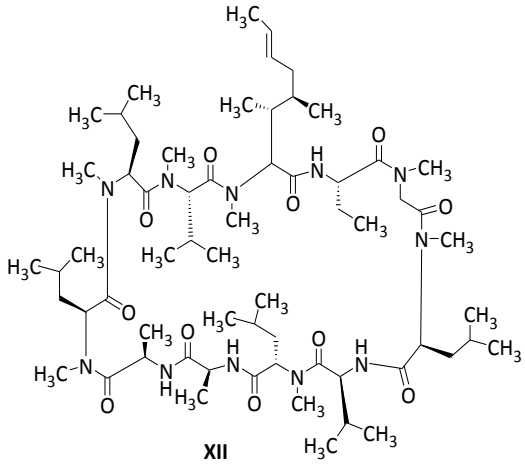

XII

Despite the great success of the 70s and 80s in natural product chemistry in our country, the policy makers and the universities have de-emphasized natural products research during the following decades. It is time to revive, lest the elevation of the pharmaceutical industry to the next level will remain a distant dream.

Table-1: Bioactivity of some drug molecules and their enantiomers

Drug Name	*Drug Activity*	*Enantiomer*	
		R -	*S -*
Salbutamol	β-Adrenergic receptor agonist	Active	Airway hyper responsiveness
Amlodipine	Calcium channel blocker	Peripheral edema	Active
Levobupivacaine	Localanesthetic	Cardio toxic	Active
Escitalopram	Selective serotonin reuptake inhibitor	Active	Faster onset
Chloramphenicol	Antibiotic	Active	Inactive
Ibuprofen	Analgesic	Distomer	Eutomer
Propranalol	β -blocker	Contraceptive	Active
Ethambutol	Bacteriostatic	(R,R)- causes Blindness	(S,S)- is Active
Penicillamine	Anti-arthritis	Active	Toxic

Synthetic chemistry for coming years

Srivari Chandrasekhar

The term synthesis in Greek means “put together”. Synthetic chemistry is the “art” of building-up complex molecular structures of organic compounds putting together smaller, easily accessible substrates. Nature makes complex molecules following biosynthetic pathway catalyzed by enzymes, starting from very simple building blocks. In fact nature is the most inspiring architect and a great chemist and biologist as well. Inspired by the nature, human beings have started practicing the synthesis of molecules by which many substances that are important to daily life are obtained at required levels. Generally the term synthetic chemistry applies to all types of chemical compounds but at large it refers to synthesis of organic molecules. A synthetic chemist synthesizes chemical compounds for many reasons: synthesis of molecules that occur in nature, i.e. natural product synthesis, is carried out to gain better understanding of the structure and characterization details. Synthesis also enables chemists to build molecular frameworks which are not available in nature; this is where a synthetic chemist has an upper hand over other researchers, wherein, a synthetic chemist can make any molecule at any scale irrespective of its natural existence. In simpler terms, the chemical compounds are made up of different atoms joined together by chemical bonds.

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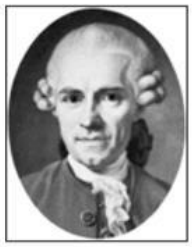
Generally, a chemical synthesis usually runs on the basic principle of breaking and making of bonds, the synthetic organic chemist follows the principles of retrosynthesis- an approach of visualizing the end product and working backward to obtain increasingly simpler substrates to carry out the synthesis of the target molecule.

Going back in history, Tobern Olof Bergman (1735-1784) was the first to use diagrams and symbols to explain chemical reactions instead of prose and he was also the first to coin the term “organic chemistry” for chemistry of the living world.



Tobern Olof Bergman
1735 - 1784

In 1828 Friedrich Wöhler synthesized urea (carbamide)- a constituent of urine, from ammonium cyanate, which is now called the Wöhler synthesis and this was the first organic compound synthesized in a laboratory. Later in the year 1844, Herman Kolbe synthesized acetic acid from carbon disulfide and these two early syntheses have paved way for the development of synthetic chemistry as a prominent scientific field.

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Friedrich Wöhler
1800 - 1882

Herman Kolbe 1818 - 1884

In 1856 William Henry Perkin, produced an organic dye (Perkin's mauve) accidentally, while trying to manufacture quinine. This discovery is widely known for its financial success and has greatly attracted the efforts in organic chemistry towards synthesis of molecules.

Another breakthrough in this endeavor was the concept of chemical structure, developed by Friedrich August Kekulé and Archibald Scott Couper independently in the year 1858, suggesting that tetravalent carbon atoms could link to each other to form a carbon lattice, and helped in interpreting the chemical reactions that the carbon molecules undergo.

Early examples of the synthesis and applications of chemical compounds were often because of a combination of luck and preparation for unexpected scaffolds. However, from the latter half of the 19th century a systematic study of chemical synthesis has started which has been evolved as an advanced and highly sophisticated area of research.

In the early 19th century, there was no unified theory of organic synthesis, however the synthesis of fats (P. E. M. Berthelot) and carbohydrates (A. M. Butlerov) was developed and at a later stage the synthesis of Indigo, camphor and other relatively simple compounds were subsequently synthesized in accordance with the development of theory of structure of organic compounds.

The seminal importance to the synthetic chemistry was developed by the work of Robert Robinson in 1920's on the preparation of a series of complex molecules by the pathways that imitate to the synthesis of molecules by nature i,e biosynthetic pathways. Since then a rapid development of chemical synthesis began with the synthesis of steroids, alkaloids and vitamins followed by the synthesis of isoprenoids, antibiotics, polysaccharides, peptides and nucleic acids starting from 1930's.

Sir Robert Robinson

These achievements continued with significant contributions from R B Woodward to the development of fine organic synthesis during the period 1940-1960's. He has synthesized important natural products like quinine, cortisone, chlorophyll, tetracycline, and vitamin B. The development of organic synthesis reached great heights with total synthesis of the gene of alaninetransfer-ribonucleic acid of yeast, which was the result of successful efforts by H. G. Khorana and group.

Our nation has produced great organic chemists like Prof. T R Seshadri, Prof. Asima Chattergee, Prof. Goverdhan Mehta, Dr Sukh Dev, Dr Venkatraman, Dr A V Rama Rao and others, who are widely known for their unique contributions in the development and progress of organic synthesis in Indian context with global acknowledgement.

The area of synthetic chemistry is believed to have no limitation in expansion and is currently progressing in many directions. Some of these include the production of industrially important products (polymers, synthetic fuels, dyes); preparation of ingredients for medicine, agriculture, food processing, and perfumery; solving structural complexity of natural products; making molecules with unusual structures for new contributions in chemistry and allied areas; development of new reactions, conditions and methodologies, like the use of catalysts, microorganisms and purified enzymes for the chemical processes; use of computers for optimization of reaction results etc.

The development of synthetic indigo is an early illustration in support of the effectiveness of synthetic chemistry. “The production of indigo from plant sources dropped from 19,000 tons in 1897 to 1,000 tons by 1914 due to the synthetic methods developed by Adolf von Baeyer, whereas, in 2002, 17,000 tons of synthetic indigo were produced from petrochemicals.

Now the synthetic chemists have reached a very high level of specialization which can be witnessed by the synthesis of extremely complicated and attractive compounds of natural origin, such as palytoxin or taxol. Chemical compounds form the basis of all earthly life and constitute a significant part of human endeavors in chemistry and therefore synthetic chemistry is an important applied science.

“Synthetic organic chemists have the power to replicate some of the most intriguing molecules of living nature in the laboratory and apply their developed synthetic strategies and technologies to construct variations of them. Such molecules facilitate biology and medicine, as they often find uses as biological tools and drug candidates for clinical development.” - K.C.Nicolaou

Ever since its inception in 1828, synthetic chemistry is advancing to new levels of performance and reach in terms of structural complexity and diversity. Its progress has been highly effective and continues to expand into new directions, thereby increasing its impact on science and society. Thus, from the small molecule urea which has only one carbon atom and no stereogenic site, synthetic chemists could dare to attempt the synthesis of complex molecules like taxol, eribulin, palytoxin and maitotoxin etc.

Over the last few decades, synthetic chemistry has aligned with advanced technologies and/or tools which led to the effective functioning of new areas like automation chemistry, flow chemistry, sustainable chemistry, and organometallic chemistry, which are the prime focus of modern researchers.

Automation chemistry is a multi-disciplinary strategy which helps in developing improved processes with high time efficiency. The research activities such as high-throughput screening, combinatorial chemistry, diagnostics, automated clinical and analytical testing, large scale bio or chemical repositories (National Mole Bank facility at CSIR-IICT) are some examples showcasing the importance of laboratory automation. The first fully automated laboratory was opened by Dr. Masahide Sasaki in 1980's and since then the automation is widely implemented in synthetic chemistry labs for process development, optimization, screening and in many allied areas like medical, engineering, analytical etc.

Flow chemistry, as the name defines is the process wherein the chemical reactions are performed in continuously flowing stream rather than in batch production. In simple terms, pumps move fluids into tubes at known rates, the fluids come in contact with one another at specified temperature and pressure which allows the reaction to take place. Flow chemistry is a well-established technique for applications at research in laboratory to manufacturing levels, including preparation of fine chemicals, natural products, Active Pharmaceutical Ingredients (APIs), and manufacturing of organic molecules including chiral compounds and others. Flow chemistry approach can also be associated to other technologies, such as microwave irradiation, supported reagents, catalysts, photochemistry, electrochemistry, 3D printing etc., to facilitate the development of improved and sustainable processes.

Organometallic chemistry is a combination study of the aspects of traditional organic and inorganic chemistry. In simple words, chemistry of compounds which contain at least one bond between a carbon atom of an organic compound and a metal. Organometallic chemistry has wide applications in research and industrial sectors, especially as catalysts which effectively serve to increase the reaction rates. Organometallic chemistry continues to bring-in great achievements including the synthesis of methyl arsenic compounds related to cacodyl, platinum-ethylene complex, Grignard's reagents, Ziegler-Natta, hydroformylation catalysis to the Nobel Prizes to Ernst Fischer and Geoffrey Wilkinson (metallocenes), Yves Chauvin, R. H. Grubbs and R. R. Schrock (metal-catalyzed olefin metathesis) and many others.

The journey of synthetic chemistry is very vast and has unlimited applications covering all scientific spaces like drug discovery, polymers, materials, food, agriculture, fertilizers, biochemistry, chemical biology, engineering etc. Further, synthetic chemistry has an edge of combining with modern trends and tools to emerge as a new and advanced technological outcome in the field of science and technology. Therefore, future direction for organic synthesis should be more focused in interdisciplinary approach to achieve significant contribution towards the societal needs.

Message

A. V. Rama Rao

Dear Prof. Dashavantha Reddy,

It gives me immense pleasure to know that Osmania University is completing 100 years and all the faculty and students are planning to celebrate this event in a befitting manner. Over the years, it produced several intellectuals, scientists, engineers and scholars. Sri P V. Narasimha Rao, former Prime Minister of India, who played a major role in reshaping our country's economic revival and Sri Shivaraj Patil, the former Minister of Science & Technology, Government of India, who was responsible for appointing me as the Director of the then Regional Research Laboratory (RRL), Hyderabad, were some of the best known alumni of Osmania University.

I was associated with the University from the early 1970s and shared a warm rapport with Prof. N V. Subba Rao, the then Head of the Chemistry Department and Prof. T. Navaneetha Rao, the then youngest Professor of Physical Chemistry, who subsequently became the Vice Chancellor of this University.

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He was indeed perhaps the finest teacher and administrator of the University, who carried on several improvements including protecting its boundaries from various encroachments. He also planted several trees to make the campus green and clean. During the year 1986, when I shifted my research group from the National Chemical Laboratory (NCL) to the Indian Institute of Chemical Technology (IICT), it was Prof. T. Navaneetha Rao who allowed me to take any number of research fellows and to register with the University for their Ph.D. program as external candidates.

I was fortunate to attract the most talented post graduate students from the Organic Chemistry Department since 1978. Year after year, several students of M.Sc. Organic Chemistry joined my research group first at NCL and subsequently at IICT. The first batch of 3 students joined me in 1979, all have secured CSIR fellowship and after securing Ph.D. degrees went abroad to join as Post-Docs in reputed Universities with well-known professors and Nobel Laureates.

Many of them have remained in the US and are now holding senior positions in several international companies. Few of them returned to India and were well placed in CSIR Laboratories such as NCL and IICT. The present Director of IICT was also from Osmania University and was the first to join my group at IICT for his Ph.D. program.

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As is always the case with such old institutes of size and stature, the task of maintaining their eminence requires a lot of funding and visionary leadership. I pray that this remarkable institution remains protected and is nurtured with all the right elements to ensure its growth and prosperity.

Cloud-Guru

Deepak Chopra

It's beautiful up here, sitting on a plane staring at clouds. Or should I say, it's still beautiful? There are invisible dangers in the atmosphere. The toxic breath of industry, the careless debris of the good life being led down below. I know this, yet these white billows, rank upon rank, look so pure that for a moment one forgets.

Thirty-five years ago, on a long migration from India to America, I wasn't worried about the clouds getting dirty and poisoned. I wasn't worried about anything. That trip was all excitement and confidence. I had a new bride by my side and a job offer clutched in my hand. Every ambitious young man I knew back in Delhi was facing West, and when word got out that the Vietnam War had created a doctor shortage in the U.S., I couldn't wait to make the leap. I expected the Good Life to come my way, and it did. I expected the Good Life to make me happy, but it didn't.

I put in almost twenty years of effort to prove both things to myself. Camped out in a threadbare New Jersey motel that first night, I turned on a color television for the first time in my life and saw a bloody victim of gangland violence being rushed to the hospital.

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Oh my God, they were taking him to the emergency room I would be working in tomorrow. In a sense those few ingredients– patients in need, color TVs, and rushing from one hospital to the next– became hallmarks of my new existence.

But by 1985 I felt adrift, seeing myself as someone who knew everything about medicine and almost nothing about healing. After casting about aimlessly, I did something none of my Indian friends were doing: I turned my face East again. Not just out of personal restlessness. Not just to find God, because that wasn't my intent. I kept thinking about something else: Why does the pursuit of happiness make us so unhappy? I had devoted myself to finding happiness, yet a looming, warning figure stood in my way.

That figure was the guru. Westerners glamorize gurus into spiritual superstars or demonize them as arrant charlatans. But in India a guru is more like your conscience. Strictly speaking, the Sanskrit word *Guru* means "dispeller of darkness," but in everyday life gurus are like a nagging inner voice reminding you that there are higher things to live for. Needless to say, gurus don't equate with the Good Life (though I know more than one Indian who invites gurus to visit and sits at their feet with a glass of Scotch in hand).

We are guilty in India of using gurus as spiritual anodynes, harmless as an English vicar but good for the soul. I decided to

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take them seriously, because for centuries the gurus have painted a clear picture: there are two ways to live. One is the pursuit of pleasure, the other is the pursuit of *Moksha*, or liberation. The two roads sharply diverge, which is why the Good Life and gurus don't mix. I had proved to myself that pleasure, in and of itself, leads to exhaustion and inner deterioration. What could the guru offer instead?

I won't recap my years with Maharishi Mahesh Yogi, except to say that the impact of a guru was everything I had hoped for and more. I found inner discipline and silence, not as ends in themselves but as openings to a great, unknown subtle realm that permeates Nature. Next, I came to trust in another face of the guru, known as Upaguru, or the teacher who is close by. Upaguru can be anyone or anything, whatever experience brings a flash of insight, a small step toward liberation. I have sat in lonely hotel rooms in Paraguay or Dubai and idly turned on the television, only to have the next image on the screen bring a sudden epiphany.

Once you are committed to dispelling your own darkness, guru is everywhere. After thirty-five years on the path, this has proved the most valuable lesson. And now I believe it is the lesson humanity has to learn. Why is our planet on the verge of ecological catastrophe? Because everyone wants the Good Life. They want it in Khartoum as much as in midtown Manhattan. As long as the Good Life means sensual pleasure, the acquisition of cars, houses, planes, boats, vacations, jet skis, RVs, and on and on, we are in peril.

Staring at the clouds today, I see guru. The message of the clouds is the same as the message of Vasishtha or Ramana Maharishi or any other true guru: *See yourself anew*. We will not save the planet so long as we see ourselves through old eyes. If man is an animal that insatiably craves pleasure, we are lost. But happiness can be defined by the other road, the pursuit of liberation. I will never be free as long as I am an isolated individual struggling against Nature. Freedom comes from surrender, and the first surrender must be to Nature itself.

Nature is a cloud. It has no boundaries. It is incredibly pure and beautiful. Its motions are unpredictable. Clouds are always here, yet they appear and disappear, seemingly at random, yet always in the service of life. To adopt such an existence for ourselves is possible. Humans have always been sky-watchers; we identify with what lies beyond the clouds.

So the guru's choice remains as clear as ever. I don't imagine that anyone will buy prime time ad space to declare that Upaguru is the way of the future. But revolutions crop up unexpectedly (like clouds, once again), and I believe the present ecological crisis has its inner dimension. The next revolution, the one that will save us, will arise inside. When it does, humanity will experience itself in a new way, and when our descendants gaze at the clouds, still beautiful and pure, they will murmur to themselves, "Ah, it's true. I am that."

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Fostering the one humanity

Domen Kočevar

Humanity is a family of 7 billion humans. Seven billion persons, each one searching for happiness as their main motivation in life. Everyone just wants to be happy. Problems arise with having or not having what we want or when my feeling of happiness excludes your feeling of happiness. These problems bring pain and all other versions of unwanted feelings.

Patanjali's short yoga sutras, a jewel of Hindu philosophy, synthesized this in his account of the 5 KLESHAS, or obstacles to the experience of union. "The lack of awareness of Reality, the sense of egoism or "I-am-ness", attractions and repulsions towards objects and the strong desire for life are the great afflictions or causes of all miseries of life."[1]. If we would know our true state of being, if we would know who we really are, all our problems would be gone. Consciousness gets identified with the matter with which it gets involved. It descends into matter, on an involutionary path, until the turning point. Evolutionary climbing towards the soul and later the spirit, if we use these terms, is the path of release from the obstacles to union so that the grip of avidya (ignorance) gets less and less firm.The Result is that our identification changes. Identifications become subtler and harder to spot and to see.

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The story of the descent and ascent of the human has been described so many times with so many words throughout history that it is now mostly clear in the minds of those who study the path. Many people know so much. And deeper realizations are also happening where knowledge is being transformed into knowing and firm action.

So many people are talking about one humanity, about oneness, the connectedness of all. In the last year when I seriously started considering doing a Ph.D. on this subject I saw the vast number of people touching the same heart of humanity. Science is revealing so many concrete examples of research that are showing the unavoidable fact that we are one. I believe that humanity is not so far from a collective jump onto the level of basic living of the qualities of the soul. Patanjali's sutras outline the steps needed to overcome the obstacles or KLESHAS to our awareness of union, and individuals have trodden these steps in the past and still do. But now the collective field is so charged that it will soon start spilling over and surprising us where it is not expected.

The path to conscious living as one big caring human family is becoming more and more attuned to the One Love, One Mind, and One Will. My observation of the world is that so many individuals are so near to attuning just enough to not be able to do each other any harm and even start actively caring and helping each other … so near. It is like a cup full of water and every

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new drop is spilling it over. Once it starts flowing it will be an irreversible process. Our inner knowing of sameness, of sharing the same dreams and fears and pains is so strong. It is also easy to see that quite the opposite is happening: that there is an undercurrent which is trying to stop the quantum jump. But I believe that the extremes that we are seeing in the world are announcing the strength of the undercurrent of the movement of the Good, of the GOODWILL of All.

Together with colleagues, Dr. Nina Meyerhof and I are working on a project in Auschwitz. This is the most horrifying and condensed expression of evil in history. The project is focused on how to go from there into a future where anything like that will be impossible. We know that today similar things to Auschwitz are happening in the world. How to go beyond the possibility of being able to do something so bad to each other? It is not important who is the oppressor and who is the victim. For me it is always just a question of HOW CAN SUCH HORRENDOUS ACTS BE POSSIBLE? That should vibrate in every one of us and push us in the actions that we know are right for each of us to do. It is daring to say that it does not matter who is the villain and who is the victim. Can you imagine the power of forgiveness needed to look at something like Auschwitz if you are the victim? And the same if you are the villain who realizes the result of his actions. The feeling of guilt is ruining many.

When seeing the violence happening now in the world I sometimes try to identify myself with the man in the tank who is firing on other human beings. How can he do it? (Yes, it is mostly He). I understand the process of command, hate arising out of pain, the process of defending and then using the chance... I can easily see how this is possible when human nature is disconnected from the whole.

But I can also see the simple change that can happen when someone identifies with the Other and sees himself in the other. He sees the other's mother and he sees himself. He sees the children of the other and sees his. When seeing the simplest smile of a woman he loves and thinks of the sadness of not coming home. Such small connections can "poison" consciousness with knowing the whole. And the "field" is really getting filled with information about our interconnectedness. From fully scientific inputs to totally practical knowing of the Oneness and Sameness of all. The outside is reaching towards the inside and the inside is trying even harder to come out. The touching points are happening in human beings all over the world. To touch the heart of the One Humanity is to know the importance of every colour in the world. It is knowing that every soul is different but knowing the Oneness of all. It recognizes the importance of everyone, each with his gifts and message. General change happens when the root standpoint changes - everything adapts to that. It is my belief that the One Humanity, the brotherhood and sisterhood of all, is nearer than we can imagine. The bowl of knowing is quickly filling up with the facts of the One Life and people will respond accordingly.

I. K. Taimni, The Science of Yoga: The Yoga Sutras of Patanjali, Section II, Sutra 3, p. 130

The need for true Islamic spirituality in the modern age

Shaykh Hamid Hasan

The current age we are living in has witnessed unprecedented advancements in science and technology, leading to rapid social and economic development. More people than ever before have been freed from poverty and are able to access a much higher standard of living than their parents' generation. Yet in spite of such progress large numbers of individuals are afflicted with debilitating conditions such as stress, anxiety, depression and drug addiction. Various research studies suggest that as many as one in ten people are on anti- depressants in large areas of the developed world.

For Muslims and Sufis in particular, the root cause of such afflictions lies in a profound sense of alienation from oneself and from the divine. Such alienation can only be overcome by reconnecting with Allah by means of our spiritual heart (qalb). In Islam spirituality is defined as being in a high state of God consciousness or 'ihsan.' In a famous hadith the Prophet Muhammad [pbuh] when speaking to the angel Jibreel [as] defined ihsan in the following terms:

'It is that you worship Allah as if you see Him. And even though you do not see Him, [you know] He sees you.' (Muslim).

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As mentioned in the above hadith Muslims believe that Allah cannot be actually physically seen or heard by humankind. Rather Allah is 'Al Lateef', the subtle one.

Vision perceives Him not, but He perceives [all] vision; and He is the Subtle, the Acquainted. [Quran 6:103]

The Quran states that the key to understanding Allah the subtle one, is by means of our own subtle inner selves, namely the spiritual heart:

"Those whom Allah wills to guide He expands their chest (heart) to Islam" (Quran 6:125)

In a hadith qudsi Allah says:

"Neither My earth nor My heavens can contain Me, but the heart of a believing servant, contains Me." (Ahmed)

This is understood figuratively to refer to the heart's unique relationship with the divine, as a purified heart is able to reflect all the attributes of God.

The Prophet (pbuh) stated:

As for the polished heart, it is the heart of the believer and its lamp is the light of faith. (Ahmed)

Polishing the heart of sins and an attachment to worldliness begins with the observance of the major acts of worship

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such as prayer and fasting. However many an individual who regularly prays and fasts still finds it difficult to attain a state of remembrance free from worldly distractions. According to Sufis the means to attaining remembrance of God lies in the regular performance of supererogatory acts of worship such as dhikr, muraqabah (heart based meditation) and daroodsharif (this is in addition to mandatory acts of worship of course). Regarding those who perform extra acts of worship Allah says:

My servant continues to draw closer to Me through performing supererogatory acts of worship until I come to love Him. And when I love him, I am for him his hearing, seeing, hand (support), heart, intellect and tongue (Bukhari).

Eventually as divine grace is realised in the heart, an individual is able to overcome the lower egotistical self and attain the quality of humility.

Has not the time arrived for the believers that their hearts in all humility should engage in the remembrance of Allah and of the Truth which has been revealed to them (Quran 57:16). Such humble individuals are able to play a positive role in society, influencing others for the better, through their loving presence rather than through angry confrontational discourse. They view Islam as a natural way of life to be expressed compassionately, rather than a mere set of ritualistic rules to be imposed oppressively upon others.

It is important to emphasise here that most Sufi orders do not advocate complete withdrawal from wider society, rather the aim is for an individual to reach the state of 'solitude amidst the crowd' whereby the heart continues to remember God regardless of whether one is alone or with others.

To remember God throughout day to day life is far more valuable than periodically making a show of remembrance. Dhikr is not a ceremony it is the very object of life. The person who remembers God finds happiness; the person who forgets finds only desolation. Most Sufi orders today do not renounce the world, but rather take part in family and professional life while also performing practices that lead towards the spiritual goal. A primary aim of students should be to meet the highest standards of their worldly occupations…I would caution you however against letting outer responsibilities become an excuse not to be regular in your (spiritual) practices. If you prefer your practices above other engagements, God will look after your needs. Try to discover those qualities and activities with which God is pleased. One of the most important of is service to His creatures. Remember the path to the love of God passes through the valley of service - service not only to human beings but to all creatures. (Hazrat Azad Rasool in 'Turning Toward the Heart').

Sufis are people of ijazah or spiritual legitimacy. The spiritual practices of the main Sufi orders are not something made up randomly by individual Sufi shaykhs, instead their origins lie in the practices of the Prophet Muhammad (pbuh). For instance the practice of muraqabah which is a heart based meditation, can be traced back to the recommendation of the

Prophet (pbuh) for one to remain sitting silently at the conclusion of the prayer in order to prolong the state of blessing. Similarly the practice of sending blessings upon the Prophet (pbuh) daroodsharif which is common to all Sufi orders, is based upon numerous sayings of the Prophet (pbuh) advising that Muslims give priority to this practice.

All Sufi orders have a silsila or spiritual lineage which can be traced back to the Prophet (pbuh). Sufi shaykhs are therefore seen as spiritual inheritors or heirs of the Prophet (pbuh). The role of the Sufi shaykh is therefore central to spirituality in Islam. As individuals who have travelled the inner path they are able to help and guide individuals towards God by directing their tawajjuh or spiritual attention towards them. Aided by the personal guidance of the a spiritual master, Sufi students or mureeds are characterised by their discipline and self-restraint, they are in particular opposed to extremist acts such as terrorism, for example. Instead Sufis typically respect the legitimacy of societies' institutions.

Sufism is integral to Islam's quest to be a positive force in society, with real spiritual depth, that is able to effect individuals' lives for the better.

Are you searching for your soul?

Then come out of your prison.

Leave the stream and join the river that flows into the ocean.

Absorbed in this world you've made it your burden.

Rise above this world.

There is another vision.

('Rumi, Whispers of the Beloved' translated by Maryam Mafi. Taken from Rumi's Rubaiyat)

Swami Vivekananda's influence on spirituality today

Swami Bhajanananda

If we look around at the world today, what comes to our notice at first is likely to be the enormous increase in crime, violence against women, terrorism, immorality, corruption and other social evils. Exaggerated accounts of these matters appear in newspapers which give rise to a sombre picture of the world. But if we look beyond these shadows, we begin to notice a brighter world of universal thought currents. Apart from the enormous increase in high-rise buildings, shopping complexes, cell-phones, electronic gadgets, consumer goods and other external things, great changes are taking place in world thought, in the collective thinking of humanity.

What is really happening is not merely the development of innumerable ideas, concepts and innovations but a basic change in man's attitude and response to life and reality. This has given rise to several megatrends in world thought. Some of these megatrends are mentioned below:

Influence of information and communication technology in all departments of human endeavour and in the life of common people.Knowledge revolution which is bringing into existence a 'knowledge society' in which knowledge is the main force driving economy.

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Globalization of economy.

Concern for the environment.

Neo-humanism which stresses human rights, especially the rights of marginalized people.

Moral relativism: changes in the norms of moral conduct.

Enormous increase in psychological and existential problems such as feeling of loneliness, anxiety, meaninglessness etc., and the quest for meaning in life.

Rise of the global spiritual movement.

Of these global trends it is the last one that is the subject of our discussion here. By 'global spiritual movement' is meant the upsurge of interest in spirituality in recent years in many parts of the free world, especially in the West. Millions of Western people have taken to the practice of meditation, Yoga, Zen, Vipassana, and other spiritual disciplines.

The present spiritual movement in the West is quite different from the earlier spiritual movement which originated in America in the 1960s and '70s under the influence of oriental ideas and under the impact of the sudden influx of yogis, gurus, lamas, kinds of spiritual and other teachers. In that early phase, spirituality often got mixed up with occult matters, healing, past life regression, rise of

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psychedelic drugs etc. It was anti-intellectual, anti-science, anti-establishment. It came to be known as 'New Age Movement', 'Human Potential movement', 'Counter-culture' etc. It never became a part of the main stream of society and, although some eminent thinkers and writers were drawn to it, the followers of the earlier spiritual movement were mostly eccentric individuals, including the Hippies.

By contrast, the present-day spiritual movement belongs to the main stream of social life and world thought. Its followers are normal, successful individuals holding responsible jobs, and include business executives, lawyers, engineers, salesmen, therapists and others who belong to all walks of life. It is a response to a genuine need for a spiritual perspective, a higher, holistic view of life and reality, and a saner, more meaningful way of life. It is not a passing fad but appears to be the result of the natural psycho-social evolution of human consciousness. It marks the attainment of maturity and autonomy of the human mind in determining its own course of development. One of its chief characteristics is that it is supported by science and technology.

The support of science to spirituality comes from the fact that the common ground between the two has been found. That common ground is consciousness. Consciousness studies have now become an integral part of several disciplines such as philosophy, psychology, neuroscience, and even quantum physics.

Science of Consciousness

A proper understanding of the nature of consciousness is necessary to understand the true nature of spirituality. This is because spirituality deals with the higher levels of consciousness.

In the West, study of consciousness as an independent discipline began only towards the end of the 19th century, after discovery of the unconscious by Bruer and Freud. Western philosophers and scientists have always associated consciousness with the mind, and the key issue for them is whether the mind is identical with the brain or is independent of it.

In India investigation into the true nature of consciousness began at least by 1000 B.C, or perhaps much earlier. The ancient sages followed the direct path of investigation through meditation, self-enquiry and interiorization. They discovered consciousness to be independent of, and different from, the mind. It is indeed the witnessing Self in man. The ancient Indian sages undertook the most thorough and deepest study of this 'witnessing Self' ever undertaken anywhere in the world. This study led to the development of two main views on the nature of consciousness: a monistic view known as Vedanta and a dualistic view known as Yoga.

Vedanta and Yoga remained separate during the early period. The first attempt to combine them into a single system was made by Sri Krishna in the Gita. During the medieval period, Vedanta became the dominant school of philosophical thought in India, and Yoga came to be neglected. In

modern times Sri Ramakrishna and Swami Vivekananda have reunified Vedanta and Yoga once again. It was this unified Vedanta-Yoga system of thought that Swami Vivekananda expounded and spread in the West and in India.

Religion and Spirituality

Till modern times spirituality had been regarded as belonging exclusively to the domain of religion. The present trend is to separate spirituality from religion. In religions of Indian origin spirituality has always formed the main stream, whereas in Abrahamic religions, which originated in the Middle East, spirituality forms a side stream known as mysticism. In recent years mysticism has been demystified and secularized to such an extent that it has become an independent discipline known as "spirituality" or "secular spirituality", an independent movement known as Spiritual Movement. In a recent poll conducted by the Newsweek in the United States, it was found that thirty per cent of Americans call themselves spiritual rather than religious.

The use of the term "religion" is usually confined to the realm of faith – faith in a founder-prophet, faith in a sacred book which is a record of the revelations that he had received, and faith in a set of dogmatic assertions which may not be in accord with the truths discovered by science. "Religion" also implies observance of a certain code of conduct, customs, festivals, rituals, etc, allegiance to certain institutions and identification with a community of believers.

What then is spiritual life or spirituality? There are now thirty or more definitions of spirituality. Psychologists, sociologists, philosophers, neuro-scientists – have all defined the term in their own ways. The most basic definition of spirituality would be: Spirituality is a view of reality or way of life which is centred on the spirit. This leads to the question, what is 'spirit'?

The meaning of the term 'spirit' depends upon our understanding of the nature of human personality. There are two main theories of personality in the religious traditions of the world. In all non-Indian religious traditions the human personality is regarded as dichotomous, that is, it consists of two entities, the body and the mind. The mind itself is known as the soul or spirit. In this sense spiritual life is only a higher form of mental life, and is not much different from moral life. A spiritual man is known as a 'holy man'. In India the ancient sages of the Upanishads discovered that the human personality has a trichotomous structure, that is, it consists of the body, the mind and the Atman. The Atman is of the nature of pure awareness or contentless consciousness (cit or caitanya). Our very notion 'I exist', (sat) is owing to the Atman. The Atman is also the source of all happiness (ánanda). Thus the Atman is described as sat-cit-ánanda (Existence-Consciousness-Bliss).

Furthermore, the Atman is unchanging, eternal and immortal; it is our true nature; whereas the body and mind are ever-changing and perishable and so they cannot be our true nature. It is this Atman that is meant by 'spirit' in the Indian tradition. Hence spiritual life means a way of life based on the Atman (ádhyátmika-jævan). Thus the basis of spirituality in the

Indian tradition is the autonomy of consciousness, its independence of even the mind.

In other religions, although the idea of the Atman is not there, a distinction is often made between a lower mind, which is the seat of desires and passions, and a higher mind which is the seat of faith, higher knowledge, etc. The higher mind is known as the 'soul' or 'spirit'. Spiritual life is a way of life centred on this soul or spirit. A modern definition of spirituality which is in accord with this view is given here: "Spirituality, which comes from the Latin spiritus, meaning 'breath of life', is a way of being and experiencing that comes about through awareness of a transcendent dimension and that is characterized by certain identifiable values in regard to self, others, nature, life and whatever one considers to be the Ultimate."

Another feature which distinguishes spirituality from religion is that in spirituality the emphasis is not on conformity to dogmas, traditions or customs but on personal quest for meaning and direct experience. Transcendental (atændriya) spiritual experience, known as "mystical experience", is recognized in all religions.

For centuries mystical life and experience had remained confined to small groups of people, most of whom were monks or nuns. In modern times Swami Vivekananda was one of the first persons to open the doors of mysticism to people belonging to all walks of life. Since then, especially after the Second World War, spiritual life has become more and more secularized, and separated from the parent religion. Direct transcendental experiences described by the great saints and mystics of all religions may be beyond the attainment of ordinary people. But everyone can have an intuitive feeling about, or faith in, a Supreme Power guiding one's life, or a Divine Presence or source of Power in one's heart. Such experiences can transform a person's whole life and enable him to lead a noble life of service to humanity. It is this transforming power of personal experiences that distinguishes spirituality from mere conformity to religious customs.

Two Kinds of Spirituality

There are at present two main streams of spirituality: Religious Spirituality and Non-religious or Secular Spirituality. Religious spirituality is spiritual life lived within the bounds of a religion. Secular spirituality is spiritual life lived without any affiliation to institutional religions. In the Indian religious tradition, since spirituality constitutes the very core and basis of religion, the distinction between religious spirituality and secular spirituality has never been very prominent. The need to have secular spirituality exists mainly in the West. This is chiefly because the foundations of faith in traditional religion have been undermined by the horrors of Wars, by the dominance of science and by the materialistic ideologies and rationalistic thought. It should, however, be mentioned here that the Western secular spiritual movement is seeping into Indian society also, especially among those people who have come under the strong influence of Western culture and also among those

who are fed up with the endless occurrences of caste prejudice and religious unrest.

The Present-day Spiritual Movement

Freed from the hold of traditional religions, and supported by science and technology, secular spirituality is becoming popular among the present generation of youths. For millions of people it has become a new way of making life nobler, enriched, meaningful, successful and fulfilling. This secularization of spirituality has been hailed as a 'spiritual revolution'. Apart from this popular aspect, spirituality has now become a major field of interdisciplinary study and research for philosophers, psychologists, neuroscientists and even quantum physicists.

What are the salient features of this new secular spiritual movement? When we study these salient features we cannot help noticing how close some of these features are to the well-known ideas of Swami Vivekananda.

A prominent feature of the present secular spiritual movement is the shifting of young people's attention from God to man. It is not theological questions about God that people are now interested in, but their own inner problems, especially existential problems such as meaninglessness, powerlessness, unfulfilment, ennui, angst, love, etc. Spiritual life is not conformity to customs and traditions but a personal quest—a personal quest for meaning, for lasting security, happiness and peace. The present generation is guided not by scriptural or institutional injunctions and prohibitions but by their own personal convictions. There is now a basic change in the attitude of young men and women towards themselves. Referring to this change as 'massive subjective turn of modern culture', Paul Heelas explains it as a "turn away from life lived in terms of external or 'objective' roles, duties and obligations, and a turn towards life lived by reference to one's own subjective experiences (relational as well as individualistic)".

The idea that the human personality has a transcendental dimension in the form of pure consciousness which is independent of mind is a unique contribution of ancient India to world thought. Swami Vivekananda was one of the first persons to spread the concept of the Atman as the spirit in man, among the common people in the West. This idea of the spirit is now being widely accepted by the present generation. The concept of human personality as a trichotomy of body-mind-spirit has now become one of the basic principles of belief underpinning the present-day secular spiritual movement.

Another basic principle animating the present-day spiritual movement is the emphasis on direct experience of life and reality rather than on 'blind faith' in dogmatic religious creeds. We may note here that it was Sri Ramakrishna who in the 1870's and 1880's propounded the idea that the test and criterion of the validity of religion and spiritual truths is direct transcendental experience. Swami Vivekananda popularized this idea in the West. The experience aimed at by the followers of secular spirituality may not be the higher transcendental experience

described by Sri Ramakrishna, Swami Vivekananda and the mystics of all religions. What the present generation seeks is a personal encounter with reality in all its dimensions—from ordinary day-to-day life to the highest mystic experience. For the present-day spiritual seekers any experience which transforms one's life inwardly and gives a higher understanding of reality is a "spiritual experience". Spiritual life is not conformity to some fossilized faith or custom or institution, but a personal, inner quest for meaning and fulfilment. Says the noted New Age author Paul Heelas: "An idea or practice is spiritual when it reveals our personal desire to establish a felt-relationship with the deepest meaning or powers governing life". Religion is often characterized as "static piety", whereas spirituality is "dynamic growth"—growth in experience, wisdom, and fullness.

Another major difference between traditional religions and modern spirituality is that traditional religions are other-worldly. That is to say, their primary focus is on life after death. What they promise is everlasting peace or happiness, known as Mukti, salvation, parinirván, attainment of heaven, Pure Land, etc. after death. And this post-mortem reward is reserved only for their followers who lead a virtuous life. By contrast, the modern spiritual movement is this-worldly: its main aim is to attain happiness, prosperity and personal well-being in the present life itself, and lead an enlightened, meaningful life in this world.

The new spiritual movement is characterized by a positive and holistic outlook on life. Good health is a basic concern; so is success in life. Success is nowadays defined not merely in terms of wealth but in terms of one's total life which includes holistic health, stress management, happy family life, creativity, self-actualization and spiritual enlightenment. Spirituality itself is now being regarded as a means of attaining success in life. Business executives, salesmen, therapists, housewives and people from other walks of life attend expensive courses on spirituality conducted by modern spiritual gurus in different parts of the world. Books which project spirituality as means of attaining success in life, written by popular authors like Deepak Chopra, Neale Donald Walsch, Gary Zukov, Wayne Dyer, Eckhart Tolle and others are among the best-sellers in recent years. There are also teachers who claim that wealth also can be acquired through spirituality.

In the Hindu religious tradition there are two ways of leading a religious life which are known as Pravìtti and Nivìtti. Pravìtti is a way of life which allows enjoyment of wealth (artha) and sense pleasure (káma), governed by morality (dharma). The overall aim of this path is material prosperity for all people (abhyudaya). Nivìtti is the path of renunciation of wealth and sense enjoyment and liberation (mukti) from bondage to the world, from ignorance and suffering. Mukti is regarded as the highest good (niësreyasaë) in this path. Thus Hindu religious tradition offers a choice of two ideals – worldly prosperity (abhyudaya) and Mukti (niëùreyasaë). In later centuries these two ideals came to be meant for two stages in life—youth and old age. It is clear

that the modern spiritual movement, which aims at material prosperity, belongs to the path of Pravìtti. Swami Vivekananda showed that a spiritual perspective can be maintained in both Pravìtti and Nivìtti. This was what he meant by "Practical Vedanta".

Another important feature of the new spiritual movement is self-empowerment. The present generation does not want to put the blame for their misfortunes and failures on God. They take up full responsibility for their troubles and failures, and trace their source to their own ignorance, to their own unconscious and to their own inherent defects. They are also at the same time aware of the spiritual strength inherent in the soul, and empower themselves to overcome their weaknesses and defects. Anybody who goes through the lectures which Swami Vivekananda gave in India or the letters he wrote to Indians can see how close these modern ideas came to Swamiji's exhortations on faith in oneself, self-reliance, fearlessness and strength. To give an example, Swamiji said, "Therefore, stand up, be bold, be strong. Take the whole responsibility on your own shoulders, and know that you are the creator of your own destiny. All the strength and succor you want is within yourselves."

One more important feature of the ongoing spiritual movement deserves mention here: it is its pluralistic approach to world religions, its openness to the spiritual paths of all religions. The internet now makes available to all people all over the world the spiritual truths of all religious traditions. The present generation is willing to accept spiritual truths wherever they are found – in yoga, in Vedanta, Zen, Sufism, Native American Indian spiritual tradition, and so on. In this way pluralism, inter-religious understanding and harmony are spreading among the common people in spite of the dogmatic and exclusivistic views still held by the theologians and the violent opposition of fundamentalists.

The attitude of acceptance towards different religions seen in the present-day spiritual movement may have several causes. Among these causes the influence of Sri Ramakrishna's doctrine of Dharma-samanvaya or Harmony of Religions occupies an important place. The importance of Sri Ramakrishna in this field is due to the fact that it was he who gave reality to the ideal of harmony by actually practising it in his own life. Without him 'harmony of religions' would have remained a mere theoretical concept.

Apart from the above, the modern spiritual movement is characterized by ecological awareness, gender equality, and free use of modern technology.

Globalization of Spirituality

As was stated earlier, the present widespread interest in spirituality in the West is actually the second phase of the spiritual awakening of the Western mind. This second phase of the spiritual movement is a product of a realistic understanding of the limitations of empirical knowledge, a deeper understanding of the human personality, and an experiential understanding of the beneficial effects of meditation, yoga, Zen, Vipassana and other spiritual practices.

What is most significant is the reconciliation of science with spirituality, and the support which spiritual life receives from the ongoing Information Technology Revolution. As Fred Turner has pointed out in his best-selling book, From Counter Culture to Cyber Culture, the unprecedented rapidity of advancement of technology is bringing into existence a new global culture known as "Cyber Culture". Commenting on the book, another writer states: "… the last decades have seen the rise of a breathless optimism in the power of technology to fulfil our dreams of a better world; to create an increasingly egalitarian, decentralized and collaborative global community; and even, some tell us, to serve the teleological goals of cultural and biological evolution."

Cyber culture is based on the view that human societies are elaborate, non-hierarchical, self-regulating information systems with feedback loops. The customary notion of human culture as conditioned by geographical areas, race, religion etc. is now becoming irrelevant in the new global context. The present computer-savvy generation is extending not only the frontiers of knowledge but also the frontiers of society, and are learning to think globally. The association of this cyber culture with spirituality opens new possibilities for the future of humanity. Aided by scientific studies on consciousness and by information technology, the present interest in spirituality is tending to develop into global spirituality. About this phenomenon the late Dr. Ewert Cousins, who was a professor of theology at Fordham University in New York and was active in inter-faith dialogue, wrote in 1996: "All the religions and all the people of the world are undergoing the most challenging transformation in history leading to the birth of a new consciousness. Forces which have been at work for centuries are drawing the human race into a global network and the religions of the world into a global spiritual community".

The new spirituality is breaking down the barriers in inter-human relationships created by race, religion, nationality, individual and collective prejudice and ignorance. This does not, however, mean that global spirituality is a homogeneous, uniform and single path or practice or discipline. In fact one of the distinctive features of the present spiritual movement is the enormous diversity of ideals, philosophical concepts, methods, practices and experiences popularized by innumerable gurus, yogis, and other kinds of spiritual teachers, and the freedom the present generation has to choose any path they like.

It may be pointed out here that more than a hundred years ago Swamiji spoke of the need for globalization of spirituality, and the need to have diversity of spiritual paths to suit the diversity of human temperaments and capacities. About the need to have a universal spiritual outlook, he said: "There cannot be any progress without the whole world following in the wake …. Every idea has to become broad till it covers the whole of this world, every aspiration must go on increasing till it has engulfed the whole of humanity, nay the whole of life, within its scope."

Swamiji's ideas on universalization or globalization of spirituality were based on his vision of the oneness of life, oneness of humanity and oneness of the ultimate Reality—without losing sight of the diversity of life or diversity of human temperament. By unity Swamiji meant unity in diversity. He stressed diversity of human efforts, creativity, spiritual paths, etc. as necessary for the preservation of human culture and the attainment of human progress. He has pointed out that diversity is an essential aspect of Nature, and variation has an important role in the evolution of life (as Darwin has shown). This applies in the field of religion also. Variation in religion caused by breaking into sects has survival value: it enables religions to survive the opposition and dissent of their followers. Swamiji wrote: "…. it seems to me that this splitting up of each religion into sects is the preservation of religion by frustrating the tendency to rigid sameness, as well as the clear indication to us of the line of procedure. The end seems, therefore, to be not destruction but multiplication of sects until each individual is a sect unto himself."

Divinization of Life

The ultimate goal of Vedanta is to free man from Maya or Ajnana and enable him to realize his true nature as Atman-Brahman. This means the attainment of everlasting Freedom, supreme Knowledge and Bliss. A person who gets this realization is known as a jivanmukta 'one who is liberated in life'. He sees the world as illusory and remains unattached. This is the ideal which has inspired thousands of people in India from Vedic times to follow the path of spirituality.

In modern times Sri Ramakrishna has added a new dimension to this ancient ideal. According to him, an illumined person with a fuller realization sees the Divine in all beings and dedicates his life to the service of suffering humanity. Sri Ramakrishna called such a person a vijðáni.

The life of such a person cannot be regarded as ordinary human life. He has gone beyond human limitations and his whole consciousness has been transformed into Divine Consciousness. His life is Divine Life. Thus, divinization of life is the ultimate goal of spiritual life.

Swami Vivekananda saw that, even as an ideal, Divinization of life has immense practical utility to ordinary people. If a person can live and work with this ideal in view, his whole life gradually gets transformed from human life into Divine life. Swamiji said, 'My ideal, indeed, can be put into a few words, and that is: to preach unto mankind their divinity, and how to make it manifest in every movement of life.'

Under the impact of the 'knowledge revolution' that is now going on all over the world, great changes are taking place in individual human life and in social life. As wealth increases, moral problems such as crime, violence and immorality, psychological problems such as neuroses and depression, and existential problems such as meaninglessness, loneliness, restlessness, etc, are also increasing at an alarming rate. These problems cannot be

solved by enforcing law or preaching moral values.

Morality is only an attempt to rise from animal life to human life. But man in his true nature is potentially divine, and unless he manifests this inherent potentiality, he cannot be fully human, his personality cannot be said to be fully developed. In other words, man should rise from moral life to spiritual life; the spiritual perspective should be the foundation for moral life, social life, economic life, and even science. This awareness is now spreading in the form of the present-day 'Secular Spiritual Movement'.

Swami Vivekananda predicted this more than one hundred and ten years ago. In a lecture on 'Necessity of Religion', Swamiji stated: 'The power of religion [by which he meant spirituality], broadened and purified, is going to penetrate every part of human life. So long as religion was in the hands of a chosen few or of a body of priests, it was in temples, churches, books, dogmas, ceremonials, forms, and rituals. But when we come to the real, spiritual, universal concept, then, and then alone, religion will become real and living; it will come into our very nature, live in our every movement, penetrate every pore of our society, and be infinitely more a power for good than it has ever been before'

Divinization of the whole human life – this was what Swami Vivekananda envisioned about the future of humanity. Universal Vedanta and Practical Vedanta together provide a comprehensive scheme for the Divinization of human life.

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Universal brotherhood

Sri Sri Sri Tridandi Chinna Sreemannarayana Ramanuja Jeeyar

Mahesh is getting ready to present his pet project to the potential investors. To make one last check he calls up his team mate from US over facetime and rehearses his presentation. With everything just perfect he starts early in his new sedan to reach the office before time. On reaching the conference hall Mahesh finds everything right in place. Right from the projector to bottled Himalyan water for the guests to the lighting air conditioning all done perfectly. The guests arrive on time and the presentation starts without any delay. Mahesh makes an incredible presentation and the investors feel that's quite an idea! Mahesh gets the most of the required funding for his project and is all set to touch the skies! A typical success story we read in media now a days. The question is did Mahesh pull off the huge task all by himself? How many would have helped him? Bunch of people? Some hundreds? Or millions? Starting from the technology to the car, to the lights in the hall, the AC and thousands of such small and bigthings some thousands of people have helped him directly and indirectly. Would this succes be a reality without such a help from innumerable sources? Man has come a long way. He has raised himself to such great heights that from that height even the Earth, the very thing on which he dwells, now appears as a tiny ball from the space.

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With the lightning fast communication, he has erased distances between the oceans and continents. The list of his accomplishments is significant and extensive. Transportation, information technology, engineering, medicine, name an area and huge accomplishments are in it. Now, whenever we come across such words of praise and admiration of human advancement, each one of us without any distinction feel proud and subconsciously credit ourselves for these achievements. While most of us are only mere consumers or beneficiaries of such incredible achievements of some extraordinary men on the planet, we readily own their merit and success! What could be the underlying human element behind such ownership?

Our lives have always been, and will always be interdependent on one another. More to say not just on a fellow human but also on every being on this planet. From the smallest of the small to largest creature, we all are in a symbiotic environment. We cannot survive without the probiotic bacteria in our intestines nor without the bees or trees and even the venomous snakes provide balance to the planet. With the world shrinking into a global village not just our ecological footprint but also our human footprint, is growing multifold. In the context of the opportunities and the challenges for the upcoming century, what can be a more significant topic to focus on than this growing human interdependency. The terms like "Universal Brotherhood", "One world family" are usually looked at

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from a philosophical or social perspective and therefore are not given as much importance. It's high time that we see this topic of one world family more as one of the fundamental necessities for human well-being and as a fuel to foster the progress of mankind. If we see the contribution of thousands of people across the globe in the above scenario of mahesh closely we can appreciate how important it is that people from across the globe stay in a friendly dynamic with each other for mutual growth.

But the same togetherness (lack of it) can be the most challenging thing for the years and generations to come. In spite of such a significant growth and advancement in things related to the brain and thought, man is yet to reach visible height when it comes to the matters of heart. This is not about being philosophical or noble in the thoughts. It's sheer logic and understanding the basic paradigm of human functionality and growth for the betterment of the world. For instance, some negative news from middle east affects the average consumer in India as the oil supply gets hit and thus transportation and eventually commodity prices go up. Or regional disturbances in some part of India or china can have its tremors felt even in Silicon Valley or five star hotels in Europe or the manufacturing plants in Japan. Those who keep an eye on the stock exchanges will be able to readily understand this. Even the rift among communities based on gender, race and color causes a massive ripple effect through the whole world. It's high time that each one of us understands this basic human dependency on harmony and fundamental relationship with each being. This will elevate us to a higher goal as one planet rather than focusing on each other's lacunae and differences. Every one of us, whether we agree or not, inevitably depend on thousands or even lakhs of other people for our survival, growth and prosperity. The human interdependency is at such a high level that we cannot afford to be anything less than being a global family. This process of rising high together starts with our universities that cater to students from across the globe, acting as miniature worlds' in themselves. These campuses are an excellent platform to inculcate the feelings of oneness amongst all with tolerance and appreciation for diversity. This is necessary for the next generation of the world, the next leaders, next technological advancements all start at this foundation of brotherhood. These centers, if proactively create an environment for universal brotherhood, then the coming generations will be much more productive and successful. The leadership that grows amongst the students in the university should strive to eradicate the differences and highlight mutual contribution of different groups and distinctions for a progressive community and world. The good old mantra of 'Uni'ty in di'versity' holds its weight in gold even today and even more for every 'university' of the world. With such an increased interdependency, the oneness of all should be pursued very seriously at least in the socio-technological and economical perspective if not just in a philanthropic aspect. Mangalasasanams once again to you all for this wonderful Sathabdi Mahothsavams.

Harmony and peace

The Dalai Lama

Wherever we live and whatever our nationality may be, this planet is our home. In the past, isolated communities could afford to think of one another as fundamentally separate. Some could even exist in total isolation. Today, with advancement in science and technology the world has become heavily interdependent. What happens in one region could affect many other areas, which demonstrates the oneness of humanity. Therefore, mutual co-operation and consideration are essential, as without them, the wellbeing of all is threatened. While governments enact laws and regulations, responsibility rests with each of us as well.

Our great human family of around seven billion people has adherents of different religious traditions as well as around a billion who have no faith. With various social beliefs, traditions and educational backgrounds, there are differences in our values and approaches to addressing our needs; however, at our core we all yearn to be happy. Our pursuit of happiness should also include the wellbeings of others. The concern we demonstrate for their wellbeing reflects the beauty of our mind. Qualities such as wisdom, courage, determination, satisfaction and calmness are all aspects of a compassionate mind.

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We pride ourselves on our material developments, often ignoring the damaging impacts on the ecology of our planet. Due to excessive consumption and the pollution of our environment that ensues, our earth faces a crisis that, if not addressed, will have catastrophic consequences. Scientists warn of global warming resulting from the depletion of the ozone layer, causing glaciers to recede, and other ecological imbalances that impact our climate. While the wealthy enjoy modern facilities, the poor and countless other living creatures inhabiting our planet remain vulnerable. If we fail to embrace the principles of love, affection and concern for others, we will be squandering our human intelligence. Animals may sometimes cause limited harm, though never to the extent we humans are capable of. The ability of our human intelligence is remarkable, and we should always use it constructively. Members of the younger generation to whom this 21st century belongs, have important responsibilities: they must learn from and rectify the mistakes of the past, and ensure that such mistakes are not repeated. We have only one Planet Earth; it is our responsibility to protect mother nature.

In ancient times, when people knew little of the world beyond their immediate environs, there may have been less harm in a disparaging attitude towards other religious traditions. However, in our deeply interconnected world, our survival

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depends on mutual respect and concern. Just as we do not resent others for their different culinary tastes, similarly, it is essential that we respect each other's beliefs. I have made the promotion of religious harmony one of my lifelong commitments. I believe that without altering our faith in our own religion, love and respect for the religious and philosophical beliefs of others is possible. The religious harmony as prevalent in India for centuries is exemplary. Another is the tradition of Ahimsa; both are based not on fear, but on care and consideration. In the practice of these two social and human values, India can serve as an example for the rest of the world.

In the past, people's ethical values used to be shaped by their faith traditions. However, in this highly developed world, many are skeptical of religion. Whether or not we believe in a creator or in the laws of karma, we all wish to be happy. Just as religious people have the right to determine what they believe, so do those without a religion. As we all cherish being loved and cared for, love and compassion are universally valued; I consider these to be basic human values. My foremost commitment in life is to promote basic human values.

Through experiment and investigation scientists have concluded that our basic human nature is compassionate. They have also proven that people possessing more love and affection tend to have stronger immune systems. Based on scientific findings, as well as our common sense and common experience, we can promote the practice of love and compassion even in those who have no adherence to religion: I call this as secular ethics. Destructive emotions such as anger, jealousy and so forth cloud our intelligence and our ability to look at things from a wider perspective, whereas education should strengthen our basic human values. Therefore, I have time and again raised my concern for the need to introduce secular ethics into modern education. The term secular must not be taken to imply any disrespect for religion; it should convey a respect for believers and non-believers alike.

In many ways, the world has changed for better. Values such as human rights, religious harmony, freedom of speech etc. are now widely accepted in many parts of the world. Whenever there is a natural disaster, the world unites in extending all forms of support. Such mass solidarity was not there before. I profoundly believe that, due to our shared desire for happiness, we possess a greater capacity for love and compassion than for anger and hatred. Our basic human values will only grow if we recognize that we would be much happier when we are compassionate.

My hope for the future lies with the members of our younger generation who will accomplish much if the existing system of education includes educating the heart together with the mind.

A journey of 'I' to the ultimate

Rama Krishna Kancha and Dashavantha Reddy Vudem

Intelligence coupled with knowledge confers wisdom-directed empowerment. The nature's wonderful display of vast diversity, beauty of subtlety and source of innumerable potential opportunities provided the exploratory platform to the intelligent species humans for achieving comfortable living and unfolding the secrets of Universe. The start of the journey of humans was no different from any known animal basically guided by instincts. It is envisaged that present day humans might have evolved about 160,000 years ago. At that point of time the struggle was for just collecting food and protecting themselves from the wild animals. Weak muscle strength might have enforced humans to live in groups for overcoming the threats from other creatures which in turn paved the way for establishing communities. Forelimb structure facilitated the use of available solids such as sticks and stones as weapons which gave advantage in fighting wild animals. Migration to different continents followed by acquiring the necessary skills contributed to their establishment in diverse environments. Acquisition of fire making skill, developing required tools with available materials, collecting the seed, growing crops, domesticating animals can be seen as most important aspects in human civilization.

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Exploring the nature for fulfilling necessities, development of language, folk culture, script and evolving code of conduct for minimizing conflicts between individuals paved the way for transmission of acquired knowledge across generations. On the material front, man has moved from Stone Age to Iron Age and acquired the skills of purification and use of elements/ metals as well as evolution of number system which changed the thought processes paving the way for problem solving by systematic approach. The shortcomings associated with the practice of exchange of goods were overcome with the creation of money in the form of coins and later as paper currency with a given value system thereby facilitating effective transactions in an acceptable manner. Diverse observation-based/ experiences resulted in well-defined practices and culture building. Challenging of systems of misbelief—now and then by persons with altogether different outlook—facilitated the correction of wrong thought processes.

Efforts of successive philosophers, biologists, physicists, chemists, astronomers and mathematicians resolved the minimum size of matter and living things as well as their origin and evolution. Keen observation of the Nature followed by questioning, reasoning and logical interpretation as well as translating the scientific output into technology paved the way for mechanical revolution. Understanding the atomic structure and capabilities developed for handling

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radioactive materials by humankind facilitated the development of double edged weapon atomic energy. Exploitation of Silica in the chip development and computational processes evolved based on natural number system empowered the human beings entering in the era of information and digital technology. Navigational tools given advantage of travelling effectively on land, water, air and space, and instant communication as well as remote sensing abilities reduced the distances between continents and planets. Combining the power of mechanics, computers and smart materials paved the way for automation in almost every walk of life.

On the life sciences front, journey started with simple observation of morphological features followed by understanding of anatomical structures, physiological processes, reproductive mechanisms both of plants and animals proved helpful in classifying them. Invention of microscope empowered the study of vast diversity of microorganisms and their exploitation for the production of useful healthcare and nutrition products. Further, study of cells, organelles and cell division processes contributed for the better understanding of divergent living systems. Study of inheritance of traits, natural selection, importance of organs use and disuse concept paved the way for modern biology. Identification of DNA as the genetic material followed by determination of its structure and function helped in understanding the language of life, inheritance of traits, and fundamental tenants of the vast diversity of life forms. The genetic material provided the scope for the conservation of genome information by true to type replication at molecular level and preserved the genome by creating sexual barriers. Contrast to this, DNA replication also facilitated provision for rare errors which laid foundation for the generation of precious genetic variability. The elegance of handling two such antagonistic aspects paved the way for the creation of novel variability followed by selection of suitable individuals allowed the evolution of life on the earth. Development of gene manipulation protocols facilitated the transfer of genes across the genera overcoming limitations imposed by sexual barriers responsible for speciation. Modern scientific advances include the genetically modified organisms, cloning of mammals, development of artificial human tissues, and creation of synthetic life. Evolvement of crops and animal species with improved traits contributed for the production of food in sufficient quantities with desirable nutritional quality. Understanding of the human developmental processes and disease mechanisms facilitated improved therapeutic interventions which contributed for longevity and a healthy life. Coming years plausibly witness the development of designer babies/crops with all the desired traits.

Based on hypothetical time factor, the *de novo* origin of Universe might have taken place more than 13 billion years ago, by an intense explosion (Big bang) of magnitude which is beyond imagination, leaving high density energy and soup of matter at a small point. Within first few fractions of a second of its formation, the compact single small point Universe started expanding

dissipating energy, increasing entropy and disorder. It is estimated that one-second-old Universe expanded distance equivalent to several light years and was estimated to attain a temperature of 10^{11} K favouring formation of sub-atomic fundamental particles such as quarks, leptons and their counter antimatter particles. Collisions of particles of matter and corresponding antimatter caused their annihilation releasing the energy. Slightly higher half-life of quarks/ leptons over their counter antiparticles might have given them an advantage of a little longer survival. In the hundred–second–old Universe with a temperature of 10^{9} K favoured aggregation of quarks into protons and neutrons giving the advantage of their existence over extinction. Balancing for the co-existence of positive charge of protons with antagonistically negatively charged electrons by spatial separation by an energy barrier gave birth to first atom Hydrogen followed by the formation of its isotopes and next atom Helium. It is envisaged that after about 200 millions of years of Big-bang, these gases started contracting owing to the gravity which built pressure and temperature within the condensing mass leading to nuclear fusions responsible for the evolution of other elements in star, stellar and supernova systems. The matter evolved in this manner got drifting with differential pace resulting in the formation of galaxies with constituent stars and respective planetary systems. The main forces such as electromagnetic, strong, weak and gravitational forces stabilized the particles in the atom by maintaining dynamic activity within the atom. The number of protons and energy levels of electrons contributed to the diverse periodic properties of various elements despite the identity of their constituent fundamental particles. The atomic forces not only contributed to the stability of atoms but also imposed the restriction on the number of protons and the neutrons to be included in the process of nucleosynthesis, limiting the number of elements to hundred plus. Reactions between elements yielding millions of compounds, of which 90% of them are carbon containing, could obviate the limitation for the diversity of molecules. Experimental results indicated the formation of amino acids, nucleosides, simple sugars and fatty acids from inorganic molecules in nature. Interaction of these molecules in the water might have been responsible for the formation of vesicles and compartmentalization of primitive genetic material (RNA) and other compounds from the environment, which might be a starting point of life. Co-operative interaction of these macro-molecules in the lipid vesicles contributed for existence of organized structures despite the ever increasing disorder in the Universe. Maintenance of organized vesicles required energy input and the same might have been trapped from chemical energy stored in the compounds. The primitive organisms surviving this way expanded their metabolic abilities by bringing co-ordination between proteins and nucleic acids which might have paved the way for the evolvement of photosynthetic bacteria that is responsible for the development of oxygen containing environment leading to the evolution of present day aerobes. Symbiotic associations between these microbes could have complimented their deficiencies.

Loose associations became permanent forming eukaryotic cells with more compartments and division of functions with regard to time and space and life is further diversified with expanding genomes and evolving complex metabolic networks. The technology driven knowledge developed in the area of sciences conclusively established a strong basis for the concept of evolution of life from non-living molecules. The existence of knowledge of ontogeny and phylogeny among life forms as well as analogies existing between matter and life forms indicate that their origin and evolution primarily depended on balancing of antagonistic forces and overcoming imposed limitations by exploring unlimited opportunities which is a fundamental law of Universe.

The **Knowledge** driven interplay of energy and matter envisaged to be initiated between 13 to 20 billion years ago, at a tiny point, is continued in the journey of '**I'**for overcoming the inherent limits of capabilities by exploring unlimited opportunities is 'on and on' as the limitations and opportunities culminate in a logical power of infinity **'I'**, leaving individual **'I'** in illusion. Continued increase in the disorder of the expanding Universe and the continued evolution of life moving in the opposite direction of more and more orderliness, suggest that these activities persist till the perfect disorder and order, respectively, are achieved at a single point of **STILLNESS**, the **ULTIMATE**.

In essence, humanity as a whole must continue this journey by harmonizing the nature and society for achieving good health, happiness, prosperity and peace.

Insights on Global Challenges and Opportunities for the Century Ahead

Basic instinct of selfishness of human beings is the root cause of all the problems in the modern society. The enormous power of observation-based hypothesis, experimentation and extrapolation of results provided the success of humans in developing the technologies beyond imagination. Power of mind determinesdiscretionary attitude and behavior of individuals in the society. Culturing of the right attitudes in the young and youth needs to be imparted by quality education. All round development of young ones into responsible citizens of the globe can be accomplished with the right type of education consisting of Literature, Sociology, Mathematics, Economics, Science and Technology as well as Spirituality as important components. To address these issues insight opinions of eminent personalities across the continents are included in the volume entitled "Insights on GlobalChallenges and Opportunities for the Century Ahead"has been brought outon theoccasion of celebrating 25, 50 and 100 years of establishmentof Centre for Plant Molecular Biology (CPMB), Department of Genetics, and Osmania University, respectively.

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