DBT-TDNBC-DEAKIN– RESEARCH NETWORK ACROSS CONTINENTS FOR LEARNING AND INNOVATION (DTD-RNA) NEWSLETTER

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The Energy and
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MESSAGE FROM DR SUCHITA NINAWE,

Adviser, Department of Biotechnology, Ministry of Science and Technology, India

"An extensive and focused research on nanomaterials for over couple of decades have revealed their extraordinary potential to not only solve and considerably improve but in some cases revolutionize many technology and industry sectors."

The field of nanotechnology have observed tremendous progress in recent years and have found practical applications in several areas such as energy, food safety, agriculture, security, medicine, healthcare & diagnostics, information technology and environment. The ability of nanotechnology to provide efficient and cost-effective solutions to various critical needs of people across economies is serving as the major driver for advanced research in this field.

Department of Biotechnology (DBT) has played a key role in undertaking nanobiotechnology related flagship programs, major investments, establishing Centre of Excellence (CoEs) and enhancing laboratory facilities, in addition to developing human resources and forging international collaborations. DBT had always emphasized on formation of required set of nanoproducts' procedures for researchers and industries and has released first "Guidelines for Evaluation of Nanopharmaceuticals in India" and first "Guidelines for Evaluation of nano-based agri-input and food products in India".

Nanotechnology has also been important in terms of industry-academia partnership. The whole ecosystem of the research program is now focussed on bringing stakeholders connections. Partnerships are no longer limited to individually driven project, however, have been promoted from single- to multi-investigators projects from beginning with single investigator projects to multi-investigator projects. Similarly, it has progressed from single institute to multi-institutional projects with a vision towards consortial projects. Irrespective of the challenges associated with the industry-academia partnerships, it is satisfying to see the lines of demarcation getting blurred to a greater extent. I believe with more and more partnerships coming in, the start-ups and entrepreneurs will play a major role. The partnerships emerging from our nanobiotech program now need to be strengthened, where the programmes such as "DBT -TDNBC - DEAKIN – Research Network Across continents for learning and innovation (DTD-RNA)" could play an important role in taking them forward. It is very important to identify sector specific disruptions that involve products, technology, on-going research along with the models of partnership, institution and governance with a motto of delivering what we envisage.

I strongly encourage all the stakeholders of Nano-community who are the future of this century and whose knowledge would contribute significantly for betterment of the academy and society at large. Nanotechnology has huge potential to change people's lives especially in the areas of health and agriculture. Both these areas are important across the continents. Collaborations build within DTD-RNA would help countries towards a greener and more advanced use of nanotechnology to help resolve challenging agricultural and biomedical issues. I believe that partnership matters greatly to shape the future and therefore great teams must come together whether they are multi-disciplinary or multi-cultural to make a change that can create global impact. Our world is a much smaller place but the need for scientific solutions is more pressing. DBT has huge expectations from this network, specifically on the great challenges of the next decade that our generation will face.

MESSAGE FROM

PROFESSOR IAIN MARTIN,

VICE CHANCELLOR, DEAKIN UNIVERSITY

In mere months, the COVID-19 pandemic has had enormous impacts globally. The scale and effects can be difficult to fathom, as they extend to the underlying systems that support our societies and are redefining how we perceive and plan for our individual and collective futures.

Even as the world contends with this generation-defining crisis, we must remember that there are many other complex challenges we face, such as climate change, the need for plentiful, sustainable energy, and the ongoing, rapid transformation of society via technology.

Thoughtful, transdisciplinary work continues on finding innovative solutions to these issues, and thanks in large part to our technological capability, we have the means to lessen the disruption the virus is causing across our institutions. Far from the idea of a fixed, 'new normal', there is now a continual, rolling change that requires, as we often refer to in our education lexicon: a 'growth mindset'. We are now in an ongoing process of adaptation, and we must ensure we have the appetite for it.

Indeed, for us at Deakin, the immediate emergency has dramatically sharpened our focus on what we do, and what we must continue to do well. While the strategic choices we make have always prioritised the current and future needs of our communities, we are more determined than ever to deliver tangible benefits and solutions across all of our activities. We must continue to execute our two core activities, education and research, to the highest standard possible. Deakin provides an education that prepares our students for fulfilling lives and careers, and through our research we generate and explore ideas that drive progress through innovation. For most universities, these are the two broad activities that really matter, as they are written into their charters, and by their nature create the outcomes that enable a university to deliver benefits far beyond the direct impacts they make. At Deakin, we know that education and employability, and research and innovation will be even more significant as we emerge from the shadow of the pandemic. While Deakin is a distinctively Australian university, we cannot deliver on our ambitions on our own. We need and value partnerships both in Australia and internationally. The TERI – Deakin partnership and the DBT – TDNBC – DEAKIN – Research Network Across continents for learning and innovation (DTD-RNA), are incredibly important to Deakin and what we are trying to achieve. As I have mentioned, the complex issues in the world today require the collaboration of specialists across a wide range of fields – multidisciplinary teams to solve transdisciplinary problems. In considering these global challenges that have very local impacts, Deakin has chosen five Strategic Themes that will guide all our activities and help us channel our resources and the work we do with our partners. They are:

- Advancing society and culture
- Building safe and secure communities
- Enabling a sustainable world
- Improving health and wellbeing
- Creating smarter technologies

Each of these themes contains elements where the work with our partners is relevant and where our expertise is complementary, increasing the potential for positive community impact. We have chosen these themes because they are globally important and they reflect areas where we have genuine strengths. The nature of these themes are truly of concern to the international community, which is why our partnerships with TERI and the DTD-RNA are so important. As we think about where we focus our efforts, it is vital that we identify areas where we can help bring about meaningful and welcomed progress for our communities.

> **"Change is one thing, progress is another. 'Change' is scientific and 'progress' is ethical; change is indubitable, whereas progress is a matter of controversy."**
>
> ***– (1950, Unpopular Essays, Bertrand Russell)***

I frequently turn to a quote from the philosopher Bertrand Russell to remind me that there is a difference between 'progress' and 'change' – that real progress relies on more than just good science and pursuing the allure of the new.

It is as a consequence of holding this view that we must bring together research teams that not only identify new ideas and potential solutions, but which have the skill-set to navigate pathways to adoption, commercialisation and public use. This brings me more specifically to the work that Deakin and TERI are doing together.

We are working in areas where there is a need for sustainable solutions that will support real progress; I speak not just of environmental sustainability but social and economic as well. Exploring the use of targeted nano fertiliser is a good example where targeted use can minimise run-off and environmental damage, expand the use of fertiliser and do so economically. There are other examples concerning seed coatings and water use among many others, but at the heart of all of these projects is the desire to see progress that makes a difference for our communities.

I have had the privilege of working with many international partners over the years and I am always struck by how many qualities we share – in our approaches and intentions, especially when it comes to working on research that improves wellbeing and the care of our environment.

Without global collaboration our ability to deliver truly sustainable solutions will be diminished greatly, which is why we place such value on this initiative. At this time, networks such as DTD-RNA could not be more important.

MESSAGE FROM

DR ALOK ADHOLEYA,

DTD-RNA COORDINATOR, DIRECTOR, TDNBC, PROGRAM DIRECTOR, TERI

"Each moment in history is a fleeting time, precious and unique. But some stand out as moments of beginning, in which courses are set that shape decades or centuries."

– Richard Nixon

The TERI-Deakin Nano-biotechnology Centre (TDNBC) was established in 2010 through a joint collaboration between India's research think-tank TERI and Australia's Deakin University. TDNBC came into existence through an MOU to integrate the complementary competencies of TERI (in Agricultural Biotechnology) and Deakin University (in Material Sciences) in 2010 at TERI's green campus in Gurugram, Haryana with the aim to establish world-class facilities for Nanobiotechnology Translational research using Next Generation Methodologies to create innovative and green solutions to challenges and imperative problems in the field of agriculture, environment, bioenergy and food security with a common vein "Nano-science". Research themes being pursued at the Centre have global relevance and pursued as platform flagship mission. TDNBC is also focused towards providing a platform to nurture young minds into science through Higher-Degree by Research training (PhD) via a joint PhD program between TERI and Deakin University initiated in 2010 across the defined Mission areas of

- Achieving sustainability in agricultural practices – through developing nanofertilizers, nanonutrients to reduce chemical fertilizer dosage
- Designing safe nano-delivery systems and efficient and cost effective diagnostics for agriculture - nanocarriers, nanomaterials based diagnosis of asymptomatic stages of plant pathogens
- Mitigation of environment-related problems – such as toxic chemicals and wastes – bioremediation and remediation through conversion of wastes into nanonutrients and nanomaterials with agricultutal applications
- Innovative solutions for cleaner and greener energy – using algae as sources for alternative fuels

Since its inception, TDNBC has been making significant strides in developing nanonutrients, nanopesticides and nanoformulations to develop targeted solutions for global challenges such as soil health, food security and water safety. The Centre is now uniquely poised to deliver path breaking technologies and products using biologicals interwoven with nanotechnologies and biocompatible materials. Simultaneously, TDNBC projects are also shouldering the scientific and social responsibility of providing safe and sustainable solutions to mankind. Such activities are being pursued jointly through strategic collaborations with Deakin University and over 26 academic and industrial partners worldwide across various research streams. The testimonial to this successful collaborative venture is 10 completed and 21 ongoing PhD projects on diverse topics of mutual interest to both TERI and Deakin University. TDNBC's research has been recognized through national and international conference presence, multiple awards to PhD students and faculty members. In the last decade TDNBC has produced over 120 Research publications in most reputed journals, 8 granted patents and 5 new patent applications and 26 externally funded projects to its credit. TDNBC has been able to develop multiple Nanofertilizer products and is now ready to introduce Nano Zinc-Iron and Nanophosphorus, and Nano NPK, Nano Sulphur, Nano Magnesium, Nano Boron, Nano Copper Nano Molybdenum products into the market and the products are currently under validation. These nanonutrients are required to be applied only in few grams per acre as compared to bulk fertilizers that are required in kg per acre and hence are of immeasurable value to our farmers.

Considering the importance and relevance of joint research platform, I am happy and privileged to bring to your attention that Department of Biotechnology, Govt of India has partnered with TERI-Deakin Nanobiotechnology Centre (TDNBC), Gurugram, India and Deakin University, Australia for creating "DBT -TDNBC - DEAKIN – Research Network Across continents for learning and innovation (DTD-RNA)". This newly established DTD-RNA aims to take next logical step to foster science and innovation across continents by offering a joint lab of Deakin University, Australia and TDNBC to scientists and scholars to facilitate their research aspirations and goals.

Nanobiotechnology research offers exciting possibilities in the areas of agriculture, health, food and environment and is the major focus area of DTD-RNA. Collaborations are the critical ingredient that drives innovation and knowledge creation. Translational research improves R&D productivity and reduces cost of translating new discoveries into outcomes that could potentially make difference to people's lives. Researchers and industries should work together to push the boundaries, come together to form a powerful team that is capable of driving innovation and economic growth. This network would offer a wonderful opportunity for everyone to come together, to learn from each other and move forward.

Human resource and infrastructure needs are certainly critical in translational research. Potential of this network is having university and research ecosystem along with human resource. Partnership of TERI and Deakin gives a more expanded stakeholder group, throwing out challenges which this group can respond to. Efforts are not only lacking in the research but also due to a missing link in the translational ecosystem that needs to be recognized and plugged.

TDNBC and DTD-RNA are committed to walk this path with more enthusiasm and committed to serve global communities by the knowledge and products currently pursued and to be pursued in future.

TRANSFORMING NANOTECHNOLOGY BASED INNOVATIONS TO COMMERCIALLY VIABLE PRODUCTS: **THE OPPORTUNITIES & CHALLENGES**

DR AMIT K DINDA, MD,PHD

PROFESSOR, DEPARTMENT OF PATHOLOGY, ALL INDIA INSTITUTE OF MEDICAL SCIENCES, NEW DELHI, HON. PROFESSOR, DEAKIN UNIVERSITY, VICTORIA, AUSTRALIA

Large number of scientists across the world are exploring multiple dimensions of Nanoscience and Nanotechnology for several decades after the concept of "Nano" has been introduced by the American physicist and Nobel laureate Richard Feynman in 1959. The term "Nano" has been derived from Greek word meaning "dwarf" indicating material with a very small size in nanoscale (10-9m).

In "Nano" dimension the nanomaterial acquires new unique properties which is different from the bulk material. The Engineered Nano Material (ENM) can be tailored for specific use thus making this nanotechnology an "enabling technology" which can be applied for every wakes of life. Several industries and technologies like information technology, security, health care, transportation, energy, agriculture & food as well as environmental science have successfully used nanotechnology for new generations of product and process revolutionising these domains. New materials with nanocomposite has led to generation of more durable, stronger, lightweight materials which are successfully used for tennis rackets, automobile parts, aeroplane, bicycles, motorcycle helmet, luggage, power tool and many other products. ENM like graphene, electrical conductive polymer and semiconductors has transformed nano-electronics applications in the area of information, communication and computer based technologies. Majority of the industries in diverse areas are using nanotechnology intervention not only for the finished product, but also for different steps in manufacturing and processing like use of additives and stabilisers in nano form.

In health care sector targeted nano drug delivery is a reality with multiple nanoformulations for cancer management which selectively destroy cancer cells sparing normal cells with less systemic toxicity and off target effects. With nanodrug delivery, requirement of total amount of toxic chemotherapeutic drug can be significantly reduced with marked reduction of morbidity and mortality. Nanomedicine (application of nanotechnology in medicine) has become a new speciality which is empowering the emerging field of "Precision Medicine". With nano-enabled systems, molecular targeting at subcellular level is feasible now. In diagnostic domain nanotechnology fuelled innumerable innovation in the area of molecular detection and biomarker research. The concept of "Lab-on a Chip" can be materialised to fabricate point of care devices for low cost rapid diagnosis which will make the current clinical laboratories obsolete in future. In the area of molecular imaging, simultaneous imaging and therapy (theragnosis), the nanotechnology applications are rapidly progressing. The methods of in-vivo imaging with functional assessment of any organ are improving and changing for better diagnosis and prognostic assessment. The nano intervention has made therapeutic technologies like photothermal ablation, cryosurgery more effective with less side effects. Nano-enabled prosthesis and regenerative medicine are also new realities. A large number of nanoenabled wound care products are available in the market. Complex technology like Nanoporation with Tissue Nano-transfection (TNT) can transform one differentiated cell to other phenotypes in-situ, like human dermal fibroblasts into endothelial, neuronal, muscle and other cell types. In short nanomedicine is rapidly transforming the current health care practices with scale of innovation which is difficult to imagine.

Considering the aim and objectives of the TERI- Deakin Nanobiotechnology Centre we may discuss about the emerging applications of nanotechnology in the domains of agriculture and food. Interestingly this area of application has a great impact for both human health and environment. The green revolution in India has been highly successful leading to our self-sufficiency in agricultural products and food. However the growing population burden needs development of new technology innovation which can further enhance our capacity and capability of higher agricultural output with minimal stress to environment, water resources, soil and related ecosystems. The central theme of discussion is how nanotechnology can help to develop a sustainable agriculture in India with high productivity. With growing population burden and industrialisation, managing water resource for cultivating crops is one of the most important challenge which needs urgent solution. Nano-biosensor can help to measure the requirement of water by the plants and optimise the supply reducing the wastage. Similarly nano-intervention can increase the water retention capability of the plants with reduction of requirement. The use of agrochemicals like fertilisers, pesticide and herbicide can be optimised through targeted delivery systems resulting in use of less quantity of chemicals with higher efficacy. This will help to conserve the soil and environment ecosystem. Enhancing the soil quality through soil microbiome enabled with nano-intervention is an emerging area. Application of nanotechnology in preservation of crops as well as seed protection are already in practice. In the domain of food this technology is being used for food processing as well as in the form of additives, stabiliser for nutrients and enzymes, preservative for colour, emulsification and many other indications. In the area of nutraceuticals, nanointervention has tremendous potential for enhancement of gastrointestinal absorption with better bioavailability of nutrients which cannot

be done by conventional methods. The application of nanotechnology in animal husbandry and fisheries are emerging areas which can increase the productivity in a sustainable manner.

In the brief discussion above, it is very convincing that there is huge opportunity for nanotechnology applications for development of novel products and process in any domain one can think of. This is supported by the large number of publications in this filed indicating its translational potential. India is also in the forefront of research in this area which occupies 3rd rank in global competition in the number of publication after China and USA. World over huge amount of fund has been invested both in academia and industry in this area. In spite of these achievements there is a very low success rate of converting a laboratory research to commercially viable product. India has a greater challenge in this issue as countries like Israel, South Korea are more successful in product development. This gap between proof of the concept studies and its successful translation should be bridged and identification of the challenges for nanotechnology based product development should be assessed.

The challenges may be explored under following subheading:

1. Identification of specific problem which needs a solution through ENM: Identification of specific problem and the existing solutions in the market should be critically evaluated. The advantage of nano-intervention over other existing solution should be clear.
2. Reproducibility of the data of laboratory studies: The reproducibility of result of the proof of the concept studies in laboratory is extremely important to assess the translational potential of any innovation. The laboratories working in this area with translational aim should follow the principle of "Good Laboratory Practice". The researchers should focus on accuracy of all basic laboratory procedures like weighing, pipetting, using correct chemicals etc. to generate quality result which is reproducible.
3. Filing of patent and protection of Intellectual Property Right (IPR): The IPR should be protected before disclosing the innovation in conference or publication. Assessment of translational potential of research outcome may be difficult in many academic institutions in India where the research is part of academic curriculum like MSc/PhD. The main aim of the researcher is to publish the research outcome or present in conference for getting the academic credit as early as possible. In many case IPR is not protected. There is an urgent need to modify this path which may cause loss of several good innovations.
4. Characterisation, safety and efficacy study should be planned according to the proposed Indian guideline: The challenge is to generate the correct data set according to the type of innovation and application. The life cycle analysis of ENM with its environmental impact as well as direct or indirect human exposure are important issues with any agricultural application.
5. Pharmacokinetic & Pharmacodynamic study in case of Nanopharmaceuticals: Drug loaded nanoparticles for targeted drug delivery systems with slow release behave like "nanosized drug depot" which may exit the circulating blood and sequester in different organ depending on its properties. This may lead to a different Pk/Pd parameters compared with the API (Active Pharmaceutical Ingredient).
6. The regulatory challenge of multifunctional nanosystems and Non-biological Complex Drug (NBCD): The regulatory parameters are not well defined for multifunctional nanoparticle like those which can be used for simultaneous imaging and therapy (theragnosis). Similarly evaluation parameters for regulatory approval of NBCD are yet to be well defined.
7. Availability of standard: A major hurdle for developing nano-products is the lack of standards for evaluation of property and functionality at different stages of development.
8. Feasibility of upscaling of the ENM in cGMP facility: Upscaling of ENM for commercialisation maintaining the physical and chemical property of ENM in cGMP environment is also an important requirement. In India more such facilities are needed to enhance the marketability of the nano-enabled products.
9. Determination of Risk/Benefit ratio: The novel nanoproducts should be assessed by risk benefit ratio like many of the pharmaceutical agents. Similarly nano-pesticide and nano-fertilisers can be evaluated. Nano-intervention can significantly reduce chemical exposure load for the environment and ecosystem.
10. Public awareness and acceptability of the nanoproducts: Increasing the public awareness of novelty and benefits of nano-enabled products may be important factors for commercial success of these products.

Development of Green Chemistry and Green Nanotechnology have a lot of benefit in future. However there are several challenges to adapt green nanotechnology for commercial production. With rapidly changing fabrication strategy new characterisation modalities should be developed. Experimental as well as analytic methods should be identified to assess the embedded nanomaterial in the complex matrices including biological system to obtain mechanistic insight about nano-system and biological interaction. New production method and synthetic technique are needed for precision engineering of nanomaterial which can be easily upscaled. Versatile purification system for the nanomaterials need to be developed to define purity of the ENM/ nanoformulation.

Conclusion: The nanotechnology can be regarded as an enabling technology which can be used in any domain and for any product development. It is modifying and changing the industrial technology for production of these novel products. Nanoenabled production needs new generations of worker/manpower . It is expected that there will be a rapid change in regulatory procedure for emerging technology based products based on strong regulatory science platform.

Suggested Reading:

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ABOUT DTD-RNA

Launch of DTD-RNA network under the gracious presence of Dr Suchita Ninawe, Adviser, DBT, Professor Iain Martin, Vice Chancellor, Deakin University, Dr Ajay Mathur, Director General, TERI and Dr Alok Adholeya, Director, TDNBC.

TERI, India and Deakin University, Australia are two destinations engaged in intensive research around agriculture, material science, food storage and safety. Innovation in the area of Nanoscience in Deakin University, Australia is also on forefront therefore in 2010, a strategic engagement was established between Deakin University in Australia and TERI, New Delhi India and the centre "TERI-Deakin Nanobiotechnology (TDNBC)" was created at TERI Gram, Gurugram, India. The New State-of-the-Art Centre building was inaugurated on 10th April 2017 by Shri Narendra Modi (Hon'ble Prime Minister of India) and The Hon'ble Malcolm Turnbull MP Australia (Prime Minister of Australia). Please visit the Centre's website http://tdnbc.teriin.org/ for detailed information.

TERI-Deakin Nanobiotechnology Centre (TDNBC), Gurugram, India and Deakin University, Australia, in association with Department of Biotechnology, Govt of India has created "DBT -TDNBC - DEAKIN – Research Network Across continents for learning and innovation (DTD-RNA)". This network was launched on 3rd September 2019. Please visit network's website https://www.teriin.org/projects/dtd-rna/ for details.

Invitation to Join DTD-RNA network

The DTD-RNA Network is honored to invite you to join this network as a member. The network is creating joint labs as country hubs and network of research institutions across all continents with the view integrating strengths from TDNBC, India and Deakin University, Australia to develop International Centre for Translational Research for research training and education in biological synthesis of Nano materials. It will undertake cutting edge Research projects to train young global students, postdoctoral fellows for collaborative Research, high end technologies for basic to advanced level of research (joint research publications), to impart education and training (joint research mentorship), workshops and networking (joint workshop/ training).

What does DTD-RNA Network provide?

- Connections and networking with Global Nanobiotechnology Community.
- Access to TDNBC's and Deakin University's facilities and infrastructure.
- Networking opportunities with Industry – key strengths in product development in agri material sensor's and food sector with high and internationally accepted standards.
- On-line as well as laboratory based Trainings/Courses for functionalization of nano material, coating formulation of nanoagri-inputs, nano food colours, biofilms for food preservation via nano coatings and many more.
- Cross fertilization of ideas via ideation centre.
- Collaboration opportunities for joint research projects, conferences, on-line and laboratory courses.
- Exchanges and interaction for developing Regulation policy and setting up standards for Nano material for various sectors.
- Complimentary registration for the conferences/workshops organized by DTD-RNA network.
- E-mail alerts regarding the updates on DTD-RNA network.
- Funds for selected experts/institutes for visits, meetings, trainings, conferences.
- Institute name and logos will be placed as Network partner.
- Participation in DTD-RNA networking dinners and start-up café.
- State-of-the-art video conferencing facility at TERI Gram, Gurugram has been set up for DTD-RNA. The facility (smart presentation system using dual screens and dual content sources) will be utilized for world class online live meetings between professionals, students and academicians located at different regions globally for research project related discussion, decision making and demonstration/ training purposes

Glimpses of DTD-RNA network events

- Discussion forum on "Landscaping of Industrial Perspectives on Biofertilizer Policy and Regulations on Biologicals in Agriculture" was organized on February 14, 2020 at India Habitat Centre, Lodhi Road, New Delhi.
- A training workshop on "Quality Control of Mycorrhiza" for National Centre of Organic Farming (NCOF), India was held on January 10, 2020. The programme aimed to strengthen the quality regulation of mycorrhizae- based biofertilizer products by capacity building of the scientific staff of the regulatory bodies.

Capacity building under DTD-RNA network

- A short term (14 days) training on Mycorrhiza for PhD Research Scholar from Plant Genetic Engineering Lab, Dept. of Biotechnology, Bharathiar University, Coimbatore and Evora University, Portugal.
- Research projects were initiated by mid-career researchers as pilot projects for technology development and business feasibility:
  - Nanobiochar for delivery of agro-chemicals
  - Chromogenic redox metabolite based Solar Cells
  - Molybdenum disulphide nanosheets for enhancing photosynthesis in agricultural crops
  - Bioremediation of recalcitrant pharmaceutical contaminants containing antibiotics in wastewater
  - Development of nanoformulation (s) for postharvest preservation of fruits and vegetables under ambient storage
  - Silk Protein-Enzyme-Inorganic Hybrid Nanoflowers for Degradation of Pharmaceutically Active Compounds.

Signing of MoUs with new partners of DTD-RNA network:

- International Iberian Nanotechnology Laboratory (INL) Braga, Portugal. It was announced during State Visit of President of Portugal to India on February 14, 2020.
- Universiti Kebangsaan Malaysia, Malaysia on July 22, 2020.

Upcoming events of DTD-RNA network:

- Webinar on Microalgal diversity: potential sources of materials and value-added products and their economy

  Date: September 03, 2020 Time: 2:30-4:00 PM (IST)

Aims of the webinar:

- Explore the diversity in algal species and value-added products and biofuel.
- Find the emerging developments in the nanoengineering of diatom surfaces.
- Burgeoning potential of 'algae' in sustainable development of diverse industries : challenges & opportunities.
- Algal based sustainable bioeconomy model: linear economy vis-à-vis circular economy systems.
- Provide an interactive platform for researchers to take advantage from the achievements made and get engaged in discussions and suggestions to find future direction of research.

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INTERNATIONAL IBERIAN NANOTECHNOLOGY LABORATORY

Microalgal diversity: potential sources of materials and value-added products and their economy

Date: September 03, 2020
Time: 2:30-4:00 PM (IST)

Join to Dicuss

- Algal diversity and uses
- Biomaterial characterization and Advances
- Harnessing Algal System for Circular Bioeconomy

Chair by **Dr. Alok Adholeya**
Director, TDNBC

SPEAKERS

Dr. Shovon Mandal
TDNBC,
India

Dr. Jagroop Pandhal
University of Sheffield,
UK

Dr. Martin Lopez-Garcia
INL,
Portugal

Dr. Durga Madhab Mahapatra
TDNBC, India