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Emerging Technologies

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Biotechnology Industry Research Assistance Council
(A Government of India Enterprise)

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chief editor's take

New technologies are changing the frontiers of R&D and product development. BIRAC's role as a biotech development agency makes it essential that we track emerging technologies with translation potential, benchmark India's standing in the emerging field and then have a focused approach to build capabilities in the areas identified. It is with this intention, BIRAC has supported numerous industry projects in new technologies such as "synthetic biology", 3D printing and many more. The new technologies have the potential to positively influence society through benefits to healthcare and agriculture. Many of the Indian biotech start ups and SMEs are leveraging the new technologies to bring products to the market and it will give optimal push to national programmes such as "Make in India" and "Startup India". BIRAC not only provides funding but helps the industry understand the hurdles during productisation. The R&D in new technologies needs a 360° strategic understanding encompassing social impact of technologies and products as well as issues related to regulation and safety. In this regard BIRAC would proactively partner with organisations such that the positive benefits of the new technologies reach to the last mile and transform communities and the nation.■

Renu Swarup
Senior Adviser/Scientist 'H', DBT, GoI. &
Managing Director, BIRAC

in this issue

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leader

The pace of change in S&T is frenetic due to several factors chief amongst them is convergence of several sciences. The interface between engineering, physics, chemistry and life sciences has grown. The sharp walls of segmentation between these fields have been replaced by porous system of knowledge flows leading to increase in use of tools of one field to understand fundamental questions in another. The confluence of engineering and life sciences is leading to evolution of new paths of discovery and translation. The case of additive manufacturing is case in point which is leading to new pastures not just in global manufacturing but also in fields such as medical technology. Another example is the growing strides in "synthetic biology", especially in our ability to read sequences accurately, and put to practice the concept of engineering modularity for making precise changes in genome as well as making long stretches of DNA de novo. Together, both 3D printing as well as synthetic biology would impact wide ranging areas such as medicine & health diagnostics, food & nutrition, renewable energy and environmental remediation to name a few.

These rapid changes present opportunities as well as challenges for India. Opportunities exist in gaining leadership position in global R&D as well as create societal value through cutting edge products. Several challenges, however, remain especially in the realm of regulation including environmental and health impact, definition of standards and maintaining and adhering to quality standards.

BIRAC through its programmes has supported several R&D projects especially in new technologies and proactively works with different stakeholders including regulatory agencies in defining the contours of regulation and take Indian industry to leadership position globally. Going forward we would need a more joined up approach in synchronising our activities with other Government and aligned organisations.■

Prof. K. VijayRaghavan
Secretary, DBT, GoI & Chairman, BIRAC

Scaling Bio-Entrepreneurship

Foundation for Sustainable Future

BIRAC marked the celebrations of its 4th Foundation day by way of hosting a high profile knowledge event at New Delhi with the theme 'Scaling Bio-Entrepreneurship: Foundation for Sustainable Future'. Organized at the India Habitat Centre, New Delhi on 20th-21st March 2016, the event was attended with great enthusiasm by a large number of professionals from institutions, agencies and businesses active in the Biotech, S&T and Innovation ecosystem of India and also several other countries. This included senior functionaries and professionals from the Government, academia, industry and start-ups, in addition to a large number of budding entrepreneurs.

Day 1

The event was kicked off with a Welcome Address by Dr. Renu Swarup, MD, BIRAC and Senior Adviser, DBT. In her address, Dr. Swarup highlighted BIRAC's increasingly proactive role in stimulating and nurturing research and innovation skills of biotech innovators. She recounted various milestones and events in BIRAC's four year journey of nurturing and promoting the start-up ecosystem across the country. Dr. Swarup also touched upon various schemes of BIRAC that have led to an enhanced level of Industry-Academic Partnerships, with concomitant delivery of new products, technologies and intellectual property. She also stressed upon BIRAC's mandate of empowering innovators through promoting a culture of fostering and openness.

In his keynote address, Prof. K. VijayRaghavan, Secretary, DBT & Chairman, BIRAC congratulated the team at BIRAC for their efforts and commitment that have helped BIRAC deliver the kind of results that it has in a short period of four years. He also cautioned BIRAC to not to rest on its oars after a hard run but to continually evolve its Programmes and activities to meet ever changing dynamics of a sector as complex as Biotechnology. Prof. VijayRaghavan also stressed the need for BIRAC to expand its reach to fields other than Biotechnology as well. He lauded BIRAC's role in scaling of innovative bio-enterprises which is a must to achieve the nation's goal to build a US$100 billion bio economy by year 2025.

Announcement of Collaborations and Presentation of Awards for BIRAC Ideathon 2016

The Foundation Day celebrations were also an occasion to celebrate new collaborations and honoring achievers.

Dr. Renu Swarup announced four new strategic partnerships with: Nesta (UK's Innovation Charity); Tekes (Finnish Funding Agency for innovation); Horticulture Innovation Australia (HIA); and Tata Institute of Social Sciences (TISS). She expressed confidence that these new partnerships will not only supplement BIRAC's role in reaching out to the world for a sustainable impact but would also compliment BIRAC's own strengths to create new synergies.

Announcements of new collaborations were followed by the presentation of awards to the winners of BIRAC Ideathon held on 19th and 20th March. Ideathon was an event dedicated to generating novel ideas in which 8 teams of students, from educational institutions all across India, had participated. The theme was Anti-Microbial Resistance (AMR) Diagnostics. These teams were selected from 27 applications that were received for participating in the Ideathon. Each team presented its innovative ideas to a jury comprising of experts from industry, academia and incubators. The jury selected two winners. (see pg. 12)

Following presentation of Ideathon awards by Prof VijayRaghavan, the Plenary Address was delivered by none other than Prof. Ashok Jhunjhunwala, IIT Madras. Prof. Jhunjhunwala stressed that a sound funding strategy requires understanding of risks at different stages of development and the ability of the founding team to understand the target markets and willingness to drive the markets. He also emphasized that Govt. funding should support exploratory stage R&D. Prof. Jhunjhunwala also touched upon the risks faced by entrepreneurs and possible ways of overcoming those risks.

The inaugural session ended with an inspirational Foundation Day Lecture by Shri Kris Gopalakrishnan, Co-Founder of Infosys Ltd. While congratulating BIRAC for successfully completing its four years of operations, Mr. Gopalakrishnan reflected upon his memorable journey at Infosys. He also mapped the diverse challenges faced by the young entrepreneurs and how mentorship could play an important role in scaling start-ups. He stressed upon the need for more incubators and supporting ecosystem where one can learn his/her peers while dealing with other challenges of enterpreneurship. Shri Gopalakrishnan also underscored the role of Government in supporting start-ups by bringing in new policies and regulations. He emphasized that India should build up capabilities in focused areas such as personalized medicine, public health and sanitation, to name a few to harness its talent pool to address urgent national priorities.

Day 2

The second day of the BIRAC's Foundation Day event started with buzzing panel discussions on issues and challenges related to scaling bio-entrepreneurship. The

Prof. Ashok Jhunjhunwala, IIT Madras and Mr. Kris Gopalakrishnan, Infosys

panel discussions not only had a galaxy of biotech sector luminaries as discussants but also attracted a robust participation of attending delegates in form of Q&A and vibrant discussions.

SCALING BIO-ENTERPRISE BEYOND IGNITION & INCUBATION	CROSSING THE 'VALLEY OF DEATH'	INCUBATION MODELS & QUALITY MENTORING - KEYS FOR SCALING START-UP VENTURES	LEVERAGING CSR FUNDING FOR DEVELOPING A ROBUST INNOVATION ECOSYSTEM
Moderator: Deepanwita Chattopadhyay, IKP **Panelists:** • Manish Tandon, Curadev • M Kuppusamy, Tergene • Bharat Tandon, Sericare • V. Bobba VenturEast Funds	***Moderator:*** *Sujay Shetty, PwC* ***Panelists:*** • Visalakshi C Tata Capital Healthcare Fund • PR Ganapathy, Villgro • Shyam Menon, Infuse • Jagannath Samavedam, VenturEast Funds	***Moderator:*** *Premnath Venugopalan, NCL Venture Center* ***Panelists:*** • Shrishendu Mukherjee Welcome Trust • Auli Pere, Tekes • Stefan Hart, J&J Innovation • Siraj Dhanani, Innaccel • Thomas Payyapilli, Axilor • Taslimarif Saiyed, C-CAMP	***Moderator:*** *Renu Swarup, SR. Adviser, DBT & MD, BIRAC* ***Panelists*** • Arvind Gupta, Digital India Foundation • D. Chattopadhyay, IKP • Mutyunjay Suar, KIIT-TBI • Taslimarif Saiyed, C-CAMP; • P. Venugopalan, NCL Venture Center • Anil Wali, FITT-IIT Delhi

Unveiling of BIRAC's Corporate Brochure

Conclusion

The event brought together the best from India's Biotech Innovation ecosystem to not only interact with each other but to also interact with policy makers and senior government functionaries. In her concluding remarks, Dr. Renu Swarup thanked all the panelists and the participants for their contributions towards framing further action plan for BIRAC. She committed that BIRAC will take-up all necessary measures to reach its goal of supporting 2000 start-ups by 2020. She also urged all the stakeholders to continue their support envisioned for the initiatives taken by BIRAC in creating a vibrant ecosystem for startups to flourish. ■

http://birac.nic.in/webcontent/BIRAC_Foundation_Day_writeup_edited.pdf

Synthetic Biology

New Frontiers

Science as a rule is a slow, iterative process, especially for it to end up as products or processes that affect the common man – there are exceptions. Often, when technology hits the market – and especially if it is disruptive (it changes dramatically the way we do things), it makes news. Some times the expectation of a disruptive innovation and its perceived impact makes sensational news.

Ramaswamy S
Professor at Institute for Stem Cell Biology and Regenerative Medicine (inStem)

One such event was when the Craig Venter group reported the synthesis of what at that time was thought of as a minimal genome of Mycoplasma mycoides (JCV-syn1.0) in 2010. The news was that "scientists can now synthesize life in the lab". However, recently the same group reduced the size of the genome for a minimally viable organism based on the same gene (from 1079 kilo bases to 531 kilo bases), and when the manuscript appeared in the magazine Science, there was very little news. But as a scientist, the most important take home message from this effort was that out of the 473 genes that were minimally required, the function of 149 was not known. The limit of our understanding today even with a very basic microbial organism is that we don't know what one third of the apparently essential genetic information is doing. Synthesising a designer organism from scratch and giving it life looks like a far cry. This is the context of where synthetic biology is today.

The term synthetic biology itself has been defined in multiple ways with a number of interpretations. I am going to use a rather loose definition – the ability to create or modify biological systems for engineering applications. This now makes the term "synthetic biology" new and not its use. Brewers have been modifying yeast to make better beer, agronomists to make plants with desired properties, etc. So, what is new about synthetic biology? Till recently most of this engineering was by trial and error, with minimal understanding. With better understanding of biology and combining biology with our expertise of engineering and information technology we are beginning to do better. Scientists are now able to design in silico gene circuits and using chemistry synthesize these genes and using molecular biology incorporate them into living organisms and test if they work as predicted. Scientists today can do bottom-up assembly of cell-like compartments with biomolecules inside them for certain functions. Atomic resolution structures of a number of enzymes and their correlation to how they carry out their activity allows the modification of their function – and improve it by techniques like directed evolution. The knowledge of gene regulatory networks allows us to engineer cells to respond in a predictable fashion to cues from the outside.

So, why should one care? For the health care industry, this has already provided some interesting opportunities. Most drugs are natural products and difficult to synthesize in a chemistry lab. The best quoted example is that of artemesinin, the precursor of which is being made by Amyris using synthetic biology (doi:10.1038/nature04640). Attempts are on to modify bacteriophages that will selectively infect anti-biotic resistant bacteria – this is an interesting way of approaching the anti-microbial resistance problem. The ability to engineer genomes and make new model organisms is a by-product of synthetic biology. Rapid detection tests for various conditions are being developed. These are some of the direct benefits of synthetic biology.

Detecting and treating diseases and chronic conditions are one part of health care, the other part is prevention of diseases and keeping people well. Here is where synthetic biology has begun to have a large impact. We now have modified bacteria that clean up the environment. Methods to modify and improve nitrogen fixing symbionts to reduce dependence on the Haber-Bosch process produced nitrogen fertilizers are on the anvil. Many industrial chemicals (spandex, adhesives, detergents) that were previously made from oil are now being made in an environmentally benign fashion using synthetic biology approaches. The food industry is beginning to make hard to make flavours – that requires destroying plants using this technique. The benefits are numerous.

But, like with every other technology the ability to misuse technologies is also great. Prof. Martin Rees, the famous cosmologist in his Ted Talks asked "what happens when people have mastered synthetic biology" – he considered that as a big threat. I am guessing this worry is normal – the correct answer might be to paraphrase what Prof. Freeman Dyson said - it will lead to the domestication of biology.

The question that is on top of my mind is if India should jump into the Synthetic Biology wagon? The answer to this is obvious – India will lose out the first wave of those who adopt a new thought process that could benefit our environment (use synthetic biology to engineer organisms to clean the Ganga, help reduce pollution in our leather industry, reduce garbage, etc.), health (reduce the cost of diagnosis), agriculture, and industrial chemicals and biotech sectors. Given that we are too far from imagining a property and designing a gene, whose product will deliver that property – the second best solution is to learn from nature. There is almost some bacteria, fungi or living organism that does exactly what we want to accomplish in a fashion that is environmentally friendly or something close to that. If we can have a concerted effort to mine our biodiversity, India will probably have the largest collection of parts – a jargon in synthetic biology for a gene and hence its product - that can do many unique things and not available any where else. This collection of parts will be the largest intellectual property asset of India. Even, if India does not create the full systems, India can easily become the largest supplier of parts. This requires patient work, in a coordinated fashion in mission mode. India can do it - as India has demonstrated in the space Programme and atomic energy Programmes. But, do we as a nation have the will and the vision? Synthetic biology can be the mission that can transform India into a knowledge driven bio-economy. There will be challenges, but India cannot effort to miss this opportunity. ■

Ramaswamy S is a Professor at the Institute for Stem Cell Biology and Regenerative Medicine (inStem), Bangalore. Prior to joining inStem he has also serve as the CEO of the Center for Cellular and Molecular Platforms, Bangalore, and also as a Mentor at Escape Velocity Accelerator, Bangalore.

BIRAC and HIA have planned to collaborate for a joint funding programme for supporting innovative technologies and solutions for sustainable and productive horticulture at global level. ■

BIRAC and Nesta, a charity organization in UK, have collaborations for Discovery Awards to populate the innovators' pipeline for competing in the coveted longitude Prize-a- challenge programme having a prize fund of 10 million pound, to help solve the problem of global antibiotic resistance.■

BIRAC-Tekes : BIRAC has signed a letter of intent with Tekes- Finnish Funding Agency for Innovation, to explore opportunities for improving competitiveness of Indian and Finnish industries through promoting collaboration in different phases of knowledge innovation chain. ■

BIRAC and Tata Institute of Social Sciences (TISS) have come together to mentor the social innovators supported by BIRAC, so as to help them evolve in the social entrepreneurship arena. TISS will also support BIRAC in assessing the impact of its social innovation initiatives and strengthen the impact of same. ■

Welcome Aboard

Shirshendu Mukherjee has joined BIRAC as Mission Director of the Programme Management Unit of Grand Challenges India at BIRAC, which manages the multilateral collaboration of the Grand Challenges Programme of Bill and Melinda Gates Foundation; Affordable Healthcare in India Initiative of the Wellcome Trust; USAID and the Department of Biotechnology, Government of India.

Shirshendu Mukherjee

Trained as Medical Microbiologist, Dr. Mukherjee has global and national exposure with more than two decades of high level work experience in top organisations. This brings to fore his cumulative perspectives on issues related to healthcare (especially public health issues and unmet medical needs), food and nutritional challenges in India as well as across the globe. He has devised and formulated strategies for mitigating challenges and bridging gaps through impact funding. He has worked independently as well as with multitudes of partners (both national & international) for a complete oversight of cutting edge translational research and deep understanding of issues that impinge upon national and global translational research. He has deep knowledge in pharmaceuticals, biopharmaceuticals and med tech industry globally.

Before joining BIRAC, Dr. Mukherjee has worked with Wellcome Trust as Senior Strategic Advisor, India, and prior to that he was Staff Scientist at International Centre for Genetic Engineering and Biotechnology (ICGEB). Dr. Mukherjee, has managed a £30 million initiative of the Wellcome Trust for R&D in Affordable Healthcare in India.

Dr. Mukherjee holds Ph.D. in Microbiology and a Graduate degree in Law. He has undertaken high level academic courses such as Advance Course in Strategy Management from IIM Kolkata, and Management and Leadership course from Said Business School, University of Oxford. ■

ACHIRA BAGS BIRAC AWARD

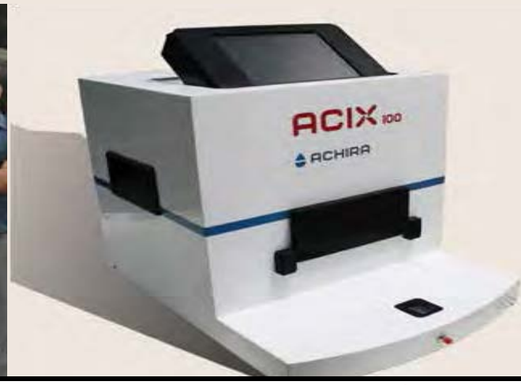
BIRAC has instituted the "BIRAC National Award for Indigenous Product Commercialization" to be given away to an organization demonstrating excellence in successfully commercializing an indigenously developed technology. The award is to be given away each year on the occasion of National Technology Day (May 11).

Achira Labs, a Bangalore based start-up, working on innovative point-of-care medical diagnostics platforms, received the first "BIRAC National Award for Indigenous Product Commercialization". Dr. Dhananjaya Dendukuri, Co-founder & CEO of Achira Labs, received the award from the Honorable President of India, Shri Pranab Mukherjee at National Technology Day event organized by the Technology Development Board at Vigyan Bhavan New Delhi on May 11, 2016. The function and awards ceremony was also graced by Dr. Harsh Vardhan, Union Minister for Science and Technology and other dignitaries from various agencies and institutions in the S&T space.

Achira Labs received the award for developing and commercializing a point of care solution that allows testing of blood samples at the doctor's clinic or a small lab at about half the cost and a fraction of the time taken by large and expensive equipment currently used for analyzing samples. This technology point of care solution, which miniaturizes the functions of a diagnostic lab on to a small chip, will empower doctors to undertake informed decisions almost immediately by having access to quantitative and confirmatory results. This success is expected to support further development of low cost technologies towards personalized health care solutions and management.

About Achira Labs

Achira Labs, a Bangalore-based company is a pioneer in developing and commercializing advanced microfluidics-based solutions for applications in diagnostics. Founded in 2009 by Dr. Dhananjaya Dendukuri (PhD, MIT), Achira has developed multiple point-of-care testing solutions for both the Indian and global markets. Achira's flagship commercial platform, ACIX 100, uses a plastic, microfluidic device to perform rapid and multiplexed immunoassays with a small volume of blood or serum. Achira has also developed the world's first fabric-based sensors to perform clinical chemistry and qualitative immunoassays. It has been recognized as one of the most innovative start-up companies in the biotechnology space in India at multiple forums and is also the recipient of grants and funding from Grand Challenges Canada, BIRAC-Govt. of India and investment from Catamaran Holdings. Achira has a portfolio of 24 issued patents across several geographies. ■



BIRAC Ideathon

Emerging bright sparks

BIRAC organized an Ideathon initiative aimed at promoting translational research in Anti-Microbial Resistance (AMR) Diagnostics.

Held on 19th and 20th March 2016, the IDEATHON brought together eight teams of bright students selected from campuses across the country in a competitive ideating exercise on the theme of AMR Diagnostics. This event was open to students and/or faculty which have not received funding support from BIRAC in the past. 10 applications were shortlisted out of all received and 8 finally participated. All 8 teams were asked to present their ideas to a Jury consisting of eminent academic and industry experts. After evaluating all presentations the jury selected two winners:

- Department of Microbiology, University of Delhi South Campus –Priyanka Bajaj (Team Leader), Abhishikha Srivastava and Bandana Kumari, Department of Biophysics, University of Delhi South Campus, Shalu Sharma, CSIR-Institute of Genomics and Integrative Biology. The prize money of one lakh rupees was conferred upon to the team.
- Central Electrochemical Research Institute, CSIR – Praveen Kumar and R. Rajaram. Theteam received the prize money of one lakh rupees, equally contributed by BIRAC and Villgro, Chennai. ■

BIRAC Hackathon and 2nd BIG Conclave

Thinking out of the Box

BIRAC along with its partners – **C-CAMP and IKP Knowledge Park**, conducted a Hackathon and BIG Conclave at Bangalore. The ***Hackathon***, aimed at ideating and hacking the innovative solutions for - Improved Point of Care Device for screening, detecting, monitoring for Non-Communicable Diseases and Assistive Devices, was conducted at IKP Eden from 13-15 June 2016. Around 16 applicants applied for the Hackathon and 10 were short listed to participate in the Hackathon. Over the period of three days, around 40 participants from 10 teams were exposed to areas of technology entrepreneurship, intellectual property and regulatory and certifications landscape related to innovations in diagnostics and devices. A pool of mentors from diversified fields including experts in diagnostics and instrumentation, tech entrepreneurs including BIRAC grantees, academic entrepreneurs and patent attorneys hand held the participants throughout the Hackathon and helped them in evolving their ideas to prototypes. IKP Eden's facilities in engineering tools, including 3D printing aided the participants to try their hands at the machines and build a working prototype for evaluation. On the concluding day, the teams presented their hacks and the business model to an eminent panel of Jury. Four Teams were then adjudged as: one Winner, one 1st Runner Up and two 2nd Runner Ups, and were felicitated at the 2nd BIG Conclave held at C-CAMP, from 16-17 June 2016.

2nd BIG Conclave organized at C-CAMP witnessed the confluence of experts from Industry, Academia, Law firms and BIRAC BIG Entrepreneurs. The conclave was a platform for the BIG Grantees to showcase their journey as an innovator and entrepreneur reflecting the aspects of starting small, scaling up, USPs of the technology, business models, investment pitch, scouting for and building the team, patenting and licensing strategies, regulatory challenges, and incubation and mentoring. Entrepreneurs and experts shared their entrepreneurial journey and experiences of and knowledge about the innovation ecosystem in the country, which benefitted the audiences immensely. Around 200 participants leveraged the Conclave to make and expand their networks for collaborative opportunities. 35 Posters were showcased during the event and Best Posters were awarded in the concluding session. The two day event concluded with the Valedictory ceremony for the BIG Grantees from the 3rd Call of BIG. ■

Best Hacks were awarded at the 2nd BIG Conclave

Pawan K. Dhar

CRISP editing towards engineering genomes

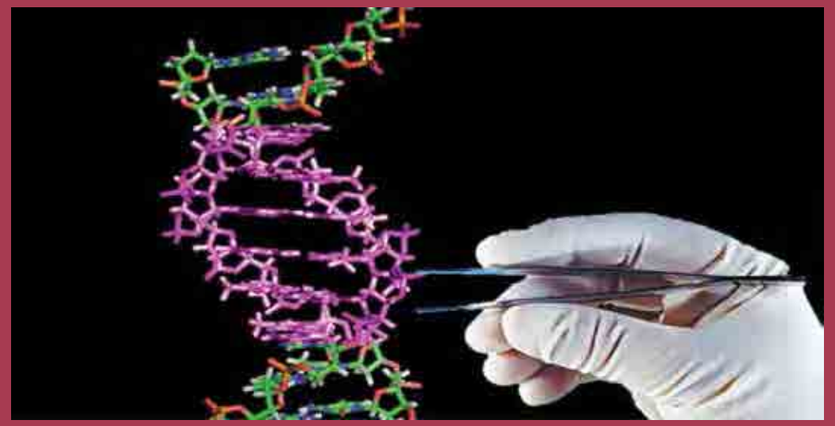
Genome Editing describes precision engineering in the form of addition, removal or replacement of DNA sequences at designated locations. This approach comes under a vast landscape of Genome Engineering that involves rational design of biological components towards useful applications. Components used in biological construction include parts (genes, RNA, proteins), modules (e.g., operons) and pathways (or networks).

Pawan Dhar
Professor and Head
Synthetic Biology Group
School of Biotechnology,
Jawaharlal Nehru University, Delhi

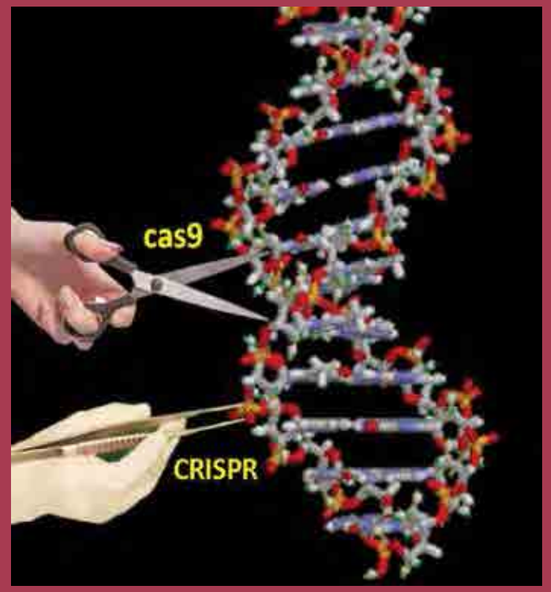
Demolishing to Designing

The classic scientific approach of studying biological systems has predominately followed a reductionist philosophy i.e., break up a cell into its constituent components and study elements one-at-a-time. In popular terminology, this approach is known as molecular biology and biochemistry. Though reductionism has been immensely successful, it gave rise to a large number of parts creating enormous challenge of explaining the phenotype as a function of individual part-behavior. To fill in this gap, a second approach was proposed i.e., create computational models of parts stitched together into virtual pathways and networks and do biology in-silico. This led to the emergence of what we know as Systems Biology. Nearly a decade back, a third approach of understanding biology emerged i.e., design and build complex systems from a standard inventory of biological components. This is popularly known as Synthetic Biology.

Building biological systems calls for rigorous engineering equivalent standards and rules of composition. Interestingly,



Pawan Dhar is the Professor and Head, Synthetic Biology group, School of Biotechnology, JNU, New Delhi. Prior to this he held faculty positions at RIKEN Genomics Sciences Centre (Japan), Bioinformatics Institute (Singapore) Keio University (Japan), Kyoto University (Japan) and Manipal University, Karnataka.
Prof. Dhar's recent work on making artificial genes and proteins from non expressing genome has won global appreciation.



in biological sciences, both are missing. A quick and efficient alternative is to build tools for editing genomes and use them for plugging-in (or plugging-out) sequences of choice. It's like removing a brick and replacing it with another one, instead of breaking down and reconstructing the entire wall ! Also, considering the efforts and cost involved, it makes a perfect sense to edit genomes instead of reconstructing variants of entire systems.

Building the editing toolbox

Fundamentally, if one has a toolbox that can recognize specific DNA sequences and make a targeted cut, a big mission gets accomplished. This is exactly what a special class of enzymes called nucleases do. They cleave phosphodiester bonds between the nucleotides producing a nick. However, nuclease are not sequence-specific and must be transported to a predefined genomic address. This is where editing component comes into the picture.

To make the nick sequence specific, three major classes of nucleases have been engineered, namely **Z**inc **F**inger **N**ucleases (ZFN), **T**ranscription **A**ctivator-**L**ike **E**ffector **N**ucleases (TALEN), and CRISPR/Cas systems.

ZFNs consist of a Fok 1 nuclease component latched onto a 'three nucleotide recognizing' zinc finger protein. Analogous to a digital lock where different digit combinations can be set for closing and opening the lock, the zinc finger proteins can be engineered to break the DNA sequence of choice. Similarly, TALENs use a Fok 1 nuclease domain fastened to a DNA recognition site with a tiny difference that the TALEN toolkit talks to DNA repeat sequences (and their combinations) for breaking DNA at precise locations.

The CRISPR/Cas system is a recent offshoot and employs a guide ribonucleic acid to find target genes and uses Cas9 nuclease to cut the DNA. Unlike ZFNs or TALENs, this method does not use a protein-based DNA recognition domain. Instead, it uses an RNA dependent DNA interaction using CRISPR (**C**lustered **R**egulatory **I**nterspaced **S**hort **P**alindromic **R**epeats) to guide the Cas9 nuclease to a predefined site in the DNA sequence and enable Cas9 cut the DNA sequence.

Genome Editing tools like ZFN, TALENs and CRISPR have potential to revolutionize biological research if the specificity issues of target recognition are effectively addressed. Currently the path from genotype edits to phenotypic outcome via expression and interaction layers is unclear. There is a need to develop methods to make edits more accurate, easy and less expensive.

From incision to industry

The CRISPR / Cas9 system has triggered a huge wave of excitement due to its enormous potential to generate applications e.g., in autologous cell therapy where defective genes can be knocked out ex-vivo and cells delivered back to the patient, introduce antiviral resistance genes, inhibiting viral replication, spatiotemporal reprogramming of genes in stem cells, to induce herbicide tolerance in plants, increased muscle growth in domesticated meat animals, treatment of eye diseases, tracing developmental lineages from handful of cells to the whole organisms and to the treatment of breast cancer, thyroid cancer, lung cancer, Beta Thalessemia, Huntington, Alzheimers. Furthermore, there is interest in creating mammalian models of human neurological diseases like Alzheimer's. However, irrespective of these exciting scientific developments there is a grave concern about biosafety and biosecurity aspects that must be addressed as the technology evolves.

Some more

It would be relevant to mention that the power of genome editing has given rise to debates on responsible innovation and regulation. The community is currently discussing legal, ethical and safety issues. It is unclear if the products delivered through elegantly edited genomes fall under the category of

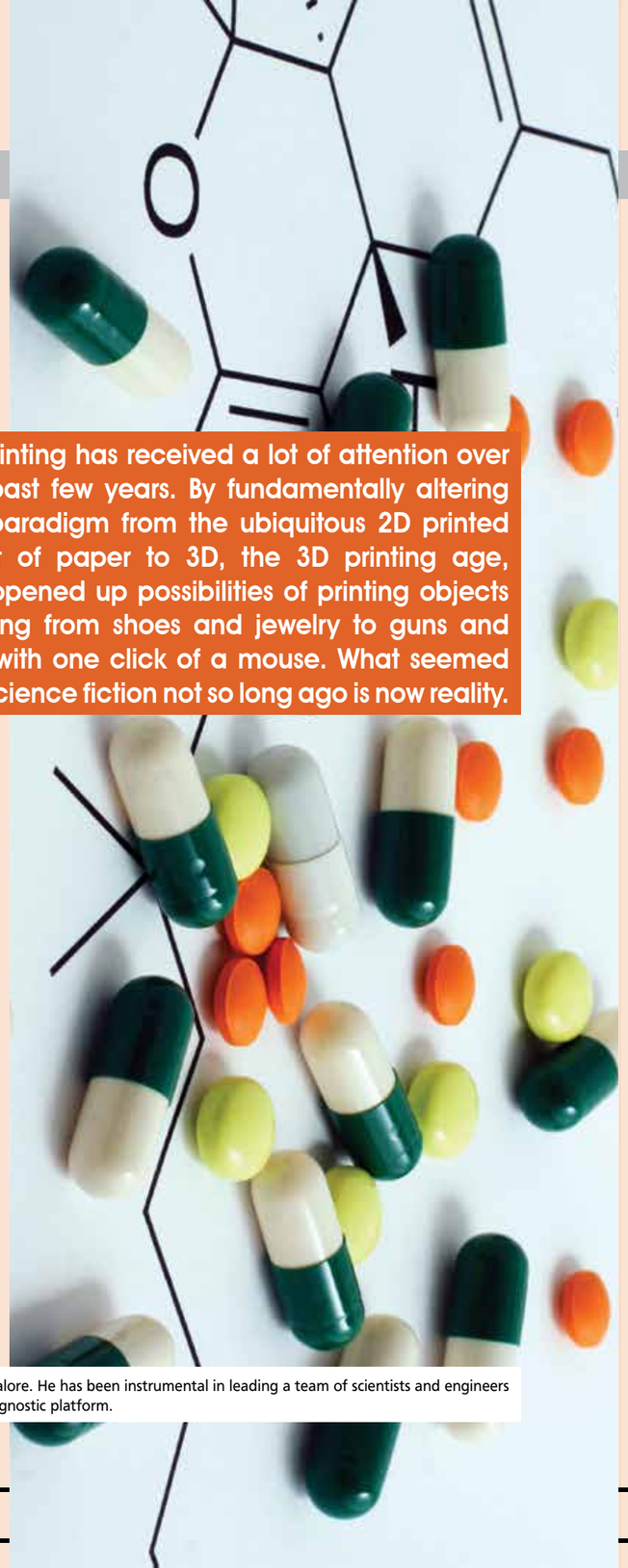
Contd. on Pg. 23

3D Printing

Impressions on Health

Dhananjaya Dendukuri
CEO, Achira Labs

3D Printing has received a lot of attention over the past few years. By fundamentally altering the paradigm from the ubiquitous 2D printed sheet of paper to 3D, the 3D printing age, has opened up possibilities of printing objects ranging from shoes and jewelry to guns and toys with one click of a mouse. What seemed like science fiction not so long ago is now reality.



There are several different kinds of 3D printers with popular types of 3D printing including Stereo lithography (SLA), Selective Laser Sintering (SLS),Selective Laser Melting (SLM), Fused Deposition Molding (FDM) and Thermal Inkjet Printing (TIJ). In the healthcare industry, SLM, FDM and TIJ have been more commonly used. In FDM, plastic is melted and extruded through a nozzle and deposited layer-by-layer on a moving platform to build a part. The most low-cost and widely available printers are based on FDM and are already being used in several model-making applications. TIJ is a non-contact mode printer, much like an existing inkjet printers, that use pulses of bubbles to eject droplets of melted plastic or other substances on to a platform. TIJ has been found to be particularly useful in organ and tissue printing. SLM has been used to custom print metallic parts including implants. Biocompatible metal powders like titania are melted and fused locally using a laser to make parts. A major part of the revolution in 3D printing has been driven by the access to cheaper computing power and improved algorithms to slice and dice 3D objects into printable 2D layers.

Dr. Dhananjaya Dendukuri is the Co-Founder and CEO of Achira Labs, Bangalore. He has been instrumental in leading a team of scientists and engineers at the company to develop India's first microfluidic point-of-care medical diagnostic platform.

The application of 3D printing to healthcare is particularly exciting for several reasons. Unlike existing technologies like molding or casting, each 3D printed part can be unique, leading to customization and personalization that was simply not possible before. A 3D printed hearing aid can be custom-made to fit into exactly your ear. Over 99% of hearing aids printed today are already 3D printed. Next, 3D Printed parts are available on demand at very affordable prices. Already in India, there are several companies offering both 3D printers for under Rs. 50,000 and 3D printed parts for a few 1000 rupees each. Unlike the past where a custom machined implant for a complex surgery could take days to design and fabricate, a 3D printed prosthetic part or implant could be available in a few hours. Further, surgeons are now using 3D printers to print entire models of the skull or other critical parts of the body to simulate the sequence of steps involved prior to a complex surgery. Existing CT or MRI scans of a body part are ported to a 3D printer and simply printed out in 1:1 scale for easy examination. Third, 3D printed parts can be made in shapes and geometries that were just not possible to fabricate earlier. Since many geometries found in nature and even inside the human body are incredibly complex, this capability to reproduce complex parts almost perfectly opens up several new possibilities. Finally, the collaborative possibilities introduced by the cloud computing revolution mean that one can now download or upload millions of unique designs. Without reinventing the wheel, a new user can access complex part designs and shapes that she would have had to make from scratch before.

There are several new areas where 3D printing is already making an impact in healthcare. Possibly the most exciting and futuristic area is organ and tissue printing. Although a 3D printed heart or liver is still several years away, the developments in this field have been very exciting. By printing both complex scaffolding and placing different kinds of cells at different locations, bio-inkjet 3D printers have the capability of building a complex organ bottom-up. Several exciting advances have been made in this area recently including the printing of vasculature which is critical to the transport of oxygen and metabolites around cells.

With all the promise of 3D printing there are some challenges and issues that need further discussion and debate. It is also important to separate some of the hype around 3D printing from what is possible today. While implants, prosthetics and models from 3D printers are already around us, 3D printed organs and tissue are still several years if not decades away. Secondly, the quality and finish of 3D printed parts does not still match mature technologies like injection molding or casting at the same price point. Significant improvements in resolution and strength of 3D printed parts is necessary before they become available for regular home use beyond one-off models. Thirdly, the choice of materials available for 3D printing is still limited although it is growing. Many complex biological parts need combinations of different materials which will need significant improvements in the hardware and software used in 3D printing. Finally, there is still some lack of clarity around the use of 3D printed parts as medical devices. The FDA constituted a workgroup in 2014 to discuss approval processes for 3D printed parts. In summary, there is already massive impact and tremendous excitement about the promise of 3D printing in the healthcare industry. Several important challenges remain that should be seen as an opportunity by new hardware and software companies. Several new applications remain to be discovered and the potential for revolutionary change is immense. ■

Figure 1: from L to R, a 3D printer printing an organ, a 3D printed prosthetic hand, first FDA approved, 3D printed polymer facial implant from Oxford Performance Materials

Grand Challenges India

The mandate of Grand Challenges India (GCI) programme is to address some of the critical challenges confronting health and development issues in India. The initiative is further strengthened with the Wellcome Trust, UK, joining the collaboration. The Programme fosters Indian innovation and research to develop affordable and sustainable solutions to improve health and ensure well-being of humankind globally.

Different Strokes

GCI tries to galvanize the potential of young and established investigators by piloting their projects within a series of thematic calls announcements or definite initiatives to be jointly funded by Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India (GoI) and the Bill and Melinda Gates Foundation (BMGF) to improve public health and beyond. The Programmes launched under GCI partnership have been shaped by experts who are luminary in their fields. Since its inception three successful calls have been launched under GCI initiative:

Achieving Healthy Growth through Agriculture and Nutrition

The Grand Challenges framework announced **"Achieving Healthy Growth through Agriculture and Nutrition"** as the first initiative under 'GCI' Programme with support from DBT, United States Agency for International Development (USAID), and the BMGF. The goal was to fund a portfolio of Indian-led pilot projects that seek to target the relationship between agriculture, nutrition, and health and to reduce the high incidence of low birth weight and early stunting and wasting among Indian infants through interventions. The primary measures of success were improvement in the survival, health, development, and quality of life of Indian children from 0-2 years of age and in women of reproductive age. Five projects undertaken under this initiative includes:

- **Enabled and Community-Driven Integrated Agriculture and Nutrition Intervention:** Digital Green conducted an external operational pilot study using a cluster randomized controlled trial (RCT) design in 30 villages to translate knowledge into optimal nutrition-sensitive agricultural and *Maternal, infant, and young child nutrition* (*MIYCN*) practices.
- **Vegetables through Veggie Lite Express:** The project involved vegetable value chain, as an integrated approach of demand-driven vegetable production for inclusive development of women. A Veggie Lite Express vehicle has been running to slum areas, selling vegetables to slum population at lower prices. The investigator has also started a missed call campaign for raising nutrition awareness among pregnant and lactating women; fruits and vegetables have been delivered at the doorstep for orders placed by people through the missed call service.
- **Integrated Farming:** The Annamalai University intended to pilot Integrated Farming System (IFS) models in the district of Cuddalore. The proposed pilot study covered six villages comprising of both upland and wetland agriculture that have similar agro ecological identities. Through the IFS designs the women who are small holder farmers, their household diet diversity was studied with enrichment of animal protein vegetables and honey.
- **Solar conduction Dryer – "Urja Mitra":** The project aimed to process fresh fruits and vegetables during seasonal availability of agri-produce to dehydrated form and ensure its availability for entire year and also for sale in open market. Tripartite intervention includes; reduce post-harvest losses; ensure nutritional security for the entire year in form of dehydrated product; ensure extra income to women farmers by sale of dehydrated products.
- **Boosting Micronutrients:** A novel approach based study, conducting multi-location field trials on crop (wheat and rice) to reduce zinc malnutrition in rural woman and children through agronomic bio-fortification practices.

Training of Urja Mitra for use of SCD at Dr. Hedgewar Rugnalaya, Aurangabad on 11th March 2015.

Reinvent the Toilet Challenge (RTTC)

Globally, issues related to poor sanitation result in 1.5 million child deaths and are responsible for the stunting of 62 million children less than five years old each year. **"Reinvent the Toilet Challenge"** initiative was launched in October 2013 to encourage grantees to drive research and development of low cost, eco-friendly and efficient 'next generation toilets'. A combined investment of US $2 million from DBT and the BMGF was pledged towards the initiative. To take the second GCI initiative forward, BIRAC partnered the conference titled- "International Congress on Green Urban Futures - *Urban Sanitation Challenges in the Developing World: Initiatives and Innovations" in association with Centre for Urban Green Spaces*, held in Bangalore, India. One of the primary themes of the conference was "Urban futures: Water and Sanitation". The projects supported under RTTC are:

- **Biological Control:** The use of viral agents, microbial fuel cell and effective recycling strategy was promoted to improve the economics of human waste disposal.
- **Anaerobic Digestion and Wastewater Treatment:** This project empowered septic tank as decentralized wastewater treatment system.
- **Transformative Technology:** The proposal led to field testing of off-grid, self-sustained, modular, electronic toilet for slums, with solar energy for Indian weather and integrated with mixed waste processing unit, with water, energy/ fertilizer recovery.
- **The Next Generation Dry Toilet:** It is a hygienic water-free toilet for preliminary design and optimization and fabrication of test-bench setup.
- **Innovative Community Toilet System:** An enterprise-driven high quality community toilet system sustaining on commercial values generated by Black Soldier Fly larvae grown on human faeces and by fertilizer derived from urine.
- **Eco-Toilet:** The project was planned with a functional metal bowl design having attached high power ultrasound transducers along with tiny flow of wash water from the tank which will scrub the bowl clean thereby removing the aspects of manual cleaning.

All Children Thriving (ACT)

The World Health Organization (WHO) has estimated that globally, over 6 million children below 5 years of age die every year and approximately 165 million have stunted growth. Although, birth defects, adverse pregnancy outcomes and developmental disabilities in children are interrelated functioning of several known determinants (such as maternal health, nutritional deficiencies, infectious diseases, genetics, enteric health, water, and sanitation). Incidentally, much remains unknown about the root cause. The ACT was launched as a third call under GCI framework in October 2014, on the occasion of 10th Anniversary of Annual Grand Challenges Meeting. The Programme intends to investigate novel cost-effective measurement tools or combination of approach and putting best strategies in place actions to ensure healthy productive life of all children and generating improvement in maternal and child nutrition. The initiative 'All Children Thriving' aimed to fund seed grants at US$ 250,000 for two years and full grants at US$1 million for four years. ■

The proposals selected for grants are:

- **Overcoming Challenges to Accelerate Linear Growth:** The proposal is aimed at improving linear growth of children in low income settings through household supported integrated nutritional environmental WASH and care interventions in pregnancy and early childhood.
- **An Intergenerational Prebiotic Approach to Establishment of a Healthy Colonic Micro Biome in Infants:** The study intends to develop an inter-generational intervention to ameliorate neonatal gut microbiota.
- **Building Better Biobanks or Archives for Knowledge Driven Interventions:** The proposal is aimed at creating a biorepository and imaging data bank for accelerating evidence generation to facilitate children to thrive.
- **Early Growth Biomarker:** This prospective study is aimed at establishing simple absolute neutrophil count as a measure of mucosal inflammation and as a predictor of linear growth in Indian infants.
- **Effect of Depression on Pregnancy and Biomarkers for Adverse Pregnancy Outcomes:** The study was planned to analyze the stress outcomes on pregnancy, fetal growth and birth weight development of methods and to identify mothers at risk of preterm birth (PTB) and intrauterine growth restriction resulting from maternal stress.
- **Novel Test for PTBs:** The proposal will test and validate the low-cost salivary progesterone for detecting the risk of PTBs in rural community settings of India.
- **Biofortification for Better Health:** The proposal is aimed at enhancing nutritional security of pregnant women, infants and young children in rural households of Tamil Nadu, India through agricultural intervention.

Way Forward

Grand Challenges Explorations (GCE) - India Round 1:

The GCE India call was launched on 15th May 2016 with specific aims to focus on seeking India specific innovations. The problem statements that align with the goals of GCE-India are listed below:

- Develop methods for simple preparation and preservation of stool samples for room-temperature transport and remote-analysis.
- Enable self-testing for cervical cancer.
- Develop Point-of-care nucleic acid diagnostics to below $2 per test.
- Develop malaria diagnostics to accelerate toward eradication.

Scientific Advisory Committee (SAC) Meeting:

The first SAC meeting was held on 25th May 2016 to advise GCI on specific scientific challenges and strategic directions that will meet stakeholder's objectives. The SAC includes the stakeholders and experts from diverse fields including Public health, Agriculture and related arenas. The SAC will advise on all areas regarding strategic and scientific opportunities related strategic planning of GCI India.

Knowledge Integration and Translational Platform (KnIT):

The first Knowledge Integration and Translational Platform (KnIT) SAC meeting was held on 29th June, 2016 to plan strategic directions. KnIT is a new GCI initiative that will provide evidence and experience based guidance on how to accelerate progress, equity, impact in public health system redesign. KnIT is focused on interventions, on packages of multi sectoral interventions, ways to deliver these combined with health system adaptations to improve converge, quality, equity, impact, sustainability in a cost efficient manner.

India Pride Award for BIRAC

Romping home

Dainik Bhaskar has instituted "India Pride Awards" as a tribute to the contributions made and excellence determined by the PSUs in public services. The seventh edition of India Pride Awards held on 4th April 2016 at New Delhi was integrated with the concept "Make in India".

BIRAC won *Excellence in India:* *Image Enhancement/ Creating a Global Brand Award*. Dr. Renu Swarup, Senior Adviser, DBT & MD, BIRAC received the award. The award was given away by Shri Ravi Shankar Prasad, Union Minister for Communications and Information Technology, Govt. of India.

Shri M. Venkaiah Naidu, Union Minister of Urban development, Housing and Urban Poverty Alleviation and Parliamentary Affairs was the Chief Guest at the Awards Ceremony while Shri Radha Mohan Singh, Union Minister for Agriculture, was the Guest of Honour of the evening.■

BIG, SBIRI and BIPP

Focus on New Technologies

BIRAC endeavours to promote the development and commercialization of new technologies in the areas of biopharma, bioagri, industrial biotechnology, med tech, bioIT, synthetic biology, system biology etc. To aggrandize the role of biotechnology in the growth of economy, Birac provides funding and mentorship support from idea to commercialization and pave the way for new technologies to make space in existing market, through its diversified programmes.

BIG (Biotechnology Ignition Grant): Flagship start-up funding programme of BIRAC which provides the right admixture of fuel and support to young start-ups and entrepreneurial individuals. These individuals can be researchers from academia or startups. Selected grantee/s are given Seed grant of up to INR 50 lakhs for research projects with commercialization potential with duration of up to 18 months. It is managed by BIRAC along with five BIG Partners (C-CAMP, Bangalore; IKP Knowledge Park, Hyderabad; FIIT, Delhi; Venture Centre, Pune; and KIIT, Bhubaneswar) to provide mentoring, monitoring, networking and other business development related activities at the ideation stage itself to nurture new technologies. 158 startups and entrepreneurs have been supported through BIG.

SBIRI (Small Business Innovation Research Initiative): Early stage, innovation focused PPP initiative in the area of Biotechnology, aims at funding high risk innovative R&D beyond proof-of-concept, and support in form of grant-in-aid for projects up to INR 100 lakhs in PPP mode. Support has been extended to 165 companies in diverse fields of frontier biotechnology.

BIPP (Biotechnology Industry Partnership Programme): Support for high risk, accelerated technology development especially in futuristic technologies having major economic potential and focused on IP creation. It provides for

- Product evaluation and validation through support for limited and large scale field trial for agriculture products and clinical trials (Phase I, II, III) for health care products
- Financial support by BIRAC up to 50% of the approved project cost
- Funding support in form of grant-in-aid with corresponding obligation of royalty payment
- Support extended to 130 companies that are attempting to bring high quality products through cutting edge R&D. ■

Workshop on

Bio-Entrepreneurship, Grant-Writing and Intellectual Property Management

7th– 8th January, 2016 | Chennai

BIRAC organized a two-day workshop on "Bio-entrepreneurship, grant writing and intellectual property management" in association with Anna University, Chennai on 7-8 January, 2016.

The workshop was attended by a total of 68 participants including representatives from academic institutes, medical colleges, hospitals, small and medium scale industries and aspiring entrepreneurs engaged in the biotech based businesses.

Day: 01 (7th January 2016)
A galaxy of eminent scientists and entrepreneurs were present at the inaugural function. These included Dr. P. M. Murali, President, ABLE & Managing Director, Evolva Biotech Pvt. Ltd, Dr. Sanjay Saxena, Head Investment, BIRAC, Dr. S. Srinivasan, Dean, Alagappa College of Technology, Anna University, Dr. K. Sankaran, Chief Co-ordinator, University Innovation Cluster, Anna University and Dr. S. Meenakshisundaram, Deputy Co-ordinator, University Innovation Cluster, Anna University.

The first day of the workshop focused on BIRAC's grant mechanisms and how the aspirant entrepreneurs could avail of the same. In their presentations Dr. Sanjay Saxena, pointed out the role of BIRAC in creating Bio-Innovation ecosystem while Dr. Shilpi Gupta, Sr. Manager Technical, BIRAC detailed salient aspects of BIRAC's funding schemes. A full session was dedicated to the key elements of Grant Writing wherein the participants were addressed by Dr. V. S. Reddy, Former Group Leader, Plant Transformation group, ICGEB. Dr. Reddy explained to the participants the nuances of writing effective and successful proposals. This was followed by a hands-on exercise on grant writing.

The second session focused on the nature of Chennai Bio-innovation Ecosystem & major opportunities and challenges for start-ups. Dr. Guhan Jayaraman, IIT Chennai talked about the start-up culture in Chennai, bio incubators and academic policies required for encouraging innovation/translational research in academic institutes.

The last session of the day was devoted to sharing of preneural the experiences by past BIRAC grantees with the workshop participants, In the session Dr. Gowrishankar (BIG Grantee) & Dr. Kavitha Sairam (SBIRI grantee) recounted their experiences with BIRAC. They made a special mention of of the support and the mentorship provided by BIRAC and also applauded the high levels of transparency in systems and professional behaviour of BIRAC officials.

These sessions and lectures were interspersed with free-wheeling discussions on pertinent issues.

Day: 02 (8th January 2016)
The second day of the workshop was dedicated to Securing & Exploiting Intellectual Property Rights In The Biotech Sector. An invigorating talk by Mr. G. Arun Kumar, Partner, K&S Partners dwelt upon the requirements of drafting a patent specification and key considerations for patenting in life sciences while also explaining the Patent Cooperation Treaty and procedures to be followed for registration of patent in India.

Ms. Swapna Sundar, CEO, IP Dome spoke on Intellectual Property Rights for Entrepreneurship and discussed with the participants the importance of IP for new entrepreneurs with real examples.

The last session of the workshop focused on the "IP & Business: Intellectual Property, Innovation and New Product Development". Mr. Jatin Vimal Kumar, President, Shasun Pharmaceuticals Ltd. shared this experiences with the participants and gave advice on how to build a successful enterprise by adopting IP strategies and how to develop an IP driven business.

To conclude, Dr. Shilpi Gupta, summed the discussions and deliberations during the course of the workshop and also sought formal feedback on the workshop from the participants. ■

23rd & 24th June, 2016 | Jammu

BIRAC conducted a two day Workshop on ***Bio-Entrepreneurship, Grant Writing and IPR Management at CSIR-Indian Institute of Integrative Medicine (IIIM)*** at Jammu on **23rd & 24th June, 2016.** The workshop was well represented by about 78 participants from academia and industry. The two day workshop highlighted BIRAC's role in encouraging and creating Bio-Innovation ecosystem, through its various schemes, and key features of Contract Research Scheme were discussed.

An effective grant writing session and hand-on training was conducted by Dr Shirshendu Mukherjee, Mission Director, Project management Unit (BMGF-DBT-Wellcome Trust), BIRAC. The session was well received by the audience, who requested for more time allotment to the session. Dr. Sujay Shad, a BIRAC grantee, from Sir Ganga Ram Hospital, shared his experiences of entrepreneurship in Life Sciences Sector. Moreover, IIIM itself being a BIRAC grantee shared learnings from the BIRAC programme.

The workshop also focused on imparting IP related knowledge among the audience. The IP component of the workshop talked about Patentable Subject-matters, Key considerations for patenting in Life Sciences, procedures of drafting and bio piracy. The participants requested for discussion on recent amendments, Genetically Modified Organisms, patenting of cloned genes & microorganisms, and legal issues related to patenting. ■

Pawan K. Dhar

CRISP editing towards engineering genomes

Contd. from Pg. 15

GMO regulation? There have been calls for regulating the end products instead of the technique itself. Given that biological technologies are almost always dual use, there is a risk of creating cheap and dirty versions of harmful microbes.

To protect good science, it's time to debate and reach a consensus on the best practices in this emerging field of tremendous value.

Suggested Readings

Barrangou, R et al. CRISPR provides acquired resistance against viruses in prokaryotes. Science 2007: 315, 1709–1712.

Carroll D et al. Regulate genome edited products, not genome editing itself. Nature Biotech 2016: 34, 477-479.

Jinek, M et al. A programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity. Science 2012: 337, 816–821.

Ran et al. Genome engineering using the CRISPR-Cas9 system. Nature Protocols 2013: 8, 2281-308. ■

BIRAC PROGRAMMES

SITARE (Students Innovations for Advancement of Research Explorations)

BIRAC SRISTI GYTI AWARDS: Aimed at supporting the innovations and creativity at grassroot level among the university students, including individual innovators.

eYUVA (Encouraging Youth for Undertaking Innovative Research through Vibrant Acceleration)

- ***University Innovation Clusters (UIC):*** UIC initiative seeks to create an entrepreneurial culture in the Universities and help students to take their novel ideas to proof of concept.
- ***SIIP (Social Innovation Immersion Programme)*:** A fellowship programme that builds the next generation of social entrepreneurs by helping them 'immerse' and interface with communities to identify gaps and then work on bridging the gaps through an innovative product or service offering.

Discovery, Early and Late Stage Funding

- ***BIG (Biotechnology Ignition Grant):*** Biotechnology ignition Grant (BIG) is available to scientists, entrepreneurs from research institutes, academia and startups, to stimulate commercialization of research discoveries by providing very early stage grants to help bridge the gap between discovery and invention.
- ***SPARSH (Social Innovation Programme for Products Affordable & Relevant to Societal Health):*** SPARSH combines social innovation and biotechnology for the well-being of the society by helping identify and support cutting edge innovations towards affordable product development with potentially significant social impact. SPARSH provides support in the form of impact funding and fellowships.
- ***SBIRI (Small Business Innovation Research Initiative):*** It is the early stage, innovation focussed PPP initiative to support incremental R&D in the area of Biotechnology to facilitate innovation and risk taking by SMEs.
- ***BIPP (Biotechnology Industry Partnership Programme):*** BIPP seeks to provide support for early to late stage high risk biotech R&D by industry and/or accelerate commercialization of new indigenous technologies.
- ***CRS (Contract Research Scheme):*** CRS scheme supports academic institutes to take forward research leads through a validation and translation cycle by the industry. Funding is in the form of grant given to both the academic as well as the industrial partner.

BIRAC BioNEST (BIRAC – Bioincubation: Nurturing Entrepreneurs for Scaling up Technology)

Birac's Flagship programme which has created 15 world-class bio-incubators to provide incubation space, mentor networks, instrumentation facilities, IP and technology management support.

Collaborative Funding

- ***Indo-French Centre for the Promotion of Advanced Research (CEFIPRA):*** Support high quality bilateral research, encourage and enable Indo-French collaboration between public, private research groups, industry, clinicians and end-users in the domain of red biotechnology.
- ***Wellcome Trust, UK:*** Support innovations in translational medicine in the domain of diagnostics for infectious diseases.
- ***Grand Challenges India (GCI):*** A consortium of DBT, Bill & Melinda Gates Foundation, Wellcome Trust, USAID, and BIRAC, focussing on supporting innovations in the areas of maternal and child health, agriculture and nutrition, sanitation and infectious diseases.
- ***USAID and IKP Knowledge Park:*** Support for new diagnostic tools for TB, with funding commitment of INR 5 crores for 3 years.
- ***Horticulture Innovation Australia (HIA):*** BIRAC-HIA Joint funding programme for supporting innovative technologies and solutions for sustainable and productive horticulture at a global level.
- ***NESTA, UK:*** BIRAC partnership with Nesta, a charity organization in UK, is aimed at supporting Discovery Awards Programme for innovators working for innovative diagnostics for anti-microbial resistance (AMR).
- ***Industry Innovation programme on Medical Electronics (IIPME):*** BIRAC in partnership with DeitY (Department of Electronics and Information technology) launched IIPME for supporting innovations in medical electronics and med devices sector.

Equity Funding

- ***SEED (Sustaining Enterprise and Entrepreneurship Development) Fund:*** Financial equity based support to start ups and enterprises through bio-incubators for scaling enterprises.
- ***AcE (Accelerating Enterprises) Fund***: A Fund of Funds to scale-up R&D and innovation in biotechnology domains of sectors such as healthcare, pharma, medical devices, agriculture, sanitation and many more.

ACTIVE CALL FOR PROPOSAL	FORTHCOMING CALL FOR PROPOSAL
Biotechnology Ignition Grant (BIG) | 01 July-2016	Contract Research Scheme (CRS) | 01-August-2016
BIPP/SBIRI | 15-June-2016	Social Innovation programme for Products Affordable & Relevant to Societal Health (SPARSH) | 15-August-2016

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