December 31, 2021

KARNATAKA SCIENCE AND TECHNOLOGY ACADEMY

DEPARTMENT OF SCIENCE AND TECHNOLOGY, GOVERNMENT OF KARNATAKA

Vijnana Vahini

Nahin Vijnanena Sadrusam

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Science & Technology For All

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From Chairman's Desk

Prof. S. Ayyappan

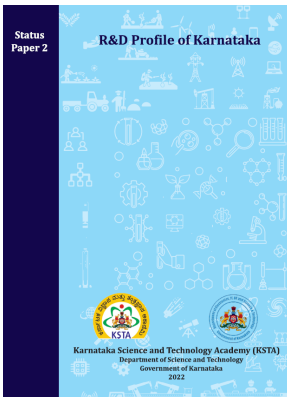
As the year 2021 draws to a close, there are mixed feelings of triumphs and losses. Management of Covid-19 pandemic through S&T tools, including the new generation vaccines received all round applause. Medical science coupled with IT demonstrated the power of science, that came to be appreciated in every household. Along with were also other natural disasters of cyclones and prolonged rains, proving the climate change projections. The UNFCCC Climate Change Meet as CoP 26 at Glasgow, UK during October-November, 2021 once again brought to focus the imminent need for mitigation measures, both globally and locally. The Nobel Prize, 2021 in Physics also recognized the scientists in the area of fundamental research relating to temperature and climate change. The Academy, as in the previous year, organized a Nobel Prize Laureate Lecture series, with eminent scientists speaking on the recipients as well as the subjects.

In order to provide a reference document with regard to the capacities of the State for various stakeholders, KSTA brought out the 'R&D Profile of Karnataka'. The National Conference on 'Fruits and Vegetables for Health and Nutrition' commemorating the International Year of Fruits and Vegetables was a major event during the quarter. An Expert Consultation on 'Mucormycosis Management' was held, along with the Lecture series for PUC Students under the Talent Search programme.

The Executive Committee of the KSTA had met during the quarter. The guidance and inputs received from the Members are gratefully acknowledged.

- S. Ayyappan

Status Paper 2: R&D Profile of Karnataka



R&D has become synonymous with economic competitiveness and modernity and hence countries across the globe seek to diversify their economies and make them more knowledge-intensive. Research and Academic Institutions as well as Individuals of different backgrounds have been contributing to the saga of societal progress with tools & techniques, processes & products, and ideas & innovations.

Karnataka is in the forefront of 'science for society' endeavours, with Bengaluru being the Knowledge Hub and Science Capital of the country. While there are databases of various kinds providing information on the multilateral

. . . . . .Continued in Page 7

Prof. H.S. Savithri

"Recently there have been attempts to reduce the time by a adopting a rational approach to the design and development of new drugs"

Rational Drug Design

"When I woke up just after dawn on September 28, 1928, I certainly didn't plan to revolutionize all medicine by discovering the world's first antibiotic, or bacteria killer"

- Alexander Fleming

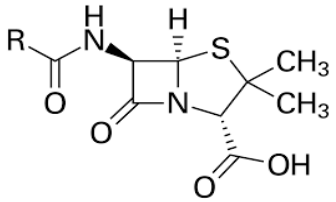


Fig 1

Alexander Fleming discovered Penicillin (Fig. 1) and even today its derivatives are the drug of choice for many bacterial diseases. Indeed this discovery revolutionized medicine. He was awarded the Nobel Prize in 1945 along with Howard Florey and Ernst Chain, who isolated the pure compound, Penicillin F, from the fungus Penicillium rubens. Penicillin and its derivatives (also called β-lactam antibiotics) are now synthesized chemically and are effective against many bacterial infections, in particular those caused by staphylococci and streptococci. This discovery of penicillin was serendipitous. Later extensive research lead to the elucidation of its mechanism of action and also the mechanism by which the bacterial pathogens develop resistance. Penicillin kills bacteria by inhibiting the activity of transpeptidases (also called penicillin binding proteins) that are needed for the cross-linking of peptidoglycans in the final step in bacterial cell wall biosynthesis. The fewer cross-links weaken the cell wall leading to uncontrollable flow of water into the bacterial cells. This results in cell lysis and death. Some bacteria produce beta lactamases, which can cleave the beta lactum ring of penicillin that makes them resistant to penicillin. In such cases, derivatives of penicillin or a combination with drugs that inhibit the lactamases are used.

Subsequent to the work of Fleming, Selman Waksman devised the zone of clearance technique for identifying natural substances that exhibit antimicrobial properties. Initially a bacterial culture is plated on an agar plate and allowed to grow over night. Then, small holes are made and different compounds/extracts are put in them and they are allowed to diffuse into the agar. If the extract has antimicrobial properties, it will kill the cells leading to a zone of clearance. The diameter of the zone cleared is an indication of the relative effectiveness of the extract (Fig.2). Even today this technique is widely used for the screening of various extracts.

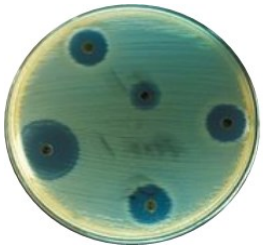


Fig 2

Selman Walksman was awarded the Nobel Prize in physiology or medicine in 1952 "for his discovery of streptomycin, the first antibiotic effective against tuberculosis. He is considered the father of antibiotics.

Discovery of a new drug involves many steps: target identification, validation, lead compound identification, lead optimization followed by preclinical and clinical trials. This generally takes tens of years with several scientists working together. More recently there have been attempts to reduce this time by a adopting a rational approach to the design and development of new drugs.

These improvements are discussed in the following sections.

Target identification

The identification of new, clinically relevant, molecular targets is of utmost importance for the discovery of innovative drugs. If we assume that there may be approximately 10 genes involved in a particular disease with some 5 to 10 additional genes linked to the disease and that there are 100 major diseases, then there could be 5000 to 10,000 targets that could be used for drug design.

However, only 500 unique targets are being used currently for therapy. Thus, many more drug targets exist and the challenge is to identify such novel targets. A drug target is a molecule involved in a particular metabolic or signaling pathway that is specific to a disease condition or pathology or to the infectivity or survival of a pathogen. As mentioned earlier, initially such targets were discovered serendipitously. They were also identified following traditional folklore remedies. However, in the recent years, a thorough analysis of the molecular and physiological processes of a disease is done to identify the most probable targets. Complete genome sequence of organisms causing the disease, the expression profile of their genes (referred to as tanscriptomes), their protein profile (proteome) are first determined. There are methods that can be used to compare the protein profile of a diseased person with that of a normal person or compare the protein profile of a normal cell with that of a cancer cell or between the host and the pathogen. Such an analysis is referred to as proteome analysis. In this method thousands of proteins from a cell/ tissue extract are separated by what is called as 2D electrophoresis (Fig. 3). The proteins are separated in one dimension (one direction of the separating gel) on the basis of their charge and in the other dimension (a perpendicular direction in the separating gel) on the basis of their size. The resolution of such 2D gels has improved enormously and proteins with very small charge and size differences can be separated and visualized as distinct spots. Proteins unique to the disease can thus be identified by computer aided comparison of the maps.

The proteins present in picomolar quantities in the unique spots are identified by mass spectrometric analysis. The present day mass spectrometers can analyze and determine the molecular mass of proteins with an accuracy

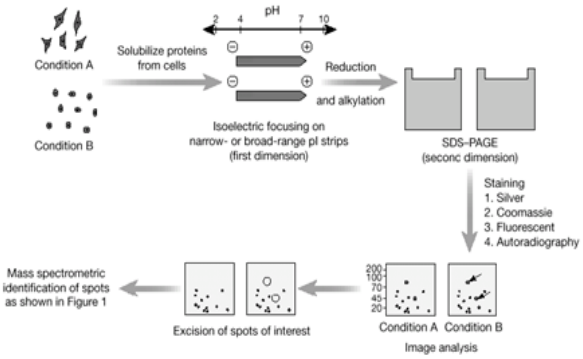


Fig 3: 2D Gel Technique example

"The identification of new, clinically relevant, molecular targets is of utmost importance for the discovery of innovative drugs"

0.005-0.1%. By such an accurate analysis, not only of the mass of the protein but also the peptides derived from it by enzymatic cleavage can be deciphered. (Fig. 4). A comparison against the theoretical finger print (mass of cleaved fragments) of all unique proteins in the protein sequence data base helps to identify the target proteins.

Target Validation

The targets identified for a particular disease need to be validated. This is done in

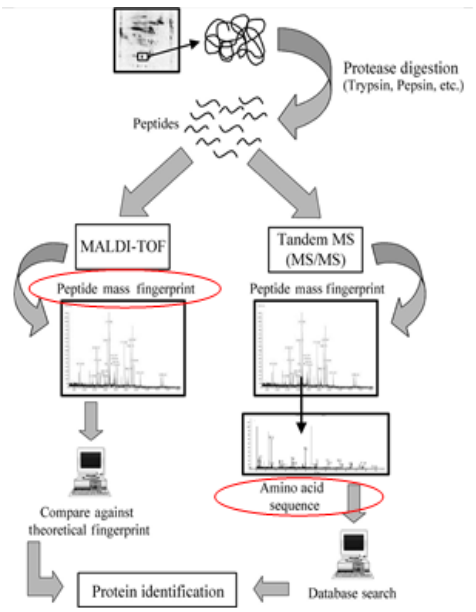


Fig 4

several steps. A systematic analysis of the target protein sequence with those present in the data base is carried out to detect if there are any mutations that could be linked with the disease. The expression level of the target protein is checked to assess if it has changed during the course of the disease. One may also analyze if the target protein is structurally similar to proteins that have been previously identified as reasonably good drug targets. In order to gain further insights into the target protein, the corresponding gene segment is amplified by polymerase chain reaction (PCR), over-expressed using appropriate vectors in heterologous systems, purified, crystallized and the three dimensional structure of the protein is determined (Fig. 5). There has been such a major technological revolution in these methods that the time scale has reduced from several years to a couple of months.

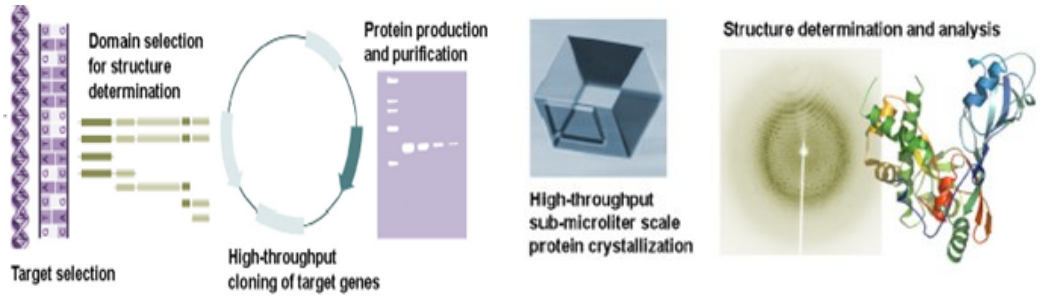


Fig 5

Lead compound identification

The structure of the target protein is analyzed using bioinformatic tools to identify probable ligand/drug binding pockets, molecules that can bind and possibly inhibit the function of the target protein. The affinity of the ligand for the target protein could be enhanced by. Computer aided design of molecules using various docking and modeling programs. A theoretical analysis of the binding constants of these molecules in silico is carried out to select molecules which have a very low Ki value, such compounds are likely to inhibit the target protein function. The compounds are then synthesized and tested for their ability to inhibit the function of the target protein in vitro. Further changes in the functional groups are made to improve solubility/ strength of binding etc and the newly synthesized compounds are once again tested for their ability to inhibit the function of the target protein. The most promising candidates are tested for their effect on the in vivo function of the target protein. Expert scientists from different fields such as Biochemistry, Molecular Biology, Cell Biology Organic Chemistry, Bioinformatics and Structural Biology work together to find promising leads.

"Scientists from different fields such as Biochemistry, Molecular Biology, Cell Biology Organic Chemistry, Bioinformatics and Structural Biology work together to find promising leads"

Lead compound optimization

Methods have to be developed for large scale synthesis, which could reduce the cost of the drug, and the designed drugs should have lowest Ki of target protein-inhibitor complex and improved potency. Further changes to the molecule are made such that it would have reduced off-target activities (leading to fewer side effects). The physicochemical and metabolic properties of the molecules are also analysed in detail. Sometimes the accumulation of the substrates of a reaction inhibited can lead to what is known as metabolic resistance. For example, a compound called phophonoacetyl L aspartate, (PAcAsp), a tight binding inhibitor of aspartate transcarbamylase, is ineffective in vivo as it results in the accumulation of carbomyl phosphate, one of the substrates of the reaction catalyzed by this enzyme. Lead

optimization is also required for the compounds isolated from natural sources. For example, Artemisinin, a leading drug in the treatment for malaria, is extracted from a grass that is found in China and Vietnam. However, it has poor solubility and hence is less absorbed into the blood stream. Further the compound is present in very low amounts in the natural source. Efforts to improve the solubility and absorption of artemisinin have lead to the manufacture of compound with increased yield and better absorption.

Preclinical and clinical development

The identified potential molecule is initially tested in experimental animal models (preclinical testing) to asses if it exhibits. drug like properties. The questions that are addressed are - Is it specific to the target? Is the target protein specific to only one isomorph of the compound? What are its ADME- Absorption, Distribution, Metabolism, Excretion properties? The liver is the organ that metabolizes most of the molecules such that they are eventually excreted in the urine. If the molecule is excreted before it can reach the site of action, the drug is likely to be ineffective. The bioavailability, different delivery methods, routes administration, dosage and their regimen need to be optimized. Toxicity, cross reactions, side effects also are assessed thoroughly before the drug is ready for clinical trials. Clinical trials are conducted with approval from concerned authorities, informed consent from the subjects, in appropriately chosen locations using double blind methods. The data obtained are analyzed by experts before the drug is approved for release into the market. Experts in the field of Pharmacology, Medicine, Statistics and Business Administration work together to achieve this. This rational drug design is truly a multidisciplinary effort that needs expertise from a large number of disciplines.

- Prof. H.S. Savithri
NASI Senior Scientist,
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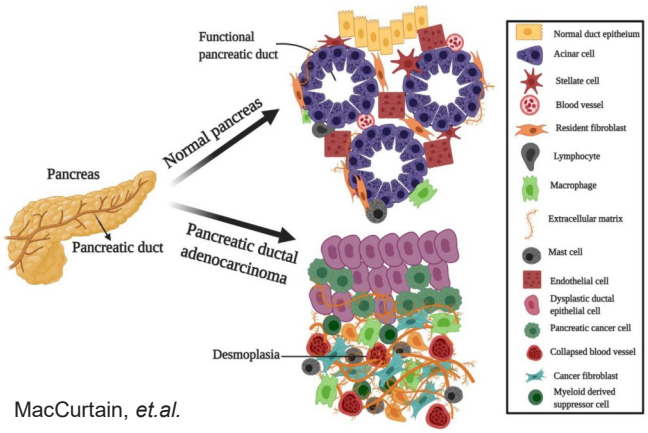
Current Science & Technology

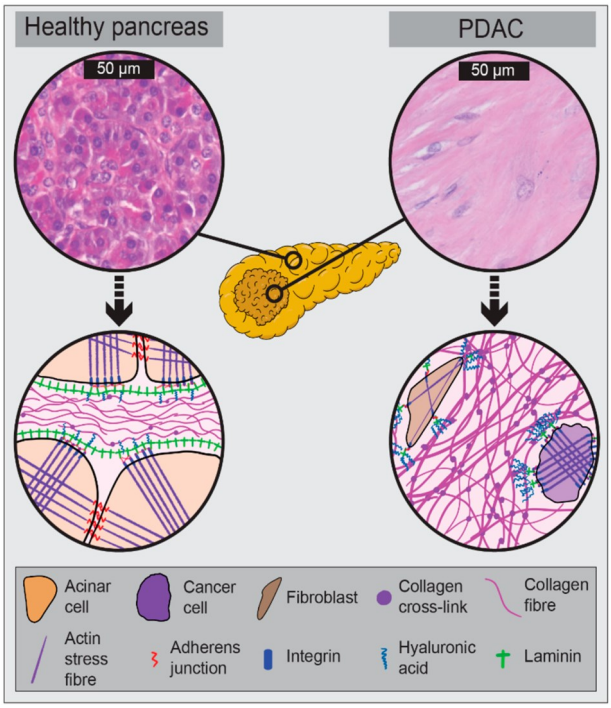
Artificial Intelligence (AI) and Machine Learning (ML) in early diagnosis of PDAC

Artificial intelligence (AI), a revolutionary technology, is playing a major role in day to day life. We are seeing a lot of evolution in various machine learning (ML) methodologies. AI & ML have become more accurate and applicable to a variety of tasks and are being widely used to solve a whole range of hitherto intractable problems. They have increasingly helping to uncover hidden insights into clinical decision-making, connect patients with resources for self-management, and extract meaning from previously inaccessible, unstructured data assets.



MacCurtain, *et.al.*

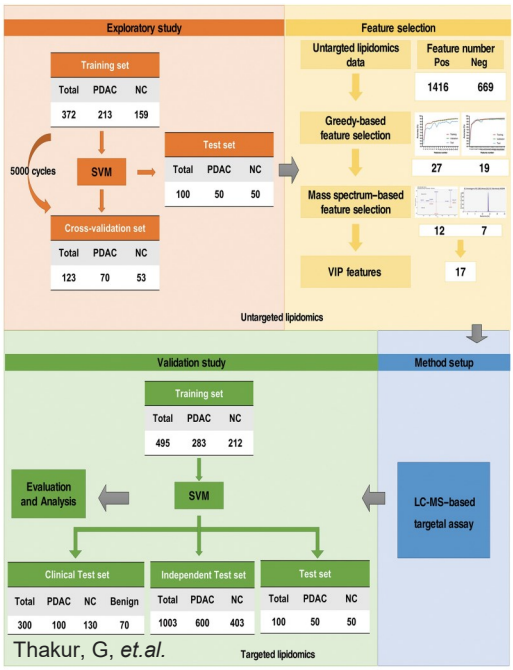
Pancreatic ductal adenocarcinoma (PDAC), a highly malignant tumor and one of the most lethal cancers, characterized by rapid progression, metastasis, and difficulty in diagnosis. Due to the anatomic location of the pancreas, symptoms (weight loss, fatigue,



MacCurtain, *et.al.*

abdominal and back pain, and malaise) and non-availability of an effective testing method at present, the early stage detection has become difficult.

A research team (Guangxi Wang. et. al., 2021) at Institute of Systems Biomedicine, Peking University Health Science Center, Beijing introduce an approach that uses ML and lipidomics to detect PDAC. Metabolomics allows the collection, detection, and analysis of all kinds of small-molecule metabolites, which are highly sensitive to biological activities and pathological conditions. Because of the great



metabolite coverage of untargeted metabolomics and reliability of targeted metabolomics, the integration of both assays is a powerful strategy for disease-related biomarker studies. Thus, accurate, robust, and low-cost metabolomics detection methods hold promise for future disease diagnoses. Through greedy algorithm and mass spectrum feature selection, the research team optimized 17 characteristic metabolites as detection features and developed a liquid chromatography-mass spectrometry-based targeted assay. In this study, they sought to combine ML and metabolomics performed with lipid metabolites of serum from patients with PDAC and normal individuals to classify and select lipid features of PDAC. Then, a targeted lipid multiple reaction monitoring (MRM)–mode quantification assay for PDAC detection was established and validated in large sizes of samples.

Using this method, the team studied 1033 patients with PDAC at various stages and achieved 86.74% accuracy with an area under curve (AUC) of 0.9351 in the large external validation cohort and 85.00% accuracy with 0.9389 AUC in the prospective clinical cohort. Accordingly, single-cell sequencing, proteomics, and mass spectrometry imaging were applied and revealed notable alterations of selected lipids in PDAC tissues. The research team is opined that this method would yield an effective, reliable, and accurate minimally invasive approach to PDAC detection.

- Dr. Anand, R.
Senior Scientific Officer, KSTA

Reference

Guangxi Wang, *et. al.*,2021. Metabolic detection and systems analyses of pancreatic ductal adenocarcinoma through machine learning, lipidomics, and multi-omics. *Science Advances,* Vol 7, Issue 52. https://doi.org/10.1126/sciadv.abh2724

MacCurtain, B.M.; Quirke, N.P.; Thorpe, S.D.; Gallagher, T.K. Pancreatic Ductal Adenocarcinoma: Relating Biomechanics and Prognosis. *J. Clin. Med.* 2021, Vol. 10, Issue *12.* https://doi.org/10.3390/jcm10122711

Thakur, G.; Kumar, R.; Kim, S.-B.; Lee, S.-Y.; Lee, S.-L.; Rho, G.-J. Therapeutic Status and Available Strategies in Pancreatic Ductal Adenocarcinoma. *Biomedicines*, Vol 9, Issue 2. https://doi.org/10.3390/biomedicines9020178

Flying Microchip

For centuries Nature has been able to work out creative solutions to support all forms of life on earth. Many technologies have been developed by humans by taking the clue from Nature. A team of engineers under Professor John Rogers at Northwestern University has developed a device called 'flying microchip' by studying the aerodynamics of wind dispersal seeds

This flying microchip, as small as a grain of sand, does not have a motor or engine. Instead, it gains flying capability from the movement of air, much like a maple tree's propeller seed, and spins like a helicopter through the air toward the ground. When they dropped at a higher elevation, these micro fliers descend at a slow velocity in a controlled manner. This not only

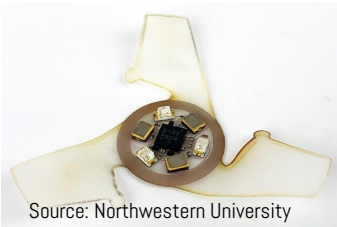

Source: Northwestern University

stabilizes its flight but also ensures dispersal over a broad area and increases the amount of time it interacts with the air, making it ideal for monitor air pollution, airborne disease, and environmental contamination. This is the smallest-ever human-made flying structures and also ultra-miniaturized technology, including sensors, power sources, antennas for wireless communication and embedded memory to store data can be mounted on it.

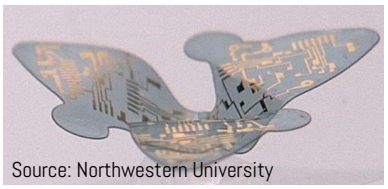
Rogers and his team have designed and built three

winged microfliers with the similar shapes and angles as the wings on a Tristellateia (Australian gold vine) seed. They have studied the computational modeling of how the air flows around the device to mimic the Tristellateia seed's slow, controlled rotation. Rogers' group then built and tested structures in the lab, using advanced methods for imaging and quantifying patterns of flow. Thus, the team have been able to build structures that fall with more stable trajectories and at slower terminal velocities than equivalent seeds that one can see from plants or trees. They also able to build these helicopter flying structures at sizes much smaller than those found in nature.

His team first fabricated precursors to flying structures in flat, planar geometries. Then, they bonded these precursors onto a slightly stretched rubber substrate. When the stretched substrate is relaxed, a controlled buckling process occurs that causes the wings to "pop up" into precisely defined three-dimensional forms. This strategy of building 3D structures from 2D precursors is beneficial because all existing semiconductor devices are built in planar layouts and thus exploit the most advanced materials and manufacturing methods used by the consumer electronics industry to make completely standard, flat, chip-like designs.

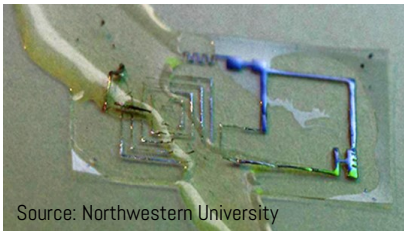

Source: Northwestern University

They have demonstrated by including sensors, a power source, memory storage and an antenna that can wirelessly transfer data to a smart phone, tablet or computer. In the lab, they outfitted the device with sensor to detect particulates in the air, incorporated pH sensors that could be used to monitor water quality and photodetectors to measure sun exposure at different wavelengths.


Source: Northwestern University

Rogers imagines that large numbers of devices could be dropped from a plane or building and broadly dispersed to monitor environmental remediation efforts after a chemical spill or to track levels of air pollution at various altitudes. Most monitoring technologies involve bulk instrumentation designed to collect data locally at a small number of locations across a spatial area of interest. However, a large multiplicity of miniaturized sensors that can be distributed at a high spatial density over large areas, to form a wireless network.

If you are thinking the fate of such miniature fliers after use. Is this going to create electronic litter? No! They have solution. They have developed transient electronics that can harmlessly dissolve in water after they are no longer needed. Much like the bioresorbable pacemakers. The team is using the same materials and techniques to build microfliers that naturally degrade and disappear when exposed to water. They have fabricated such physically transient electronics systems using degradable polymers, compostable conductors and dissolvable integrated circuit chips that naturally vanish into environmentally benign end products when exposed to water


Source: Northwestern University

- Dr. Anand, R.
Senior Scientific Officer, KSTA

Reference: "Three-dimensional electronic microfliers inspired by wind-dispersed seeds" by Bong Hoon Kim, Kan Li, Jin-Tae Kim, Yoonseok Park, Hokyung Jang, Xueju Wang, Zhaoqian Xie, Sang Min Won, Hong-Joon Yoon, Geumbee Lee, Woo Jin Jang, Kun Hyuck Lee, Ted S. Chung, Yei Hwan Jung, Seung Yun Heo, Yechan Lee, Juyun Kim, Tengfei Cai, Yeonha Kim, Poom Prasopsukh, Yongjoon Yu, Xinge Yu, Raudel Avila, Haiwen Luan, Honglie Song, Feng Zhu, Ying Zhao, Lin Chen, Seung Ho Han, Jiwoong Kim, Soong Ju Oh, Heon Lee, Chi Hwan Lee, Yonggang Huang, Leonardo P. Chamorro, Yihui Zhang and John A. Rogers, 22 September 2021, Nature.

Status Paper 2: R&D Profile of Karnataka *..... continued from Front Page*

S&T efforts, it is hard to obtain a glimpse of these in one place, as observed by the KSTA Team. In order to fill this gap, the Academy undertook an exercise to enlist Institutions and human resource involved in R&D efforts, both in public and corporate sectors, which resulted in this document. The major areas that have been included are: ICT and Electronics; Biotechnology; Education; Astronomy, Space Science and Defence; Health and Medicine; Production and Manufacturing; Energy; Agriculture and Food Technology; Earth, Environment and Ecotourism; and Frontier Science and Technology, along with ranking of the State with regard to S&T as well as Development pararmeters. Being one of the first efforts in consolidating the R&D resources in the State in their entirety. More data and information need to be collected and collated, which would be addressed in the subsequent editions. It is hoped that this would serve as reference material for researchers in both R&D and academic institutions.

KSTA meetings

Executive Committee (EC): The 14th EC meeting of KSTA was held on October 29, 2021 under the Chairmanship of Prof. S. Ayyappan, Chairman, KSTA from 3:00am to 4:00pm.

MOU and Collaborations

During October - December 2021, 03 MOU were signed and till date 37 MOUs with organisations/ institutions were signed with the following purpose and scope:

- Inculcating scientific temper across civil society through science communication
- Facilitating technology dissemination through Academia-Farm-Industry interface, with a focus on rural areas
- Fostering innovations and entrepreneurship for societal benefits
- Organising conferences & outreach programmes
- Capacity building in frontier areas of Science & Technology
- Any other aspects with mutual consent

Sl. No.	Organisations/Institutions	Date of MOU
1	Institute of Public Health, Bengaluru	16-11-2021
2	National Institute of Agricultural Extension Management (MANAGE), Hyderabad	20-11-2021
3	Bangalore Institute of Technology, Bengaluru	01-12-2021

Programs carried out during Third Quarter (October - December 2021) of FY 2021—'22

During October – December 2021, following programs related to frontier areas of science and technology were conducted through both Video Conference (VC) and Physical modes in association with research institutes/ science forum/ educational organizations.

Physical Mode

Sl. No.	Date	Topic	Association
1	November 08 – 10, 2021	National Conference on Fruits and Vegetables for Health and Nutrition (FVHN 2021)	University of Horticultural Sciences, Bagalkot Indian Institute of Horticultural Research, Bengaluru and Vigyan Prasar, New Delhi
2	December 22, 2021	International Seminar : Medical Ethics in Teaching, Research and Practice	BLDE Shri B.M. Patil Medical College, Hospital and Research Center, Vijayapura

Video Conference (VC) mode

Sl. No.	Date	Topic	Association
1	October 4 – 9, 2021	World Food Day	St. Aloysius College, Mangaluru
2	October 8, 2021	Emergency Trauma Care	Garden City University, Bengaluru
3	October 27– 29, 2021	Nobel Prize Lecture Series 2021	-
4	Nov 30 – Dec 10, 2021	Science Talent Search Program	KSTePS
5	December 20 – 31, 2021	Science Talent Search Program	KSTePS
6	November 23 – 25, 2021	Science Videography Training Programme	Kutuhali, Vigyan Prasar, New Delhi

Vijnana Loka — Bimonthly Magazine and Special Issue on 'Climate Change'

The Sep-Oct2021 and Nov-Dec2021 issues of *Vijnanaloka* were sent to subscribers including pre-university and science degree colleges, science centres, libraries and other organizations across the state. A 120 page special issue on 'Climate Change' was also been published. All the issues are made available in KSTA website.

Upcoming programs/publications

Award and Fellowships

Prof. CNR Rao Lifetime Achievement Award in STEAM, KSTA Lifetime Achievement Award for STEAM Communication in Kannada and KSTA Fellowships (FKSTA) will be awarded in the month of January 2022.

Vijnana Loka — Bimonthly Magazine

Jan-Feb 2022 and Mar-Apr 2022 issues of *Vijnanaloka* will be published during last quarter of FY 2021-22

Publication of book *'Dumbigala Nartana'*

KSTA is publishing the Kannada version of the famous book 'The Dancing Bees' written by Karl von Frisch and translated by Arundati Savadatti in the month of January 2022.

Small Grant/Short term Study

Supports for Workshops, Symposia and Seminars, and also short term Studies, to spread scientific awareness, specially among students; introduce teaching faculty to new horizons of Science & Technology; create awareness on contemporary issues related to Science & Society will be provided. The last date for submission is January 21, 2022. For further details visit KSTA website.

Innovation Award for UG, PG and General Public

Exemplary innovations / solutions emanating from Science & Technology or any segment of economy that have helped transform the lives of people, particularly in rural areas or have enabled enterprises and employment would be recognised and awarded. The Award carry a cash prize of Rs 10,000 and a certificate. The last date for submission is January 21, 2022. For further details visit KSTA website.

Essay Competition for UG, PG and General Public

Essay writing competition in Kannada and English is being conducted for Under Graduate, Post Graduate and General Public. Last date of Submission is January 30, 2021. Send your essay to our email-essay.ksta@gmail.com. For further details visit KSTA website.

Science and Technology Annual Conference

Karnataka Science and Technology Academy Conference will be organized in Tumakuru in association with Siddaganga Institute of Technology (SIT) during February-March 2022. Invited talks by leading scientists and scholars on various science and technological developments as well as harnessing S&T applications for sustainable development will be organized apart from poster presentation by research scholars in the Conference.

Science and Technology Conference in Kannada

Fourth Science and Technology Conference in Kannada will be organized in Dharwad in association with Agricultural University during February-March 2022. Invited talks by Scientists as well as leading science writers and communicators will be organized apart from poster presentation in Kannada by research scholars in the Conference.

Digital Content Generation, Production of Science Capsules, Short Feature Films /Clippings

KSTA is developing teaching and learning videos for High School students in Kannada and same will be distributed to Government and aided High Schools in the State.

Policy/Strategy/Status Paper

KSTA is working out Policy/Strategy/Status Paper on Mucormycosis, Green Building, Ecosystem Services' and Water Resource Management and proposed to publish the last quarter of FY 2021-22

KSTA, a Unit of the Department of Science and Technology, Government of Karnataka, established on 5th September, 2005, has been mandated for science promotion and popularisation in the State. KSTA has the Vision of 'Nurturing and Enabling Science & Technology for All' and Mission of 'Playing a pivotal role in Science promotion, Technology dissemination and fostering Innovations for Societal welfare'. The Objectives of the KSTA are to inculcate scientific temper across the civil society through science communication, particularly in Kannada; facilitate technology dissemination through Academia-Farm-Industry interface, with a focus on rural areas; foster Innovations & Entrepreneurship for Societal benefits; recognise talents and contributions through Awards; organise Conferences & Outreach programs; serve as Resource Centre for Capacity building in frontier areas of Science & Technology; and act as a Science, Technology & Innovation Policy (STI) Advisory Body for the State.

Scan me to view Program Videos

KSTA

Science & Technology for All

Contact

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