सत्यमेव जयते

Annual Report

2021-22

विज्ञान और
इंजीनियरी
अनुसंधान बोर्ड

Science and
Engineering
Research Board

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वार्षिक रिपोर्ट 2021-22 **Annual Report**

From the Secretary's Desk

I am delighted to share the 11th Annual Report (2021-2022) of the Science and Engineering Research Board (SERB), Department of Science and Technology, a premier funding agency of the country. This report illustrates comprehensive details and an exhaustive review of our focused efforts and activities supporting R&D ecosystem in the country in all areas of science, engineering and quantitative social sciences. Since its establishment, SERB has been continuously striving in developing robust, state-of-the-art and sophisticated research facilities & infrastructure across the country in order to significantly elevate the quality of research up to global standards and competitiveness. It is remarkable that throughout Covid-19 pandemic, SERB was able to provide continuous support to scientists, students and other research personnel involved in R&D across the country to ensure unhindered release of funds for research and fellowships/ stipends.

Out of many new initiatives, SERB-SIRE (SERB-International Research Experience) stands out in its mandate to strengthen R&D capacity building and to impart high-end research training in frontier areas of science and engineering to those scientists who have obtained their PhD degrees in India. This programme allows them to avail a competitive opportunity to visit leading institutions/universities across the world for a period of up to 6 months. The objective of this programme is to build national capacity in niche areas of research and support collaborations in less explored, yet critical, S&T areas in the Indian context.

Being the premier national research funding agency, SERB is always committed towards raising the quality of research, footprint of disciplines and measurable outputs by accelerating calibrated research support for investigators at all levels of engagement. As a nation, it is essential for us to keep pace with and break new grounds in exponential technologies by motivating early career researchers and women scientists. It is expected that the research outcomes can be made use of in national missions and to achieve sustainable development goals, to realize that indigenous science remains dedicated to the nation by being relevant, visible and impactful.

This Annual Report provides an exhaustive overview of our focused efforts and significant mark at the global level. I wish to extend our sincere gratitude and appreciation to the SERB Board members, all members of the Programme Advisory/Expert Committees and industrial partners and stakeholders, for their unflinching support to ensure that the processes enshrined in the governance of SERB programmes are adhered to at the highest levels of quality assessment, transparency, and integrity. We believe that SERB funding opportunities will further nurture a deep S&T culture to raise the spirit of innovation, bring in inclusion and diversity, and foster collaboration to develop a robust R&D environment for a secured and Atmanirbhar future for our country.

Jai Hind!

Sandeep Verma
Secretary, SERB

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THE ORGANISATION

The Science and Engineering Research Board (SERB), a statutory body of the Department of Science and Technology was established in the year 2011 for planning, promoting and funding internationally competitive research in emerging areas of Science and Engineering. SERB, since its inception has been instrumental in building a sustainable research ecosystem in the country through its diverse programme portfolio that includes research grant funding, fostering young researchers, recognizing and rewarding research excellence, promoting scientific networks and partnerships, along with enhancing gender and social inclusiveness. Through its programmes, policies, procedures and practices, SERB strides ahead in its mission to advance scientific research in the country.

Fig. 1.1: Screenshot of Science and Engineering Research Board online portal

1.1 Vision, Mission & Goals

To better focus on its energies and resources on realization of its mandate, SERB defined its vision, mission and goals as per the following.

Vision

To position science and technology as the fulcrum for social and economic change by supporting competitive, relevant and quality scientific research and development.

Mission

As the premier national research funding agency, raise the quality and footprint of Indian Science and Engineering to the highest global levels in an accelerated mode, through calibrated, competitive support of research and development.

Goals

I. Stimulating the search for new knowledge and encouraging invention, discovery, innovation and development by supporting bottom-up research competitively and at all levels of our research eco-system.

II. Support conceptually new directions, even when risky, but having the potential for non-incremental and transformative success. Strengthen deep-expertise in specific domains and link them through inter-disciplinary and multi-institutional 'top-down' programmes that address challenging national problems.

III. Develop funding programmes which connect with needs of our society and identify key scientific questions, both basic-science and application that have concrete societal values.

IV. Launch and strengthen programmes to bring in researchers from under represented regions, weaker and marginalized segments of the society.

V. Realizing the importance of gender parity, ensure that all programmes pro-actively have mechanism to encourage enhanced and equitable representation of women scientists.

VI. Initiate and strengthen schemes that link teachers in colleges and resource-poor universities with opportunities in active research, thereby aiding in expanding the footprint of quality science.

VII. Through global bilateral and multilateral partnerships support collaborative top-quality research in cutting-edge areas to ensure the rapid growth of quality science in India.

VIII. Scout, mentor, incentivize and reward exceptional performers, teams and institutions.

IX. Show unstinted commitment towards science by constantly improving our methods and swiftness for research support, while ensuring the highest adherence to financial processes.

X. Recognizing that all research support has at its base the development of quality, well-trained researchers; initiate and strengthen programmes of identifying research potential, mentoring, training and hands-on workshops, on a broad-based national scale.

XI. Make SERB the vehicle of choice for all R&D funding agencies for their core programmes by developing inclusive processes and proactively synergizing with them for the requisite integration and consolidation of the research effort in Science and Engineering in the country.

Fig. 1.2: The vison, mission and goals of SERB.

1.2 ORGANIZATION CHART

The organization structure of SERB is given in Figure 1.3

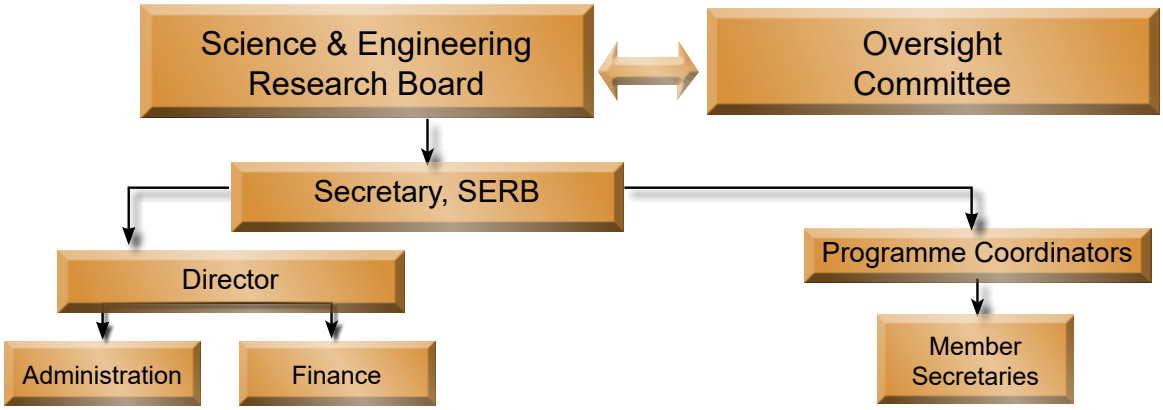


Fig. 1.3: Broad Working Organization Chart of SERB

1.3 PROGRAMME CHART

The various scientific programmes and schemes handled by SERB are given below (Fig. 1.4)

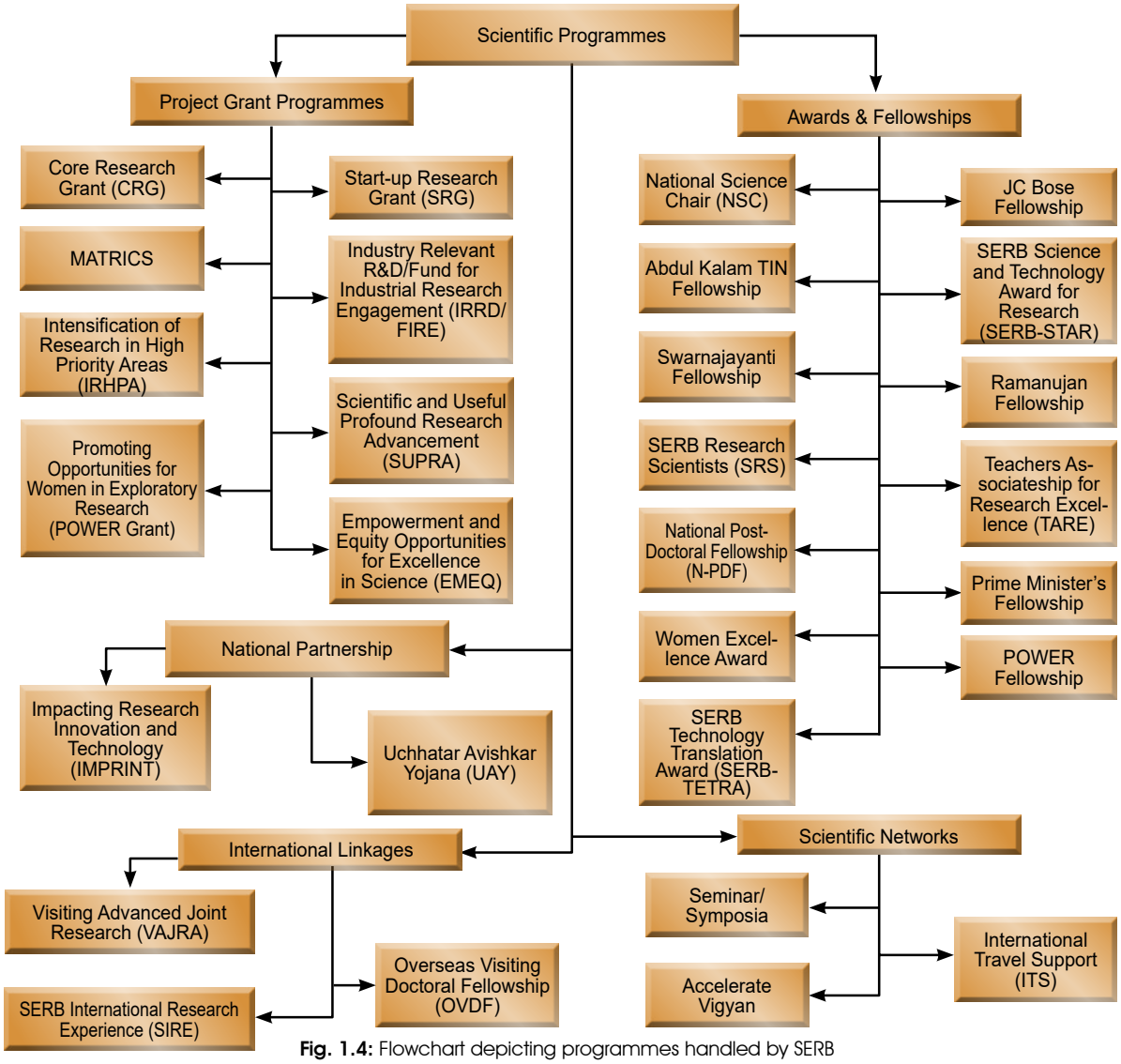


Fig. 1.4: Flowchart depicting programmes handled by SERB

1.4 BOARD & OVERSIGHT COMMITTEE

a) The Board

The Board, chaired by Secretary, Department of Science and Technology (DST), is comprised of 17 members including a few eminent Indian Scientists and six Secretaries to the Government of India. Following are the Members of the Board as depicted in the Flowchart (Figure 1.5).

Fig. 1.5: Members of the Board and Oversight Committee

b) The Oversight Committee

The SERB Act provides for constitution of an Oversight Committee to advise and assist the Board. A scientist of eminence and international repute chairs the Oversight Committee with Secretary to the Government of India in DST as Vice Chairperson and a few distinguished experts,Secretary to the Board and Presidents of Indian National Science Academy, Indian Academy of Sciences and Indian National Academy of Engineering as members. The members of the Oversight Committee are depicted in Figure 1.5.

1.5 THE PEER REVIEW COMMITTEES

The Board has a robust peer review mechanism for taking funding decisions. The proposals received under various schemes and programmes follow a peer review process, which involves two levels of appraisals. At first stage, the proposals are sent to domain experts for their comments and decision is taken by preliminary screening comittee. At second stage, the proposals are generally evaluated for funding by specific committees afer peer review. A number of Committees have been constituted to evaluate R&D proposals and other applications for seeking support under various schemes and programmes. Major Committees are listed below:

1.5.1 Empowered Committee

An empowered committee is constituted under the Chairmanship of Secretary, SERB. If the recommended cost of the proposal is greater than Rs.80 Lakh, it is referred to an Empowered Committee. This committee is empowered to approve projects upto Rs. 5 crores, whereas for proposals costing more than Rs. 5 crores the same committee will serve as an appraisal body to the Board.

1.5.2 Expert Committees / Task Force

Five Expert Committees are to help the Board in taking decision on Start-up Research Grant (SRG) and National Postdoctoral Fellowship (NPDF) proposals. A Task Force constituted under the Board takes decision on proposals received under EMEQ Scheme. These Committees take funding decisions on proposals received under the said schemes. Two expert committees help SERB in evaluation of proposals in SERB Research Scientist (SRS) Scheme and Teachers Associateship for Research Excellence (TARE).

1.5.3 Programme Advisory Committee (PAC)

Programme Advisory Committee (PAC) is the first level peer review committee in the system. Sixteen PACs in various disciplines, each with a composition of 7 - 10 core members and a cohort of experts who can be co-opted in the committees whenever required, were constituted. PACs role is critical in taking decision on R&D proposals submitted under the schemes.

1.6 GROWTH PROFILE

The Board has brought forth with several innovative programme and schemes to identify potential scientists and support them for undertaking R&D in frontier areas of Science and Engineering. The Board interventions were primarily focused to expand the research base in the country without compromising the quality of research.

1.6.1 Milestones

The Board has come a long way in its journey from the erstwhile SERC to its current profile and some of the major milestones over the years are shown in Figure 1.6.

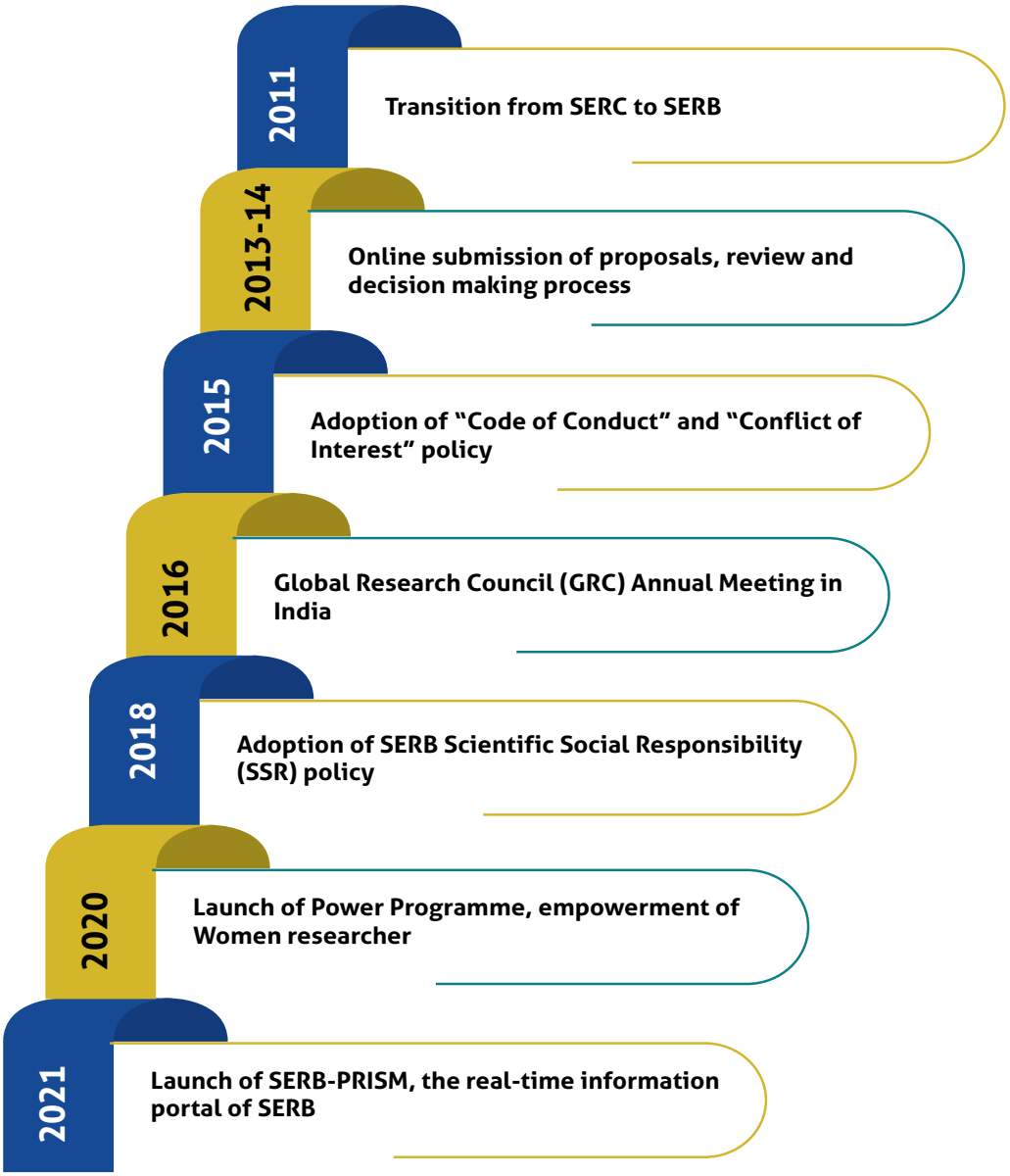


Fig. 1.6: Key Milestones of SERB since inception

1.6.2 Adaptability

The Board, since inception had introduced several schemes and programme to cater various segments of the scientific community. Its adaptability to suit the changing S&T needs of the country is depicted in Figure 1.7.

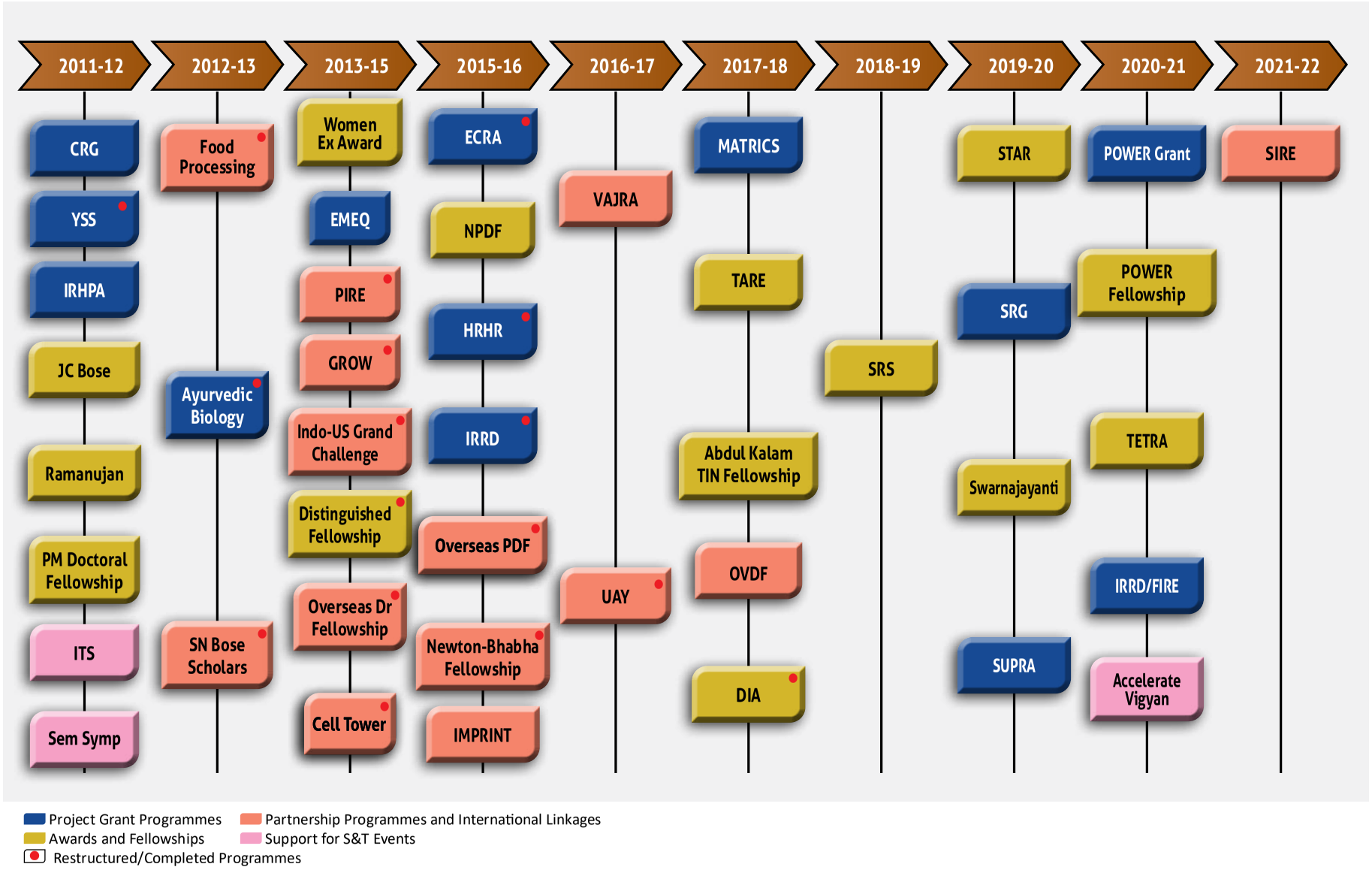


Fig. 1.7: The growth profile of SERB programmes since inception

1.6.3 Budget

A steady growth in terms of the budgetary allocation for SERB was observed over the past many years. The allocation for SERB since inception is shown in Figure 1.8.

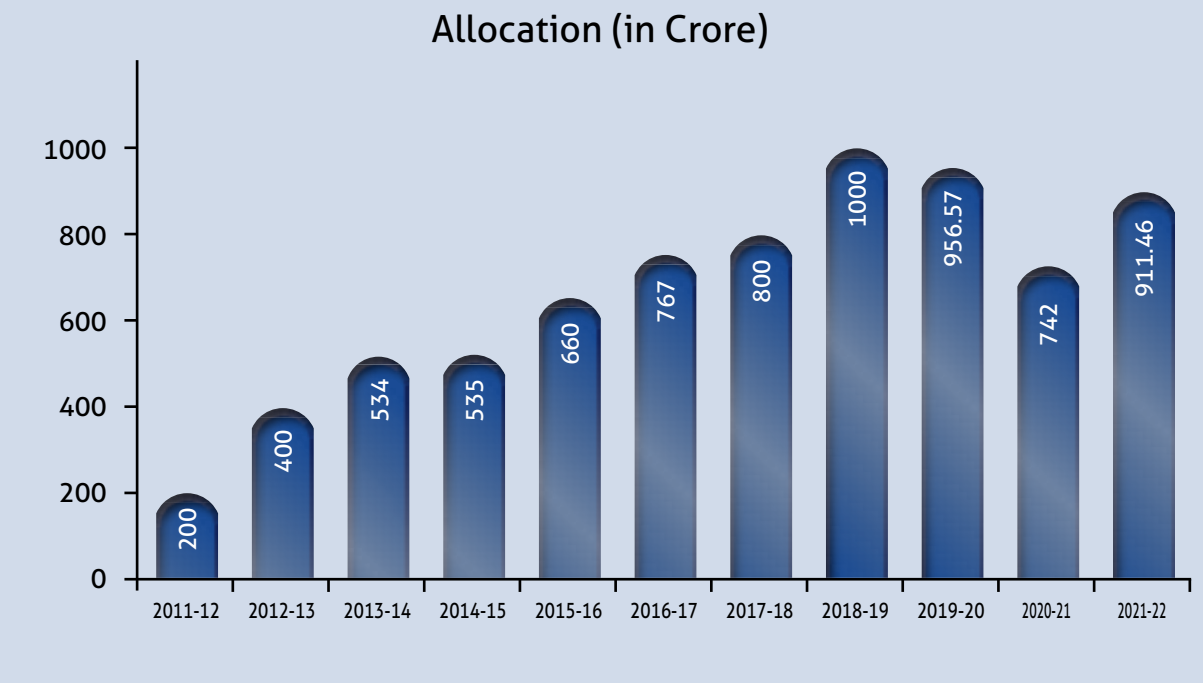


Fig. 1.8 : Budget allocation

2

OVERVIEW

SERB serves as a premier national funding agency in terms of planning, promoting, and supporting competitive basic research in all frontier areas of Science and Engineering. The programmes and schemes are designed to support all good ideas to foster a rich research culture by enabling synergy between academic institutions, research and development laboratories and industry for promoting basic and translational research in all emerging areas in Science, Technology, Engineering, Mathematics and Social Sciences (STEMS). The Board ensures transparency, accountability and responsiveness by way of various policies, procedures and practices that have been adopted from time to time.

In the midst of second wave of the pandemic SERB formulated special call to catalyse the R&D activities on critical components and innovations concerning Make-in-India Oxygen Concentrators to meet the emerging health care requirements. SERB continued the R&D support for the COVID-19 related projects that are initiated during first wave of the pandemic in the area of affordable diagnostics, drug repurposing, vaccine development and mathematical modelling to combat the transmission of COVID-19.

In addition to the above, SERB continued its normal research funding through its various programmes and schemes. In spite of the unprecedented challenges, SERB functioned as usual adhering to its commitments and upholding the aspirations of the research community. The proposals received under various programmes and schemes were evaluated and funding decisions made within the funding cycle. The evaluation meetings as well as monitoring meetings to review the progress of ongoing projects were held in virtual, physical and hybrid modes. In order to advance the innovation and discoveries beyond the frontiers of current R&D activities SERB launched new programmes. Taking into consideration the disruptions caused by the pandemic, several measures were taken to address the difficulties faced by Research Fellows and Principal Investigators (PIs) of ongoing projects. The tenure of the ongoing National Post-doctoral fellowship was extended with fellowship support. The ongoing projects were accorded extension for successful completion of the committed work. While a detailed account of activities and initiatives of SERB in the year 2021-22 are presented in the following chapters, the highlights are briefly indicated in this overview.

2.1 Ongoing Programmes / Schemes

SERB continued its research support through its ongoing programmes and schemes, the salient aspects of which are described below.

Core Research Grant (CRG) is the flagship programme of SERB. It provides individual-centric research support to researchers from academic institutions, research laboratories and other R&D organizations for undertaking research in all frontier areas of science and engineering. The support is provided for three years with no upper limit for funding. One call for proposals was solicited and 8378 applications were received. A total of 1080 projects were sanctioned under the 16 research verticals.

Start-up Research Grant (SRG) aims to assist researchers to initiate research career in a new institution. It is meant to enable researchers to establish themselves and move on to the mainstream core research grant. The support comprises of a flexibly structured research grant of Rs. 30 lakh plus Overheads for a period of two years. One call for proposals was solicited and 2397 grant applications were received. A total of 489 projects were sanctioned under SRG in the year 2021-22. The ongoing projects under the erstwhile Early Career Research Award (ECRA) was continued to be supported and the completed Young Scientist Scheme (YSS) projects were processed for settlement and closure.

MATRICS is to provide fixed grant support to active researchers with good credentials in Mathematical Sciences, Theoretical Sciences and Quantitative Social Sciences. The main feature of the scheme is submission of a simple proposal and a flexible grant to cater to the specific needs of Mathematical and Theoretical Sciences research. One call for proposals was solicited and 955 proposals were received. A total of 186 grants were sanctioned in the reporting period.

Scientific and Useful Profound Research Advancement (SUPRA) is formulated to explore new scientific breakthroughs, challenging the existing hypothesis and offer disruptive technologies at the cutting edge. The proposed research is expected to contain significant risk elements but promise of high reward if the difficulties could be circumvented. The funding is provided normally for a period of three years. In the reporting period, a total of 887 proposals were received and 26 proposals were sanctioned under the SERB-SUPRA scheme.

Empowerment and Equity Opportunities for Excellence in Science (EMEQ) is aimed to provide research support to researchers belonging to the Scheduled Caste and Scheduled Tribe to undertake research in frontier areas of Science and Engineering. Support consists of a project grant upto Rs. 50 lakh excluding Overheadss for a three-year duration. One call for proposal was solicited in which 1139 proposals were received. 253 new projects were sanctioned in the reporting period.

National Science Chair (NSC) intends to recognise distinguished Indian superannuated scientists for their outstanding contributions in the areas of Science, Technology, Engineering and Mathematics (STEM) to promote excellence and growth in R&D. The NSC is provided in two modes, Mode 1: Scientific Excellence, the objective of which is to extend continuance of support for excellence in R&D activities and Mode 2: Science Leadership which is more to do with recognition for thought leadership made by the awardee in his professional career. For the reporting period 5 National Science Chair were sanctioned under mode-1.

J C Bose Fellowship is awarded to active scientists as a recognition for their outstanding performance in the field of Science and Engineering. The fellowship is scientist-specific and very selective. 39 fellowships were sanctioned under J C Bose Fellowship scheme in the reporting period.

Abdul Kalam Technology Innovation (AKTIN) Fellowship is awarded to outstanding engineers to recognize, encourage and support translational research of excellence in the fields of engineering, innovation and technology development. 10 AKTIN fellowships were recommended in the reporting period.

SERB Science and Technology Award for Research (SERB-STAR) is a prestigious award instituted by SERB to recognize and reward outstanding performance of PIs of SERB Projects. The award consists of a fellowship of Rs. 15,000 per month, research grant of Rs. 10 lakh per annum and Rs. 1 lakh per annum as Overheads charges for a period of three years. The third call for nominations was made in the year 2021- 22.

22 projects were sanctioned under SERB-STAR award.

SERB-Technology Translation Award (SERB-TETRA) is to catalyze the technology translation in academic setting. SERB-TETRA will challenge scientists executing SERB grants to establish an effective, functional and synergistic working collaboration with an industry partner to elevate their breakthroughs results and technologies to TRL-5 and beyond. The awardees are supported with unstructured research grant of Rs. 15 Lakh per year including Overheads for a period of two years. In the reporting period 9 projects were sanctioned.

Swarnajayanti Fellowship was instituted by the Government of India, to commemorate India's fiftieth year of independence. The aim of this scheme is to incentivize young scientists with excellent research track record, by supporting their innovative projects in frontier areas of Science and Technology. The award is scientist-specific, and very selective. The award consists of a fellowship of Rs. 25,000 per month, in addition to salary drawn from the parent institute, for a period of five years. SERB supports the project component of the award through research grants. The award entails a flexible funding module to tailor support suited for individual research needs, which helps to diversify and broaden the scope of research. A total of 16 fellowships under Swarnajayanti Fellowship scheme were sanctioned by SERB in the year 2021-22.

Ramanujan Fellowship offers support to brilliant Indian scientists and engineers returning from all over the world to pursue their research career in India. These fellowships are for young researchers below the age of 40 years with a proven outstanding track record. The Ramanujan Fellows can work in any of the scientific institutions and universities across the country. The amount of fellowship offered under the scheme is Rs. 1,35,000 per month with a research grant of Rs. 7 lakh per annum and Overheads charges of Rs.60,000 per annum for a period of five years. In the reporting period 30 Ramanujan Fellowships were sanctioned.

SERB Research Scientists (SRS) was initiated in 2018-19 to provide a platform for sustainment of research careers of INSPIRE Faculty and Ramanujan Fellows for an additional period of two years. The amount of fellowship is Rs. 1,20,000 per month and in addition a research grant of Rs. 7 lakh per annum and Overheads charges are provided. In the reporting period 26 applications were received and 16 Fellowships were recommended out of which 3 fellowships were sanctioned.

Teachers Associateship for Research Excellence (TARE) intends to facilitate mobility of faculty members working in state universities, colleges and private academic institutions to carry out research in an established public funded institutions such as IITs, IISc, IISERs, NITs, national institutions and central universities, preferably closer to the institution where the faculty member is working. The support consists of research fellowship of Rs. 60,000 per annum subject to completion of minimum 90 days research work per year in the host institution and a research grant of Rs. 5 lakh per annum and Overheads. In the reporting period one call for applications was solicited and 671 applications were received. A total of 136 associateships were sanctioned in the financial year 2021-22.

SERB National Postdoctoral Fellowship (NPDF) is designed to support and foster highly potential young researchers in leading research labs with accomplished mentors. The support consists of fellowship of Rs. 55,000 per month plus HRA, research grant of Rs. 2 lakh per annum and Overheads for a period of two years. In the reporting period one call for proposal was solicited and received 4745 applications. A total of 272 SERB NPDF fellowships were sanctioned.

SERB Women Excellence Award is a prestigious award instituted to recognize and reward outstanding research achievements of young women scientists in frontier areas of Science and Engineering. The award strives to serve as a source of inspiration to women scientists who have the potential to become world class leaders in their field of research. Women scientists below 40 years of age who have received recognition from one or more of the National Science and Engineering Academies are considered for this award. The awardees are supported with a research grant of Rs. 5 lakh per annum for a period of three years. 9 women scientists were recommended the SERB Women Excellence Award in the year 2021-22 out of which 6 awards were sanctioned.

SERB-POWER (Promoting Opportunities for Women in Exploratory Research) is to mitigate

gender disparity in science and engineering research funding in various S&T programmes in Indian academic institutions and R&D laboratories. SERB-POWER is specially designed to provide structured support towards enhancing diversity in research and to ensure equal access and weighted opportunities for Indian women scientists engaged in R&D activities. The funding framework consists of two categories: SERB – POWER Fellowship and SERB – POWER Research Grants.

The one call for proposals under SERB–POWER scheme was solicited and 2695 proposals were received under SERB–POWER Grants and 76 projects were sanctioned. For SERB POWER fellowships 137 nominations were considered out of which 25 were recommended and sanctioned in the reporting period.

IMPRINT (Impacting Research Innovation and Technology) is a programme piloted by the Ministry of Education (MoE) (previously, Ministry of Human Resource and Development) and Department of Science and Technology (DST). The programme aims to address and provide solutions to the most relevant engineering challenges faced by our nation by translating knowledge into viable technology (product and processes) in selected domains. IMPRINT-IIC.2, consortium-based approach was also initiated under this programme, to include strong and complementary expertise from different disciplines to address major technological breakthrough in designated areas towards addressing societal/industrial importance. SERB has been entrusted for the implementation of this programme. The ongoing projects of IMPRINT-II received continued support in the reporting period.

Visiting Advanced Joint Research (VAJRA) Faculty Scheme aims to tap the expertise of overseas faculties/scientists including non-resident Indians (NRIs) and OCIs to undertake high quality collaborative research in public funded academic and research institutions in India. 37 scientists were offered the facultyship. Out of which 19 were sanctioned in the reporting period.

International Travel Support Scheme (ITS) provides financial assistance to Indian researchers for presenting a original research paper or chairing a session or delivering a keynote address in an international scientific event held abroad. In addition, support is also provided to young scientists (less than 35 yrs) for attending training programs, short-term schools and workshops. For attending the specific event SERB supports round the trip economic class air fare by the shortest route and airport taxi and visa fees for attending the specific event. Registration fee is also provided to young scientists in addition to the above support. A total of 201 researchers were recommended for attending the various international events.

Assistance to Professional bodies & Seminar/ Symposia is to support events having strong orientation towards scientific research in the areas of basic sciences, engineering, technology, agriculture and medicine. SERB, extends partial support for organizing seminar/symposia/ training program/workshops/conferences at national as well international level in the above-mentioned research areas. The support is provided to Research institutes/ Universities/ Medical and Engineering Colleges and other Academic Institutions/ Professional bodies who organize such events for the scientific community to keep them abreast of the latest development in their specific areas. A total of 123 events were recommended in the reporting period.

Accelerate Vigyan is an inter-ministerial initiative scheme conceptualized and steered by SERB. The aim of the scheme is to expand the research base, with three broad goals – consolidation and aggregation of all national scientific training programs, initiating High end Orientation Workshops and creating opportunities for Research Internships. During the reporting period, 740 applications were received for High End Workshop (Karyashala) and Training & Skill Internship (Vritika). A total of 107 and 84 applications were sanctioned for High End Workshop and Training & Skill Internship, respectively.

SERB- Vision Oriented Thought Exchange (VORTEX) Programme is to strengthen national S&T activities by interconnecting the active researchers to exchange the emergence of newer ideas in the field of Science and Engineering disciplines. SERB conducted- one VORTEX programme under Inorganic and Physical Chemistry PAC. The main objective of this conclave was to deliberate and discuss the current strength, emerging research topics and identify focussed areas for priority funding which are aligned with the national mission. SERB VORTEX (Inorganic and Physical Chemistry) meeting was organized at Gurukul Kangri University, on 17-

18th November 2021 and the following thematic areas were deliberated.

(a) Catalysis and Beyond (b) Translational Materials Chemistry (c) Ultrafast Photonics (d) Inorganic Chemical Biology (e) Controlling Chemical Reactivity.

2.2 New Initiatives

IRHPA – BSL/ABSL-3: Under the IRHPA scheme, a call for proposals has been made to establish state-of-art Biosafety Level (BSL3/ABSL3) facilities to address biosafety issues in handling existing and emerging infectious diseases required for basic research and diagnosis. SERB received 34 applications and recommended three ABSL-3 facilities with an equal budget to National Institutions placed in Bengaluru, Hyderabad, and Ajmer, as well two BSL-3 facilities at Tirupati and Kharagpur with an aim to cover different geographical areas where such facilities are in need.

SERB- Centres for Antibody Engineering: In order to advance the research in antibody technology SERB announced a special call for proposals under IRPHA scheme to create state-of the art research infrastructure to drive innovative and interdisciplinary collaborative research in recombinant antibody engineering with following broad contours.

(i) **R & D for antibody generation and modification**: (a) Multidisciplinary approaches in antibody production including biosimilars, purification, functionalization strategies and scale-up; development of novel antibody libraries. (b) Antibody conversions, humanization, fragment engineering, post-translational modifications. (c) Novel technologies, such as new display and hyper-mutation technologies, Human B cell clone selection and expansion.; novel vector systems and library platforms.

(ii) **ADC Therapeutics**: Antibody-based drug conjugates, ADC-based biosimilars; pre-clinical trials and validation of models for therapeutic applications involving antibodies; pharmacokinetic study and safety assessment modules; study and development of novel effector functions.

(iii) **Antibody-based diagnostics**: Development of high-quality detection of pathogens and immunodiagnostic test kits.

SERB received 32 application and 3 SERB-centres for Antibody Engineering were awarded to Indian Institute of Technology (IIT), Madras, Indian Institute of Science and Engineering Research (IISER), Bhopal and Mohali.

SERB-Centre for Energy Transformation and Storage: Clean energy is the bedrock of any society hoping to offer healthier, resilient and sustainable environment. In order to intensify the research and innovation in the field of smart energy transformation, storage and management to offset the dependence on conventional energy and to provide stable power to off-grid areas, SERB solicited the proposals under IRHPA with following broad thematic areas.

(i) Electrochemical energy storage systems for micro-grid installations

(ii) Technologies for utility-scale high-capacity batteries

(iii) Transparent photovoltaics for devices and surface integration.

SERB received 63 application and 5 SERB-centres for Clean Energy transformation has been supported to institutions placed at different geographical locations namely Indian Institute of Science, Bengaluru, Indian Institute of Technology at Bombay, Roorkee, Kanpur and Khargapur.

SERB-Centres on AI- based Earth systems modelling: A call for proposal under IRHPA scheme was made for developing Artificial Intelligence (AI) and Machine Language (ML) approach in the arena of geohazard and weather and climate prediction in the following thrust areas

(i) AI& ML for better weather and ocean forecasting and long-term environmental sustainability.

(ii) Deep learning models for early warning of extreme geohazards.

(iii) AI/ML models to predict climate extremities and climate change mitigation through high-precision analytics.

One special call for proposal was solicited and received 66 proposals.

OVERVIEW

CRG- Special call for proposals: SERB has been promoting and supporting novel ideas in the field of science and engineering under the flagship programs such as CRG, IRHPA and SUPRA and etc. In order to explore emerging innovation ecosystems and to provide better technological solutions to a particular scientific problem the special call for proposals were announced under the CRG scheme in the following thrust areas.

(a) **A wearable electronic for biomedical applications**: Wearable technological solutions are providing a transformation in the mobile health era in terms of improvising healthcare and providing real-time analysis on improved health management and tracing.

The focus of proposals under this category is expected to develop portable, wearable & implantable electronic devices those are essential for medical purposes such as diagnosis, examination, treatment, care, assistance, and research. One special call for proposal was solicited and received 401 proposals.

(b) **Biology of Plants under extreme environments**: Plant life covers much of Earth land's surface, providing structure to ecosystem, habitat for consumers, and regulating the exchange of energy and chemicals with the atmosphere. Climate related extremes such as high and low tempratures, light, abiotic and biotic factors, are becoming more dangerous. The special call for proposals under plant sciences and climate are invited under this area to understand the wide range of effects of climate change both interms of geographical location and productivity on plants in terms of physiology, biochemistry and gene regulation pathway. One special call for proposal was solicited and received 337 proposals.

(C) **Reagent less organic synthesis**: In order to achieve maximum atom economy through 'clean' chemical reactions with minimal waste generation to avoid adverse environmental impact. A special call under chemical sciences was initiated for disruptive developments in reagentless enabling strategies for synthetic applications both at lab and kilo scale reactors. One special call for proposal was solicited and received 135 proposals.

(D) **Selective Flourination strategies**: Preparation of many fluorinated pharmaceutical building blocks and active agrochemical intermediates remains a significant challenge. A special call for proposals under chemical sciences and pharmaceutics discipline for development of benign fluorination strategies for diverse organic substrates and amides, including late-stage fluorination. One special call for proposal was solicited and received 51 proposals.

SERB-Centre for Advanced Process Technology for Rare Earth Magnets: The most essential technologies to realize electric mobility are Lithium-ion battery (120-130 Wh/kg) and high-performance Neodymium Iron Boron (Nd-Fe-B) magnet. Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), an autonomous institution under Department of Science and Technology, is known for the development of permanent magnets such as high coercive ferrites, Grain boundary engineered Nd-Fe-B magnets, Metal-bound samarium-based magnets, etc. In view of available knowledge-base and expertise in the field of magnetics, SERB supported a project to establish pilot plant production of Nd-Fe-B magnets by adopting a novel technology, known as New Press less Process (NPLP) with following broad objectives,

(i) Setting-up pilot plant with all facilities required to manufacture near net shaped Nd-Fe-B magnet by adopting NPLP technique

(ii) Optimization of process parameters and demonstration of manufactures of near net shape Nd-Fe-B magnets with BHmax= 35-45 MGOe and Hc= 10-15 kOe at room temperature using imported raw materials.

(iii) Processing Nd-Dy-Fe-B magnet using imported powders suitable for operation at elevated temperatures for Electric vehicle (EV)

applications (Hc=10 kOe @ 150-200 °C).

(iv) Prototype motor development in collaboration with industries using NPLP processed magnets and performance evaluation.

(v) Production of Nd-Fe-B magnets using NPLP process with indigenous raw materials as per "Make In India" objective

SERB-International Research Exposure (SIRE): A new programme is initiated to impart high-end research training in frontier areas of Science and Technology for young scientists. The candidates selected under this programme will be supported for a period of 02-06 months to visit top institutions around the globe, preferably to the institutions where internationally acclaimed scientists are working. The first call for proposals was announced and received 789 proposals for consideration.

2.3 COVID-19 related R&D initiatives

In response to the second wave of the coronavirus (COVID-19) pandemic and considering emerging health care requirements SERB-Technology Development Board (TDB)-jointly announced a special call under CRG scheme to catalyze R&D on critical components and innovations concerning Make-in-India Oxygen Concentrators. The call is to develop individual/portable oxygen concentrators in domains of alternate materials and mechanisms for oxygen separation: design, development and manufacturing of critical components such as values and oil-less compressors, design improvements for greater performance, etc. Under this special CRG call 130 proposals were received and 11 proposals were supported.

Parallelly another CRG special call on "Wastewater-based epidemiological monitoring for SARS-CoV-2 Virus" has been initiated to monitor the open drain systems to identify the prevalent SARS-CoV-2 strains in circulation. Waste water surveillance is to track the pathogen present in that population and also help to tract the transmission levels; this data would supplement the current measures taken towards the combating COVID-19 pandemic. One special call for proposal was solicited and received 69 proposals for consideration.

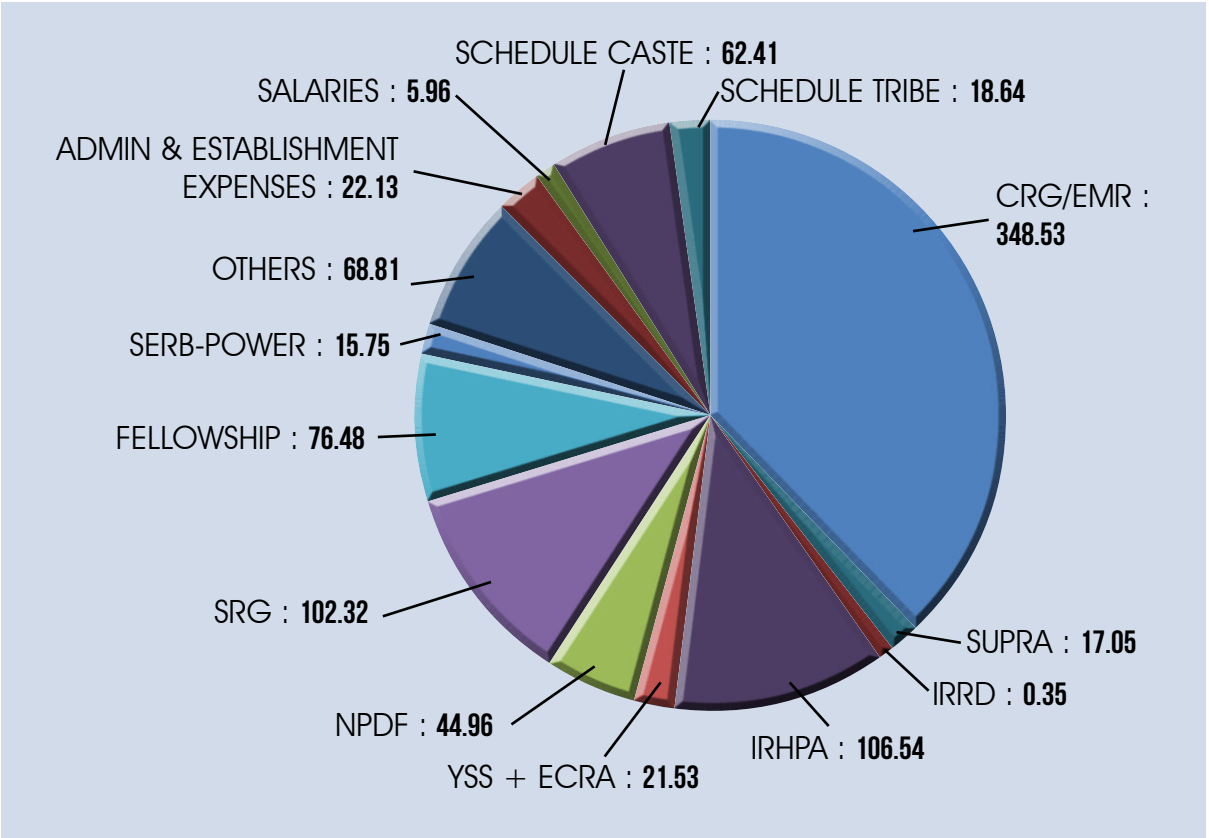
SERB also conducted interim monitoring meeting to evaluate the work progress accomplished for the ongoing and completed COVID-19 projects supported during first pandemic.

Extension of ongoing National Post-Doctoral Fellowship (N-PDF) tenure: Considering the impact of COVID-19 pandemic during second wave, tenure of N-PDF was extended for a period of six months with fellowship assistance. The extension was provided to successfully complete the proposed research work that was affected due to lockdown. Annual online poster competition was conducted as a part of third-party evaluation mechanism.

Extension of Ongoing CRG, EMEQ and SRG: In view of the extraordinary situation due to COVID-19, projects supported under CRG, SRG and EMEQ Schemes which completed within 1st April 2021 and 30th September 2021 were given six months no-cost extension to complete the unmet objectives due to nationwide lockdown.

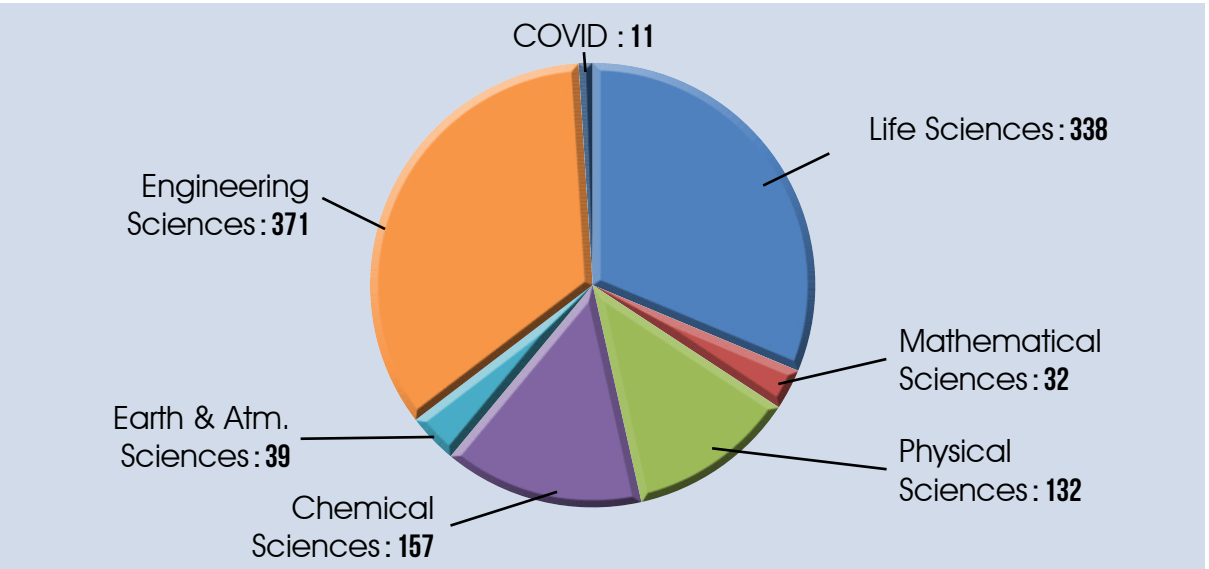
2.4 TOTAL EXPENDITURE FOR THE YEAR 2021-22

The below chart depict the total expenditure of Rs. 911.46 crores in the year 2021-22 under different schemes and administrative heads.

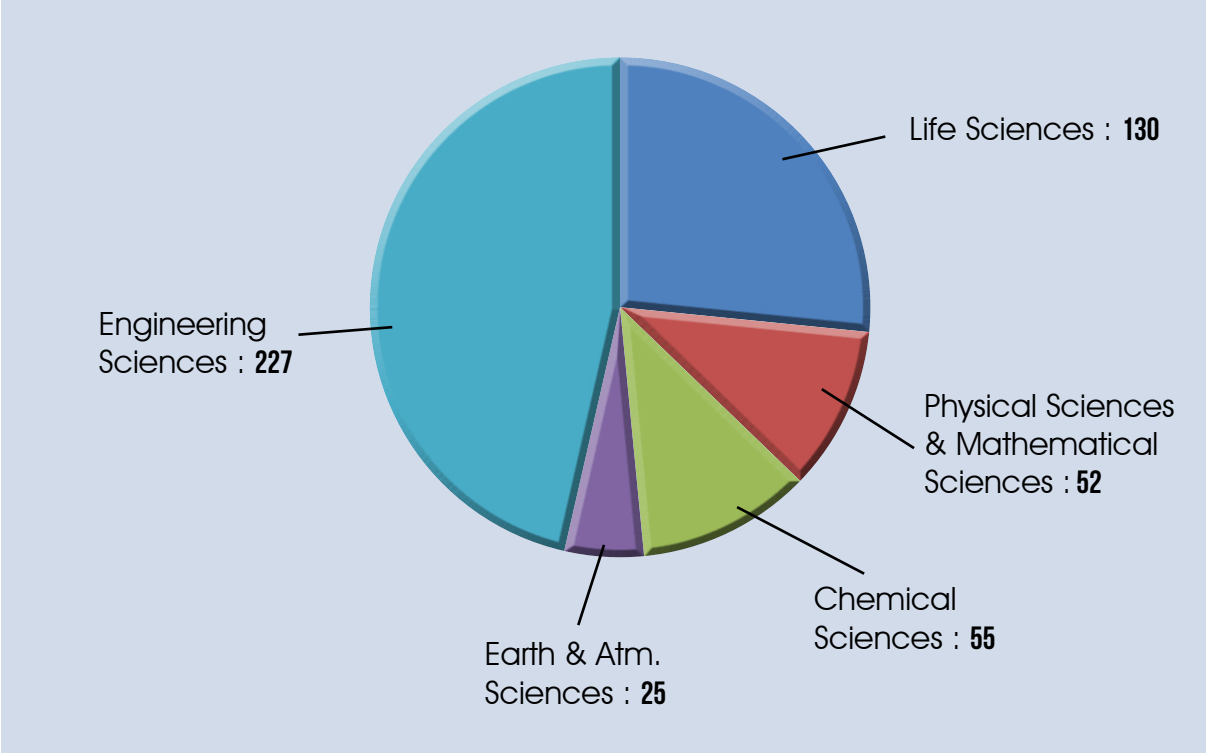


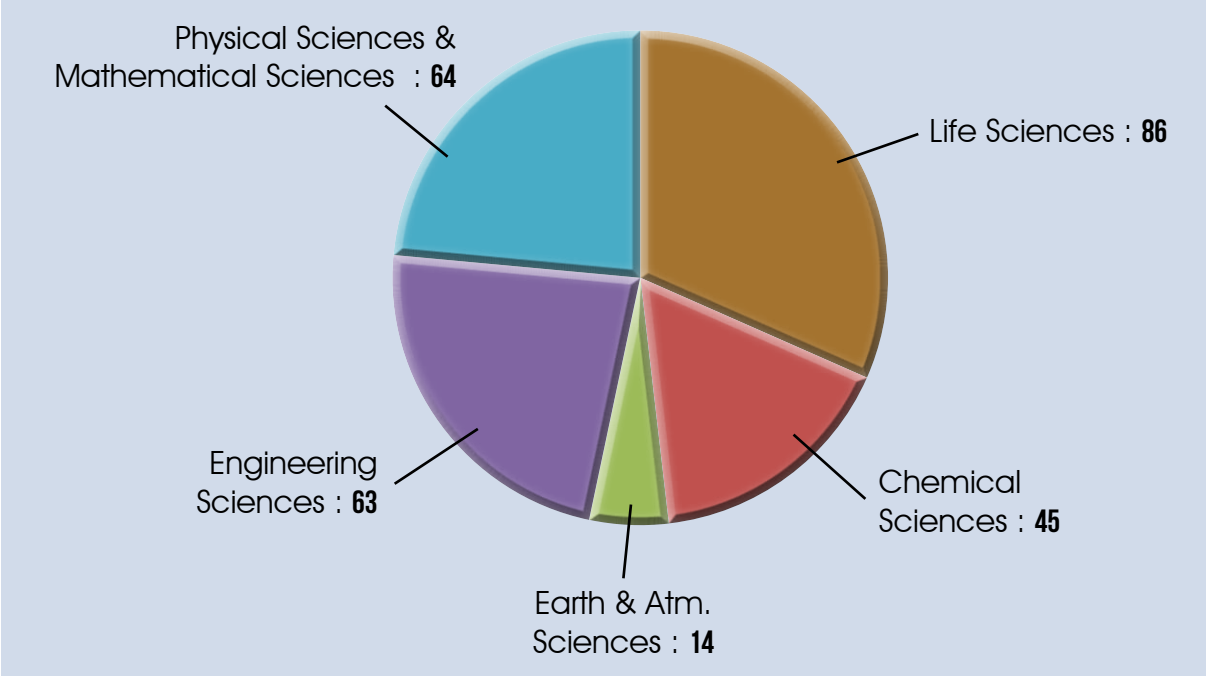
2.5 NEW PROPOSALS SANCTIONED DURING THE YEAR 2021-22

The number of new Proposals sanctioned in the year 2021-22 under CRG scheme distributed sub-discipline wise is given below :



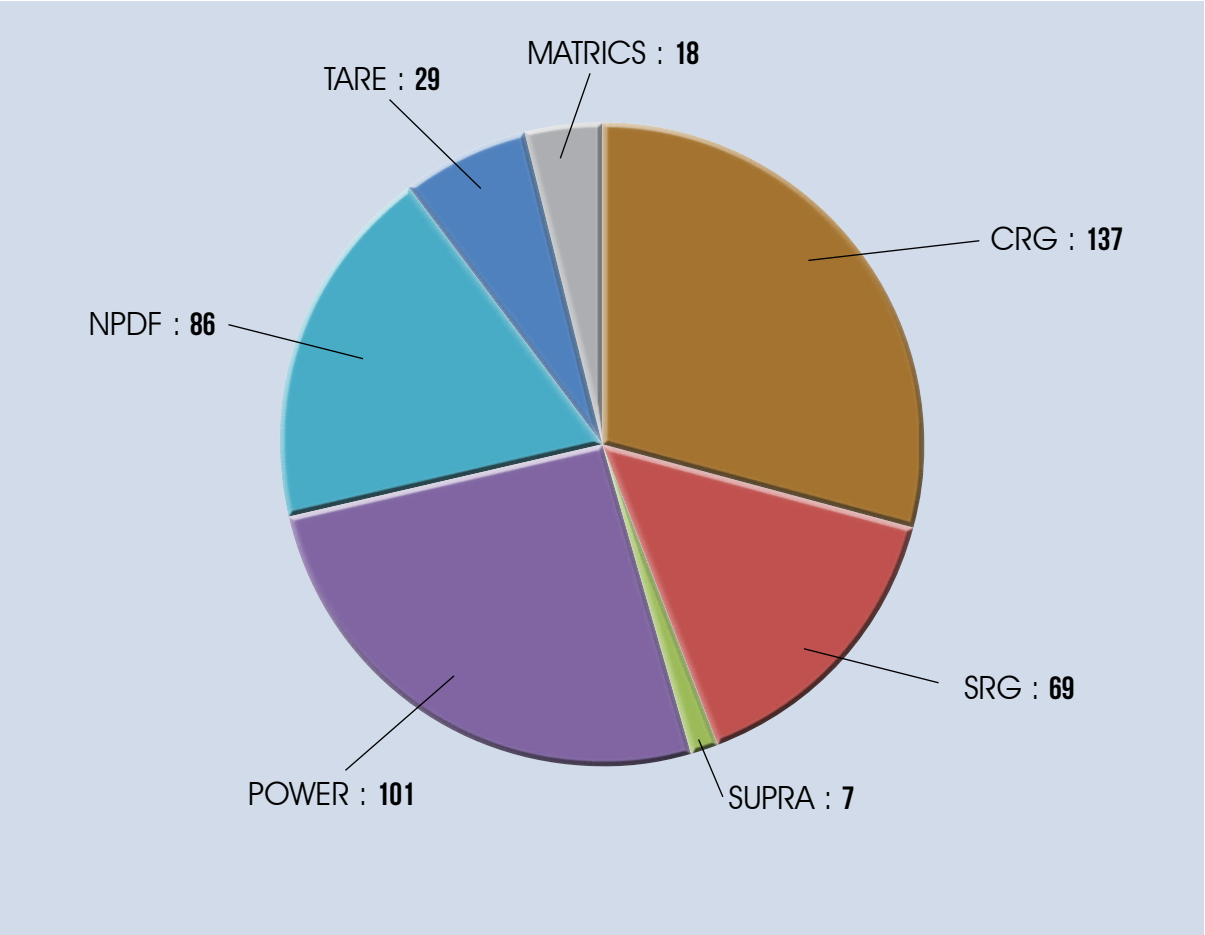
The number of new Proposals sanctioned in the year 2021-22 under SRG and N-PDF scheme distributed sub-discipline wise are given below :





OVERVIEW

The number of new Proposals sanctioned to Woman Candidates in the year 2021-22 under different schemes are given below :



3

PROJECT GRANT PROGRAMMES

SERB was set up by an act of parliament in 2008 to serve the country as a premier funding agency for promoting basic research and providing financial assistance to the scientific community. It has been playing an important role to foster and nurture vibrant research culture and scientific temper across the country through its project-based funding and scholarship programmes. Various programmes like Core Research Grant, Young Scientist Scheme, Intensification of Research in High priority Areas, Start-up Research Grant etc. have been launched by SERB in different times. Recently, SERB has initiated several other new programmes with definite goals and characteristics with a focus to address specific requirements maintaining synergy between academic institutions, research laboratories and industry. Further, some of the programmes have been re-formatted and replaced depending on changing needs and evolving research scenarios.

Core Research Grant (CRG), earlier known as Extramural Research (EMR) programme is the flagship programme of SERB, catering to the research fraternity without any restrictions in age of the Investigator or limitation in budget. Start-up Research Grant (SRG) is for helping young researchers of the country to initiate their scientific career in a new place. As the requirements of Mathematical and Theoretical research are distinct in comparision to experimental research, a specially conceptualized programme named MATRICS was established to offer fixed grant support to active researchers in Mathematical, Theoretical and Quantitative Social Sciences areas. The IRHPA programme follows the startified approach where important scientific areas have been explored with immediate needs and researchers are invited to submit proposals addressing those burning issues. Scientific and Useful Profound Research Advancement (SUPRA) is an exclusive programme for inviting proposals of superior quality with novel ideas and disruptive thinking.

SERB takes poignant steps for promoting research excellence with equitable rights and all-inclusive approach. Special schemes have been launched to facilitate enhanced participation of weaker sections of the society. The scheme, Empowerment and Equity Opportunities for Excellence in Science (EMEQ) provides project support to researchers belonging to the SC and ST communities. POWER (Promoting Opportunities For Women in Exploratory Research) Grant is formulated to mitigate the problem of gender disparity in science.

In this chapter, the activities of programmes offering project-mode funding are described along with research highlights of some of the projects supported under these programmes.

CRG - PROGRAMME ADVISORY COMMITTEES

CHEMICAL SCIENCES

- Inorganic & Physical Chemistry
- Organic Chemistry

- Earth & Atmospheric Sciences

ENGINEERING SCIENCES

- Chemical & Environmental Engineering
- Civil, Infrastructure & Transportation Engineering
- Electrical, Electronics & Computer Engineering
- Materials, Mining & Minerals Engineering
- Mechanical, Manufacturing, Aerospace Engineering & Robotics

- Exponential Technologies

LIFE SCIENCES

- Biomedical & Health Sciences
- Interdisciplinary Biological Sciences
- Organismal & Evolutionary Biology

- Mathematical Sciences

PHYSICAL SCIENCES

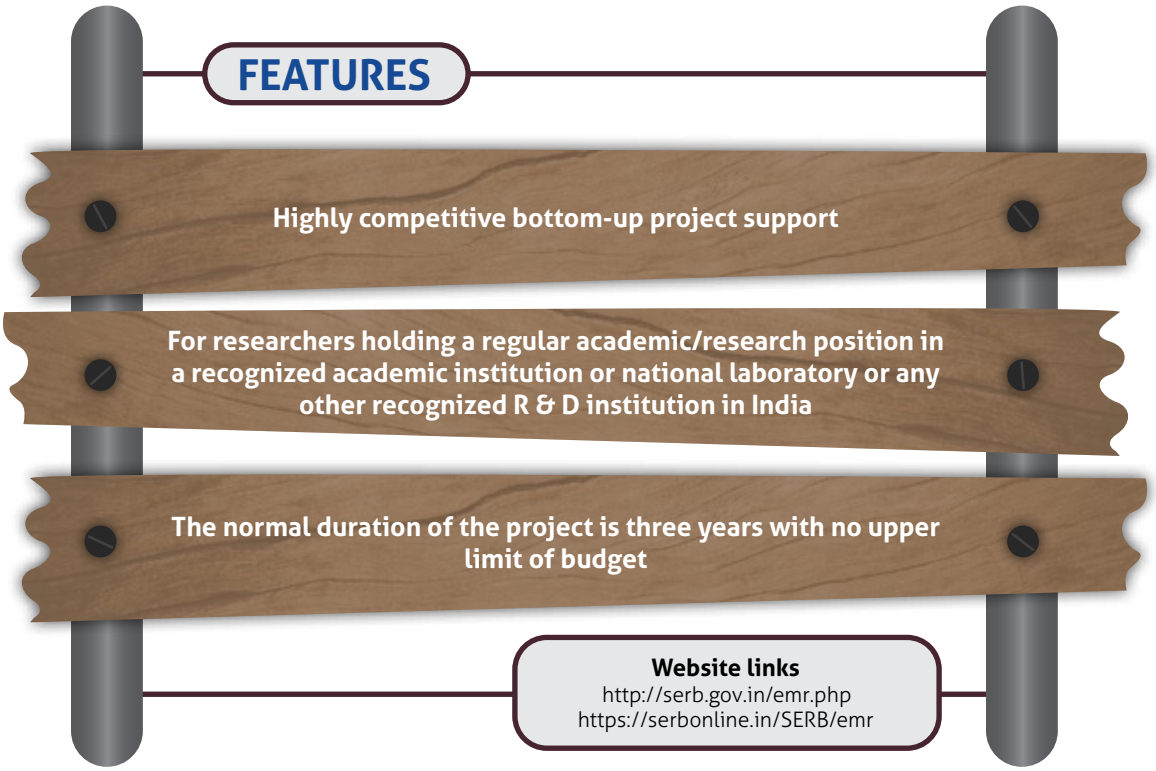
- Physical Sciences - I (CMP & MS)
- Physical Sciences - II (PHENNA-LOAMP)

- Quantitative Social Sciences

3.1 SUPPORTING CORE RESEARCH

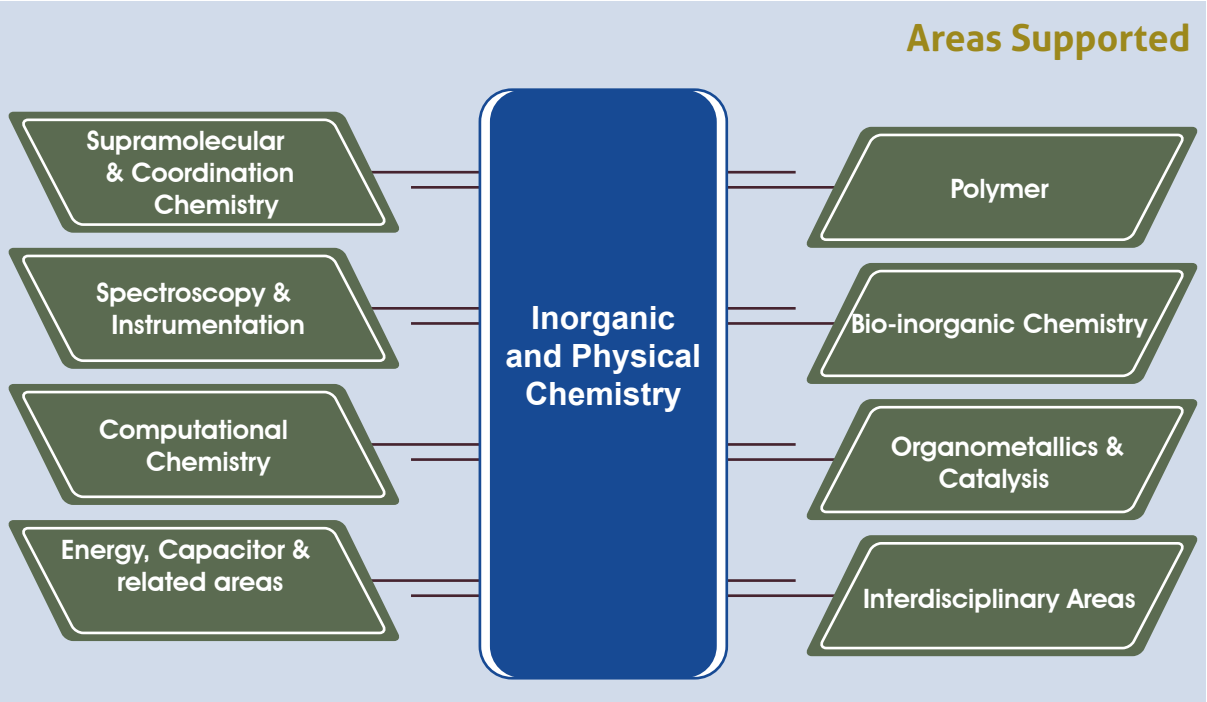
3.1.1 Core Research Grant (CRG)

The flagship programme of SERB – Core Research Grant- has always been in prominence since the inception of Science and Engineering Research Council (SERC) four decades ago. It provides competitive-mode projects to individual researchers belonging to academic institutions, research laboratories and other R&D organisations to carry out basic research in all frontier areas of Science and Engineering. The CRG programme had played a pivotal role in building research capability across the country and sustaining the research interests of scientists. CRG programme functions across 16 disciplines/ theme wise verticals with individual Programme Advisory Committees and programme officers.



3.1.1.1 Inorganic and Physical Chemistry

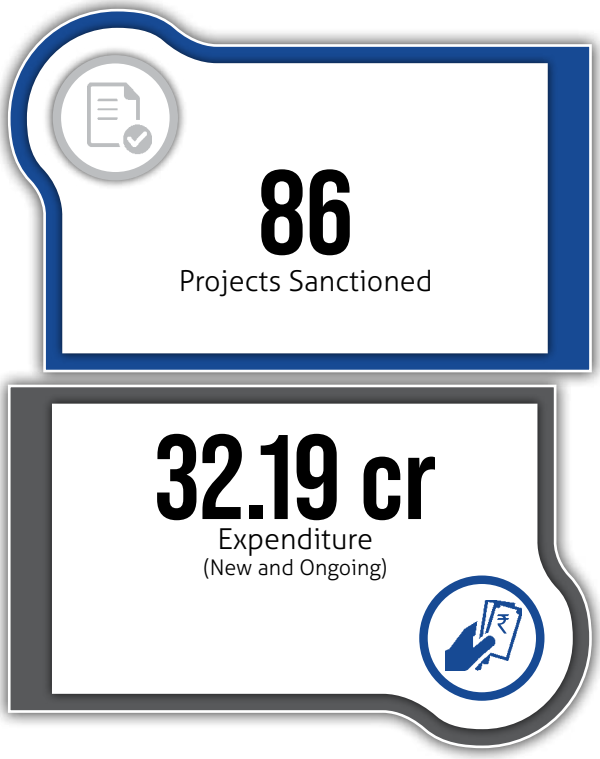
In the reporting period, 86 new projects were sanctioned. The areas supported under CRG – Inorganic and Physical Chemistry are shown in the following figure.



Research Highlights

Surface-Anchored Metal-Organic Thin-Film Devices

Developing electrically conducting/ semiconducting metal-organic coordination polymers (CPs). Fabrication of thin-films of CPs (SURMOs). Patterning thin-films by electron-beam lithography/photo-lithography. Fabricating thin-films for electronic device applications (diodes and transistors). Fabricating thin-films for electrochemical device applications (supercapacitors and batteries). High-quality thin film of metal-organic frameworks (MOFs) were successfully fabricated employing the layer-by-layer (LbL) approach (Figure 3.1). Thermally-driven resistive switching in thin films of MOFs was demonstrated for the first time. Spontaneous reduction of Cu (II) to Cu (I) at the solid-liquid interface resulting in the generation of a new MOF has been captured. Generation of open-metal Cu (II) sites in thin films of MOF grown at solid-liquid interface. Significant enhancement in in-plane electrical and an unheralded cross-plane current rectification ratio exceeding 10^5 both at room-temperature and at an elevated temperature



(450 K) were achieved in TCNQ doped Cu-BTEC thin films, similar to those of commercial Si rectifier diodes. Successful generation of AB- and BA- type hetero-structured thin films of MOFs having different oxidation states of Cu, different coordination motifs and mismatched lattices exhibiting current rectification, attributed to the formation of well-defined interface resembling a p-n junction- a hitherto unreported phenomenon (Figure 3.2). Unravelled the role of pH of in direct growth of thin films of Ag-based coordination polymer on functionalized Au substrate. This project aided the development of exotic porous semiconducting MOFs, functionalized graphene-based nanocomposites with S=1/2 kagome lattices as well as 1D plasmonic nanostructures. This work was done at Indian Institute of Science Education and Research, Pune.

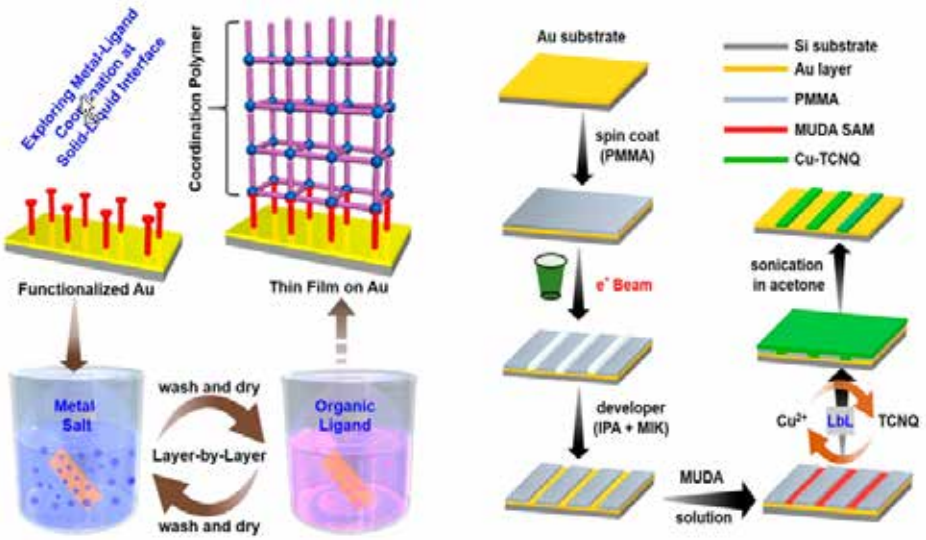


Fig. 3.1: Fabrication of thin films of coordination polymers via layer-by-layer (LbL) technique (left panel) and Patterning thin films by electron-beam lithography/ photo-lithography (right panel).

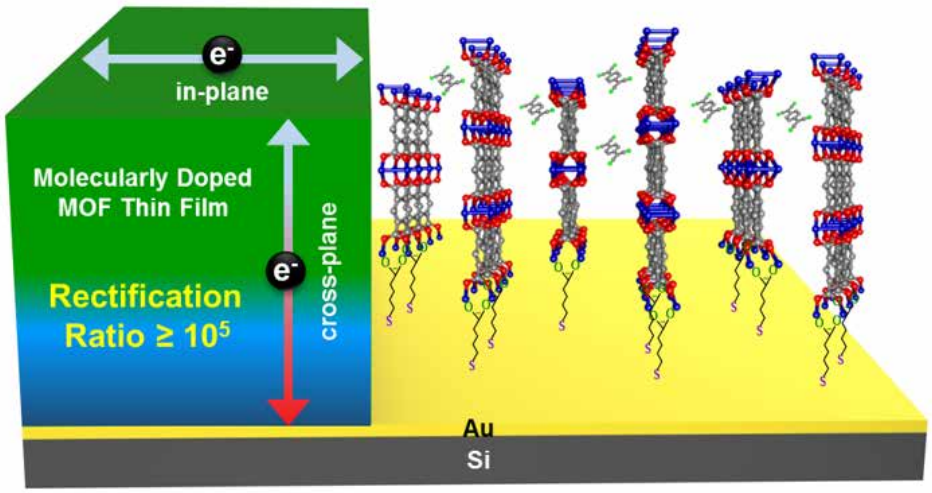
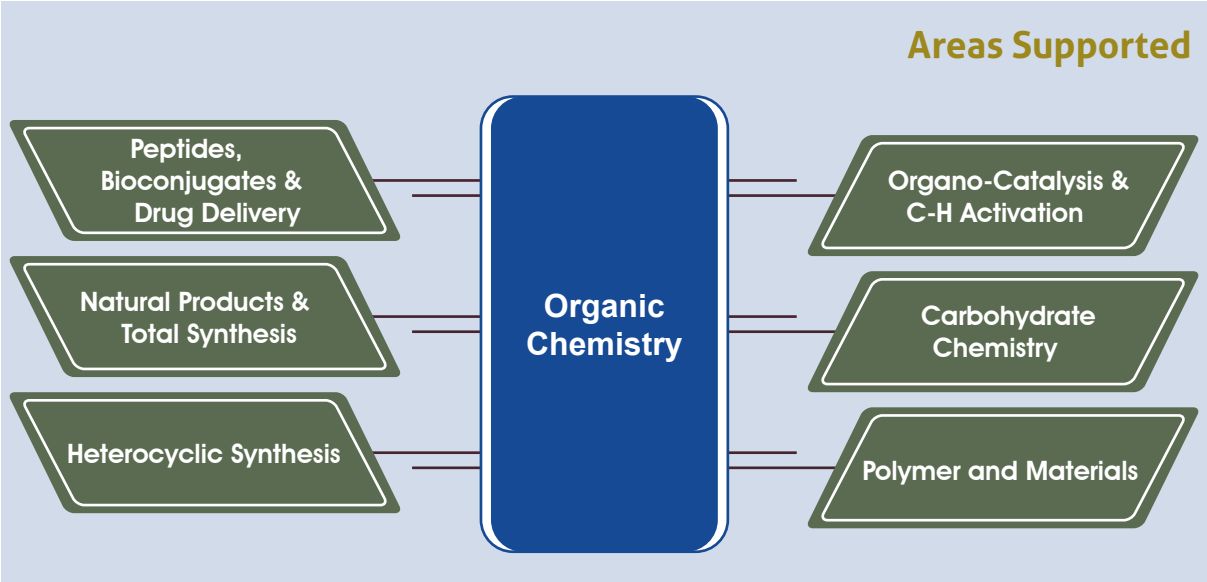


Fig. 3.2: Schematic of the molecular doping of Cu-BTEC thin film fabricated via LbL. A significant enhancement in in-plane electrical conductivity and an unheralded cross-plane current rectification ratio (exceeding 10 ^ 5 both at room-temperature and at an elevated temperature) were achieved.

3.1.1.2 Organic Chemistry

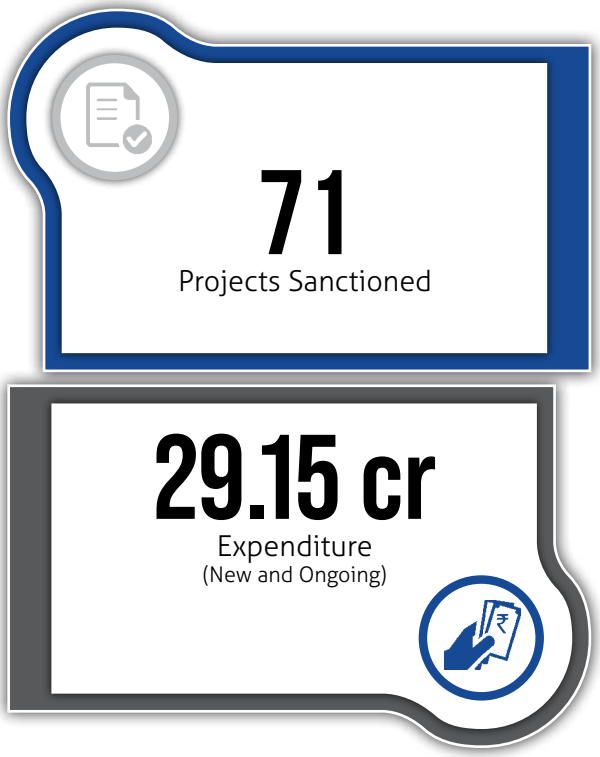
In the reporting period, 71 new projects were sanctioned. The areas supported under CRG – Organic Chemistry are shown in the following figure.



Research Highlights

Remote Stereocontrol through Catalytic Enantioselective Desymmetrization

The main goal of the project was to develop catalytic enantioselective desymmetrization reactions with the objective of generating stereogenic centers away from the reaction site – a feat difficult to achieve by other means. The reactions envisioned include enantioselective C(sp^2)–H alkylation and *de novo* construction of chiral (hetero)arenes as well as their applications to complex targets. Ladderane phospholipids, isolated in 2002 from anerobic ammonium oxidizing (anammox) bacteria, revealed never-seen-before structural features in nature – a highly unusual ladder like arrangements of concatenated cyclobutane rings. These ladderane phospholipids are composed of either (+)-[3]-ladderanol or a mixture of (+)-[3]-ladderanol and (–)-[5]-ladderanoic acid. Despite their fascinating structure and other necessary impetus, only a few synthetic studies of these molecules have been reported so far. The team devised a concise total synthesis of [3]-ladderanol, a component of ladderane phospholipids, using an organocatalytic enantioselective desymmetrizing formal C(sp^2)–H alkylation (Figure 3.3). The synthetic strategy rests on the late-stage introduction of chirality, thus allowing facile access to both enantiomers of [3]-ladderanol as well as an analogue.



In addition, Investigators have adopted enantioselective *de novo* construction of arenes and heteroarenes for the desymmetrization of various prochiral and *meso*-compounds. One such example is the use of the century-old Fischer

indolization reaction for the desymmetrization of prochiral diketones containing enantiotopic carbonyl groups, namely 2,2 disubstituted cyclopentane-1,3-diones. This reaction is catalyzed by a combination of spirocyclic chiral phosphoric acid and $ZnCl_2$ – known as Lewis acid-assisted Brønsted acid (LBA) and shown to proceed through dynamic kinetic resolution (DKR) of the initially formed enantiomeric hydrazones (Figure 3.4). The products of this reaction – cyclopenta[*b*] indolones, bearing an allcarbon quaternary stereocenter, are formed in moderate yields and with good to excellent enantioselectivities. Central chirality in arene derivatives arising out of unsymmetrically substituted arene ring is a fascinating yet rarely explored research topic. Not only the chirality of these arenes is dictated by the remote substituents, but an exchange of positions of these substituents results in enantiomeric arenes. This work was done at Indian Institute of Science, Bengaluru.

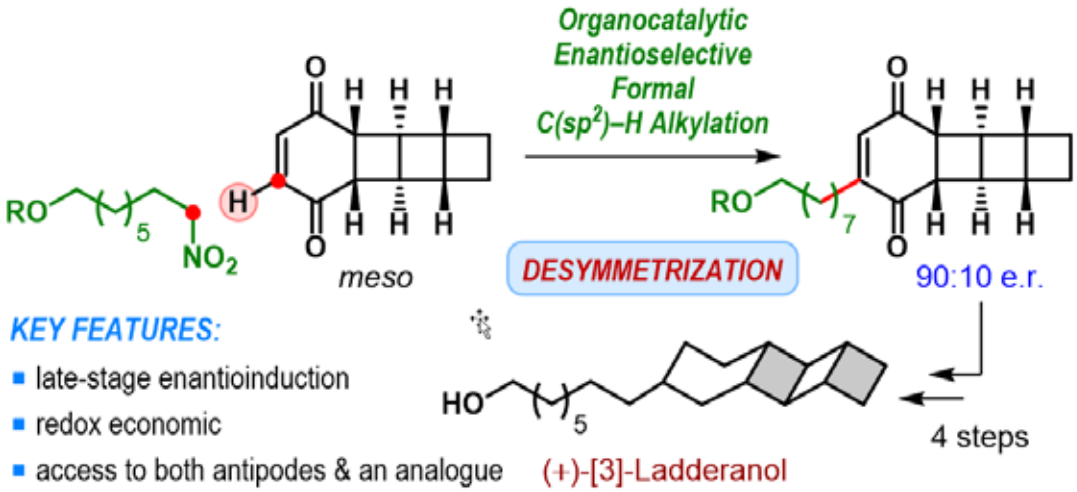


Fig. 3.3: Enantioselective total synthesis of (+)-[3]-ladderanol

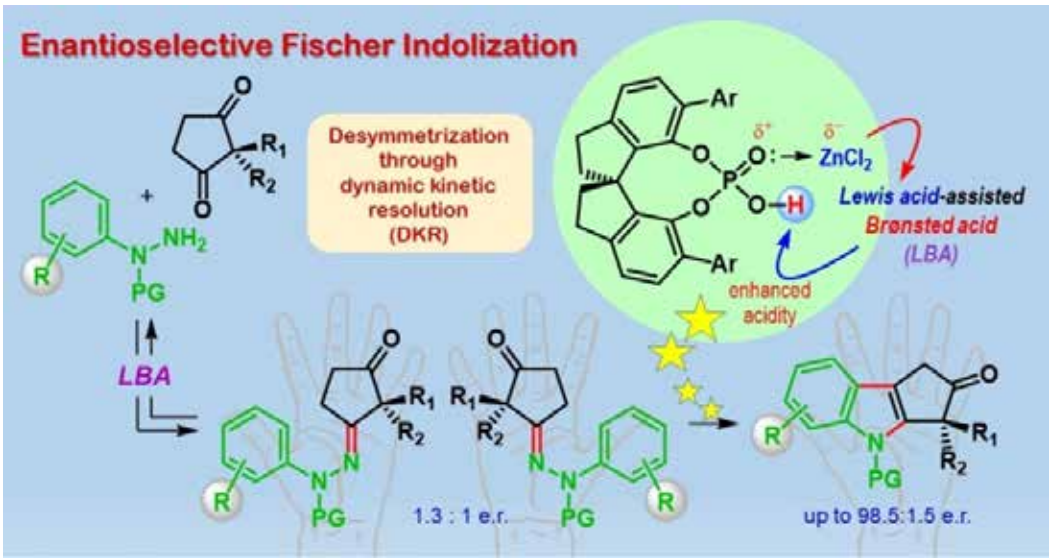
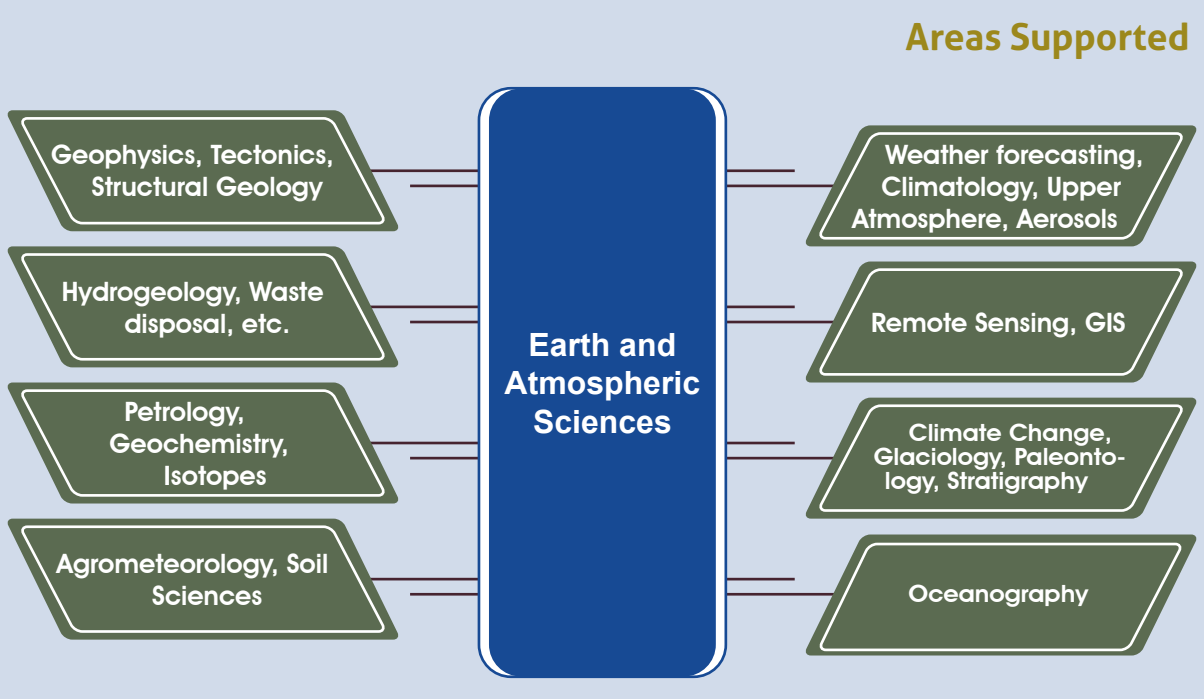


Fig. 3.4: Catalytic enantioselective desymmetrizing Fischer indolization of prochiral diketones

3.1.1.3 Earth and Atmospheric Sciences

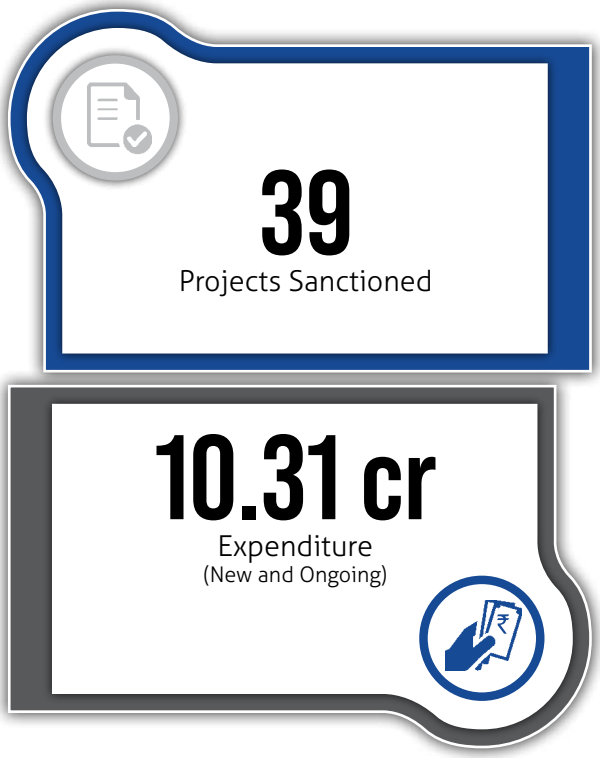
In the reporting period, 39 new projects were sanctioned. The areas supported under CRG – Earth and Atmospheric Sciences are shown in the following figure.



Research Highlights

Spatially distributed erosion estimation and hydrological modelling on a glaciated and ungauged river basin of Arunachal Pradesh using geo-informatics:

The Soil and Water Assessement Tool (SWAT) model was calibrated (2004–2005) and validated (2010–2012) for an ungauged river basin (Mago basin) of Arunachal Pradesh.Curve number was found to be the most sensitive parameter for the region. Investigating the impact of snow dynamics on the hydrology of the basin revealed that the contribution of the snowmelt to the total runoff was around 8% (out of 631.03 mm of annual total runoff, 50.91 mm was snowmelt). This showed that the hydrology of Mago River Basin was dominated by rainfall, where more than 90% of the annual streamflow came from rainfall. However, the contribution of snowmelt runoff seems to be particularly important during dry seasonal flow. The presence of snow cover and snow pack acted as water reservoir as well as evaporation inhibiting agent, thereby reducing the evapotranspiration and supplemented the water deficit by adding the melt water into the precipitation during the lean months. This substantiated the importance of the presence of snow cover and snow pack/glaciers in the basin and the necessity to preserve the regional hydrological balance and eco-system against



the global rise in temperature, anthropogenic or otherwise. Estimation of the average annual sediment yield showed that a large portion of the study area (73.34%) was under slight sediment yield class and the rest of the areas were under moderate to very severe sediment yield classes. The temporal variation in area under the slight sediment yield class showed a decreasing trend at a yearly rate of 3.2 t/ha/yr, while increasing trend was observed for areas under moderate to very severe sediment yield class, which implicated an increased sediment yield and a shift from slight to severe sediment yield class. The average total sediment yield in the Mago River Basin was estimated to be 17.92 t/ha/yr and the average annual sediment yield for each year crossed the permissible soil loss limit of 12 t/ha/yr by water. Climate change study of the region projected an increase in average annual precipitation, maximum temperature, minimum temperature, streamflow, water yield, actual evapotranspiration, groundwater while soil water was projected to decrease under RCP. 4.5 and RCP 8.5 scenarios by the end of the twenty-first century (Figure 3.5). This work was done at North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli (Itanagar), Arunachal Pradesh.

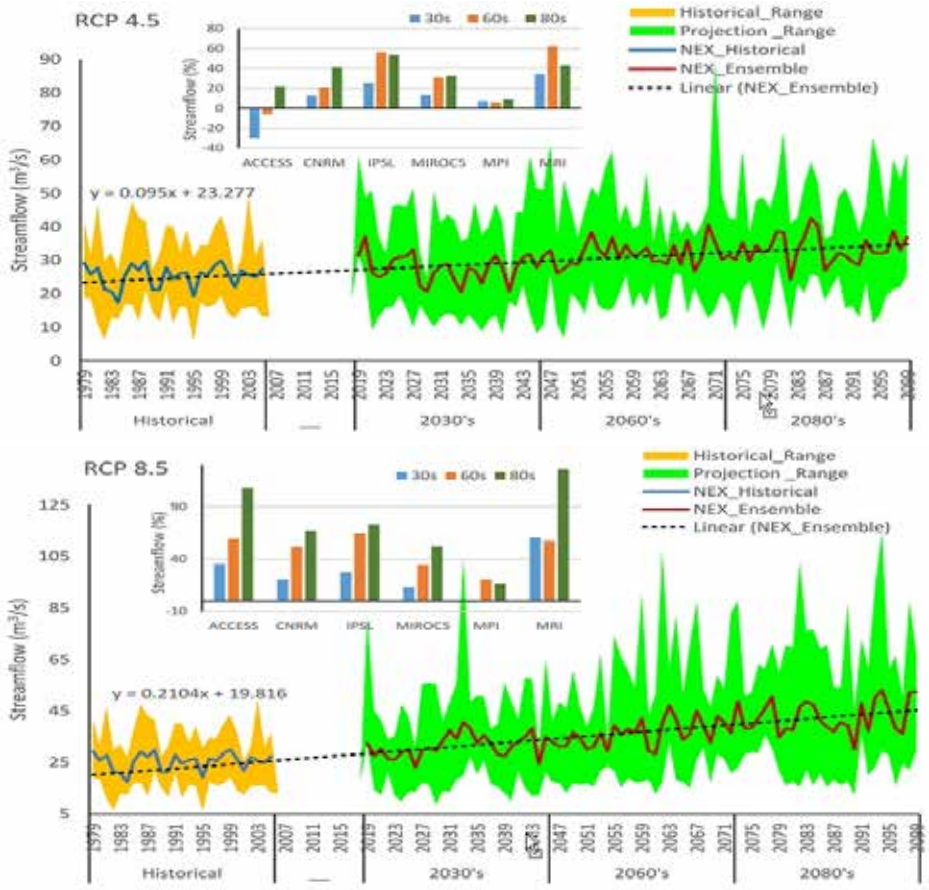
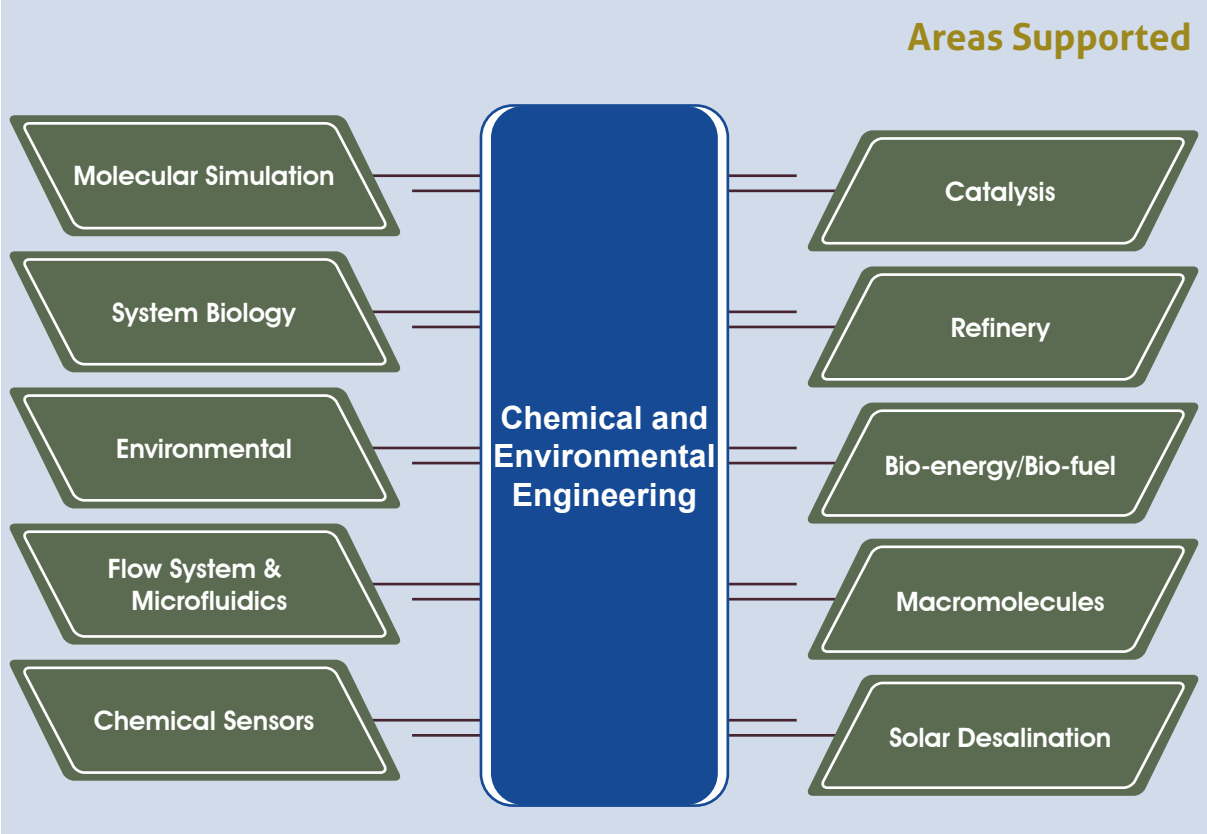


Fig. 3.5: Relative change in average seasonal streamflow with respect to the baseline values on seasonal basis under (a) RCP 4.5 and (b) RCP 8.5 scenarios.

3.1.1.4 Chemical and Environmental Engineering

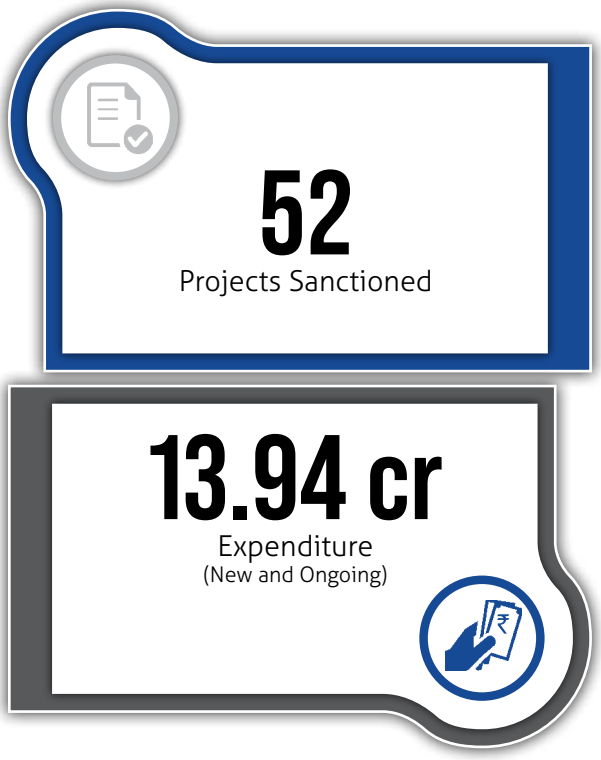
In the reporting period, 52 new projects were sanctioned. The areas supported under CRG – Chemical and Environmental Engineering are shown in the following figure.



Research Highlights

Microscale investigation of miscibility behaviour of CO_2 with crude oil for enhanced oil recovery and its geological sequestration potential in Cambay Basin

Carbon dioxide (CO_2) injection is one of the most effective methods to enhance oil recovery from the matured oil field. The mechanisms of oil recovery by CO_2 flooding include both immiscible and miscible flooding. However, the oil recovery from miscible flooding is higher than from immiscible flooding. The minimum miscibility pressure (MMP) at which the crude oil and CO_2 become miscible is a key factor because, in general, the CO_2 is not miscible at first contact with reservoir oils but may achieve dynamic miscibility through multiple contacts. Miscible CO_2 displacement is only attained under specific reservoir conditions viz., reservoir pressure, reservoir temperature, injected gas composition, and crude oil chemical composition. At pressures above MMP, the most dominant mechanism is miscibility between CO_2 and the reservoir oil. The miscible process is best



applicable to light and medium gravity crude oils. The use of CO_2 for EOR is considered one of the most promising methods for commercial application. A zero (or tends to zero) interfacial tension value is essential and adequate for the accomplishment of miscibility which further leads to an increase in capillary number and subsequently improves or attains nearly perfect microscopic displacement efficiency. Hence, the oil recovery by CO_2 miscible flooding from the matured reservoir is highly promising. Moreover, it is a cheap technology as an ultimate long-term geologic storage solution for CO_2 owing to its economic productivity from incremental oil production offsetting the cost of carbon sequestration and exhibits high displacement efficiency and the potential for environmental contamination decrease through its disposal in the petroleum reservoir.

The minimum miscibility pressure (MMP) is defined as the lowest operating pressure at which the oil and gas phases can become miscible in any portion through the dynamic multi-contact miscibility (MCM) process at an oil reservoir temperature. Thus, accurate determination of the MMP for a given crude oil–gas (e.g., CO_2) system is required for a gas injection EOR project in an oilfield. In the literature, several theoretical models, numerical simulations, and experimental methods have been developed to determine the MMPs of various crude oil–solvent systems. In general, the experimental methods are considered to be the most accurate and reliable. In particular, the slim-tube tests and core flooding tests are commonly used to measure the MMP. The slim-tube tests have been widely accepted and used by the petroleum industry as a standard method for the MMP measurement. The major component of the experimental setup for the slim-tube tests is a long and small coiled tubing, which is packed with proper particulate materials (e.g., the Ottawa sands or glass beads) and saturated with the crude oil to be tested as shown in Figure 3.6. The gaseous solvent (e.g., CO_2) is injected at different pressures and the actual oil reservoir temperature through the long coiled slim tube to simulate the crude oil–gas two-phase flow through the porous medium by effectively eliminating the viscous fingering and entrance effect. The mechanisms of miscible flooding can be established by measuring the gas composition through Gas Chromatography.

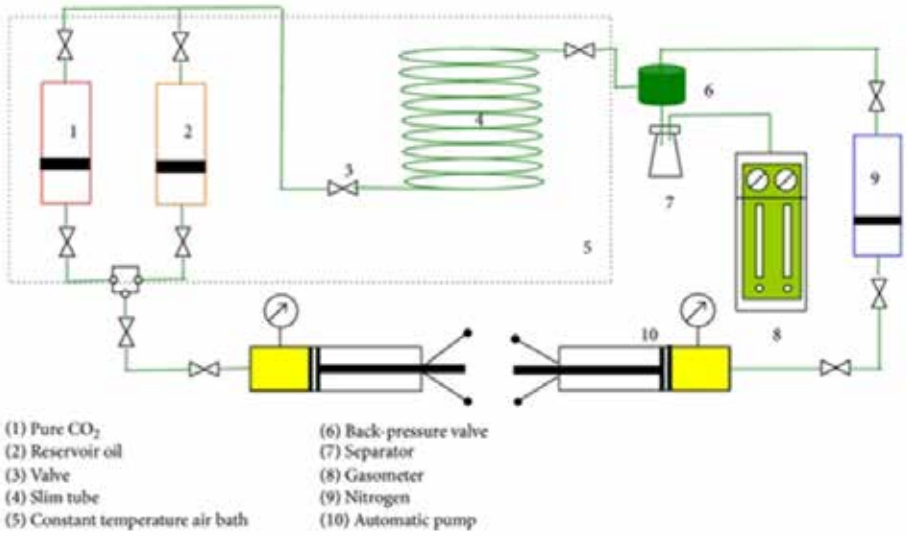


Fig. 3.6: Schematic of Slim-Tube Apparatus.

The core flooding system was used for the CO_2 experiment, manufactured by the D-Cam Engineering shown in Figure 3.7 The water-assisted CO_2 gas flooding for the Indiana limestone carbonate core sample. In which the water flooding was performed as secondary recovery and the water-assisted CO_2 gas flooding as tertiary recovery.

The different pressures were used to check the miscibility level of water-assisted CO_2 gas flooding. After water flooding, the first injection of CO_2 was carried out at the 1100 psi in the super critical state around 1 pore volume. Then for the 2 days, the CO_2 gas has been given for interacting with the oil at the same temperature in closed conditions. After 2 days a significant amount

of pressure in the gas has been reduced up to around 700 psi. This reduction in the pressure is due to two major phenomena in the miscible condition i.e., Vaporizing and Condensation. Both the process was going on simultaneously causing the gas to get richer in lighter components and the crude oil to get the lighter by enriched in the gas component showing the oil swelling effect resulting in the mobilization of oil. The mobilized oil was recovered after the flood with the water. The total incremental recovery was 6 %. The Second pressure was 1400 psi and the same procedure was followed resulting in an incremental recovery was 5.67%. The Third pressure was 1700 psi and the same procedure was followed in this pressure the mobilization of the oil was quite good as compared to the previous pressures. The incremental recovery at the stage was 14.68 %. The total incremental recovery after the water flow by the water-assisted CO_2 gas flooding was 26.65 % of the original oil place.

Fig. 3.7: The core flooding System.

The pore volume verses recovery factor and the differential pressure were plotted in the graph as follows in Figure 3.8. The results are quite encouraging compared to other EOR methods. This work was done at Indian Institute Of Technology (Indian School Of Mines), Dhanbad.

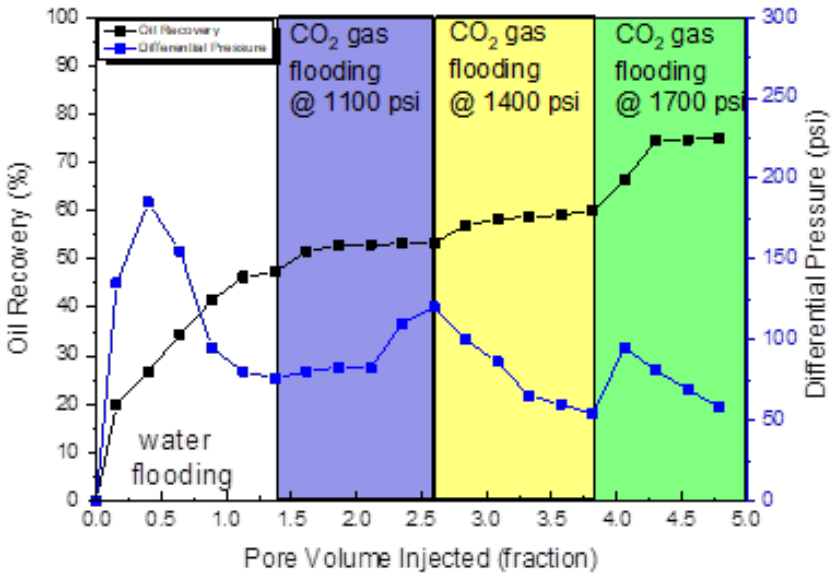
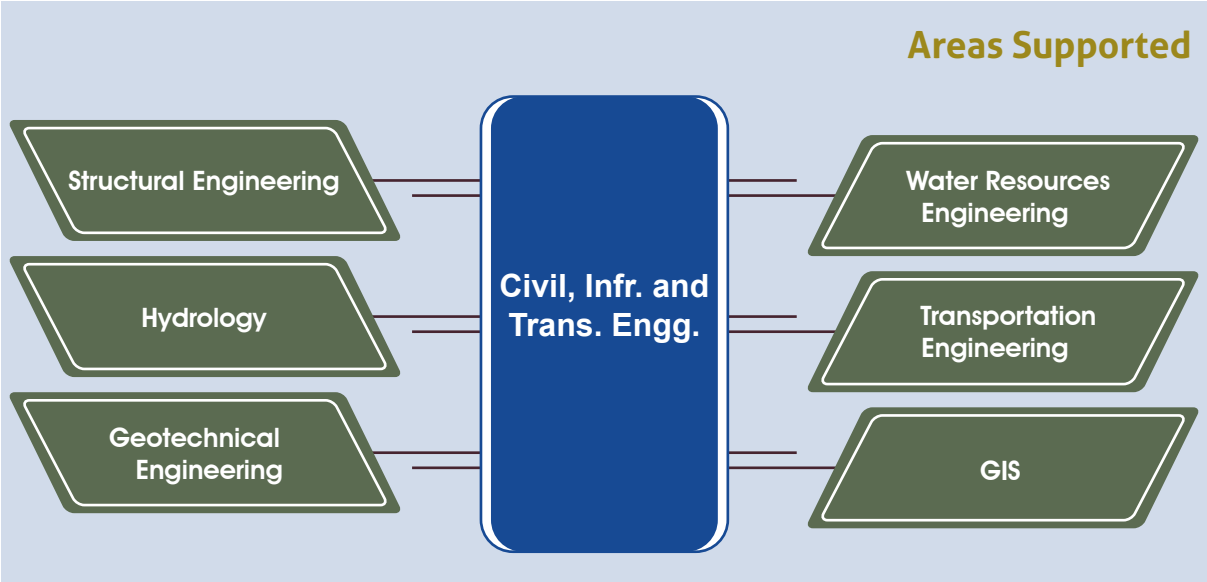


Fig. 3.8: The Plots of Pressure differential and cumulative oil recovery as a function of fluid pore volumes injected at 70°C of the Core Flooding Experiment.

3.1.1.5 Civil, Infrastructure and Transportation Engineering

In the reporting period, 35 new projects were sanctioned. The areas supported under CRG - Civil, Infrastructure and Transportation Engineering are shown in the following figure.

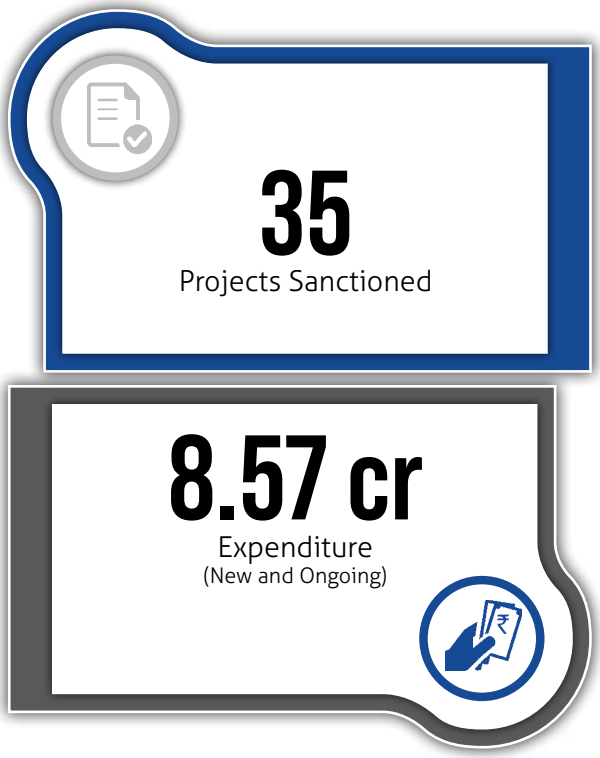


Research Highlights

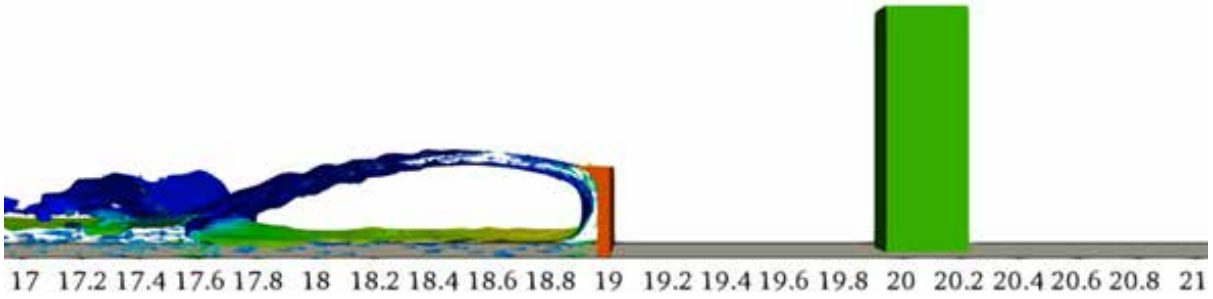
Improved design perspective for violent wave impacts during extreme natural disaster events (IDWavImp)

The objective of the study is to investigate the vertical wall interaction with different parapets for breaking waves to understand its breaking wave characteristics during interactions, loads and impact pressure in order to improve the design guidelines for the vertical wall attached with different parapets.

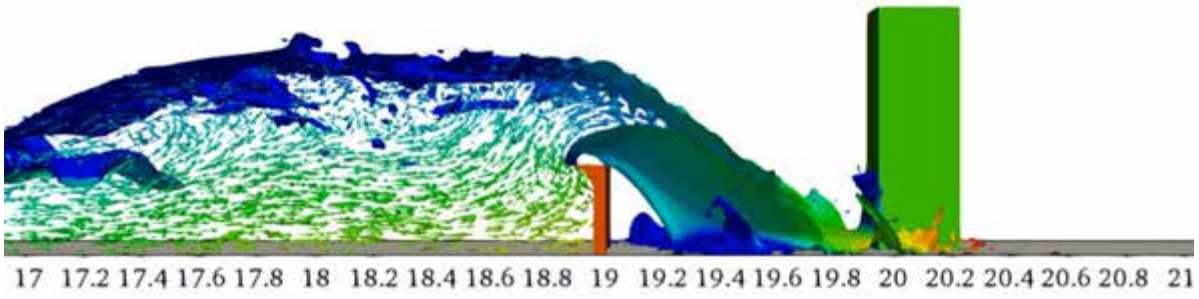
Important Contributions: Recommendations are provided for selecting suitable parapet types and load altering capacity of parapet is proved for the first times. The effect of curvature between plain parapet and recurve parapet is quantified and differences are put forth. The design methodology for vertical wall with recurve parapet is provided by proposing equations to estimate impact pressure and forces. One-to-one comparison of impact pressure and force between two scales are performed for the first time to quantify the scale, model and laboratory effects. Methods to scale wave elevation, impact pressure, rise time and pressure impulse are validated and Cuomo-Froude method is proposed for scaling impact pressures. The numerical model investigations on vertical wall with recurve parapets for breaking waves and bore are performed (Figure 3.9 and Figure 3.10) and the results reconfirm the findings from the experiments. Different calibration approach for tactile sensor are tested and the best method is proposed. This work was performed at Indian Institute of Technology, Madras.



a) $t(g/d_{50})^{0.5}$ =7.92



b) $t(g/d_{50})^{0.5}$ =15.35



c) $t(g/d_{50})^{0.5}$ =25.58

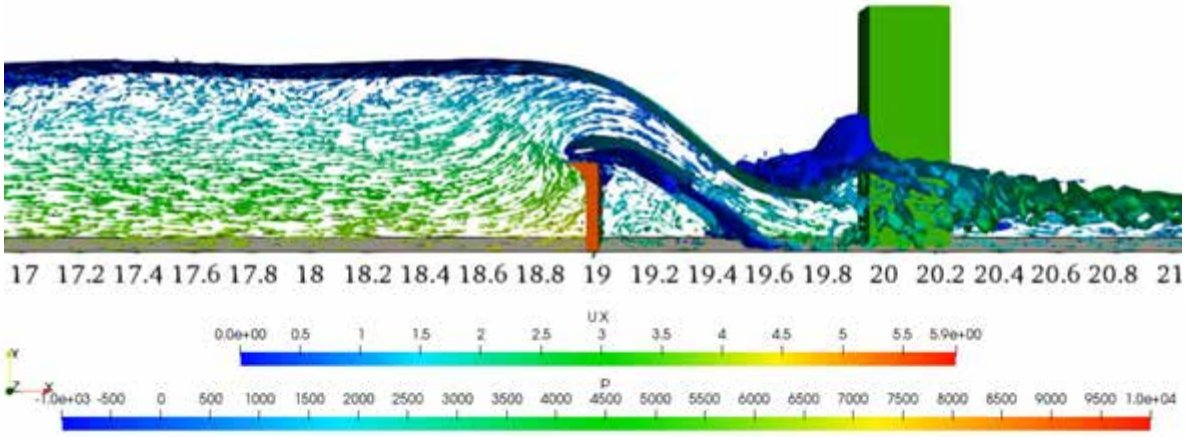
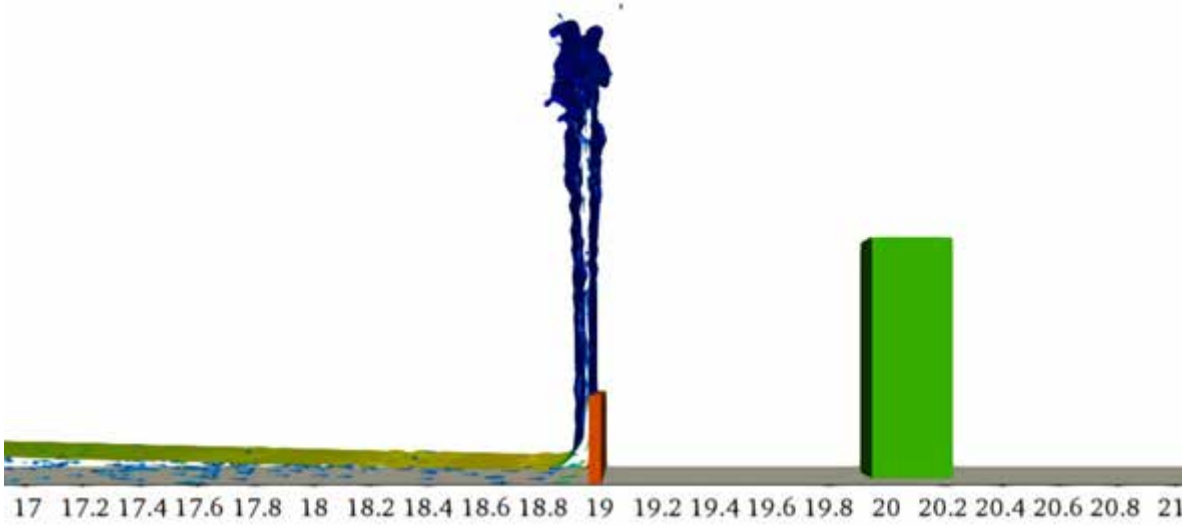
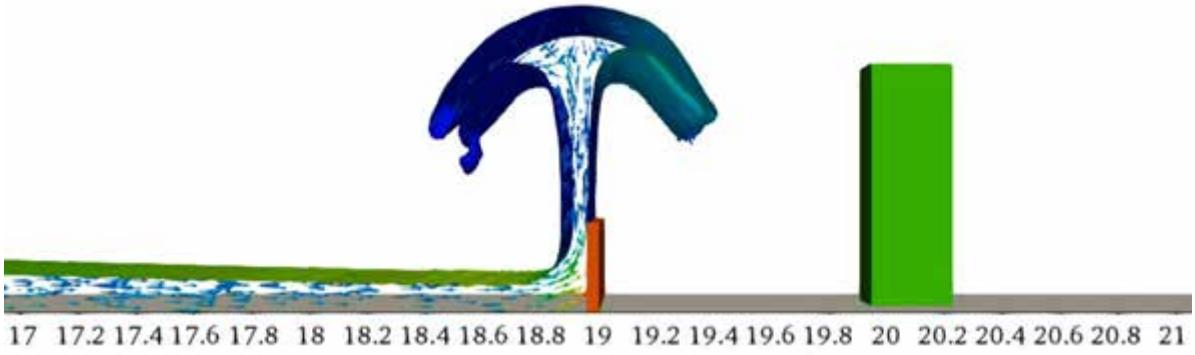


Fig. 3.9: Extreme flow interactions with recurve wall.

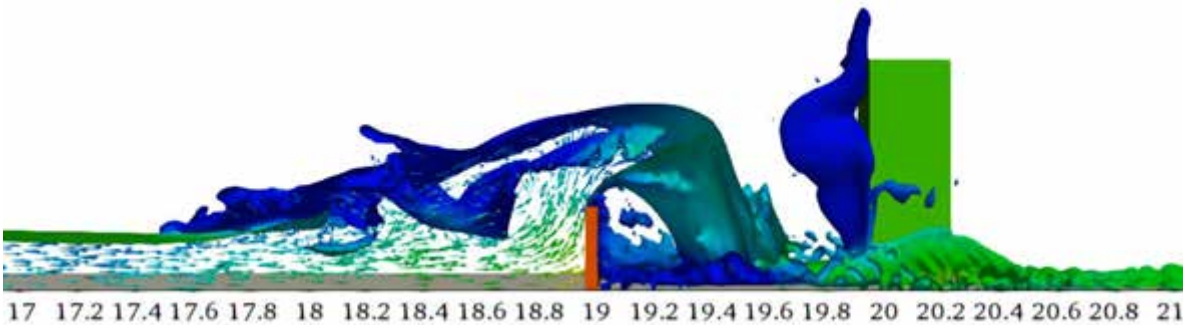
a) $t(g/d_{\nu})^{0.5}$ =7.92



b) $t(g/d_{\nu})^{0.5}$ =9.57



c) $t(g/d_{\nu})^{0.5}$ =12.71



d) $t(g/d_{\nu})^{0.5}$ =25.58

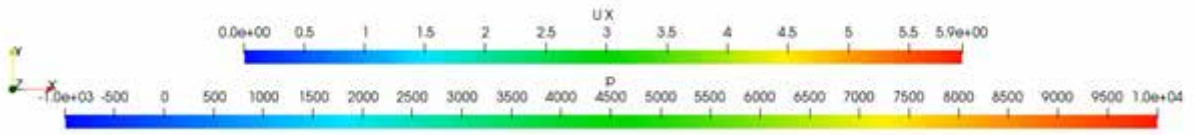
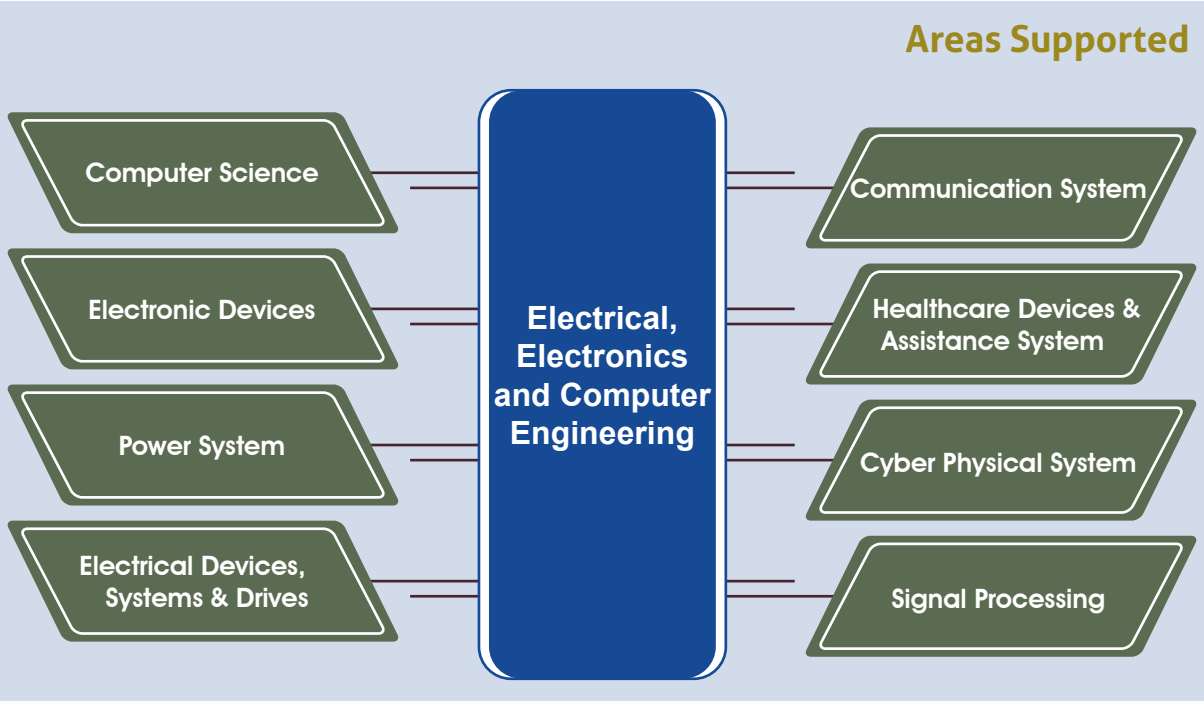


Fig. 3.10: Extreme flow interactions with vertical wall.

3.1.1.6 Electrical, Electronics and Computer Engineering

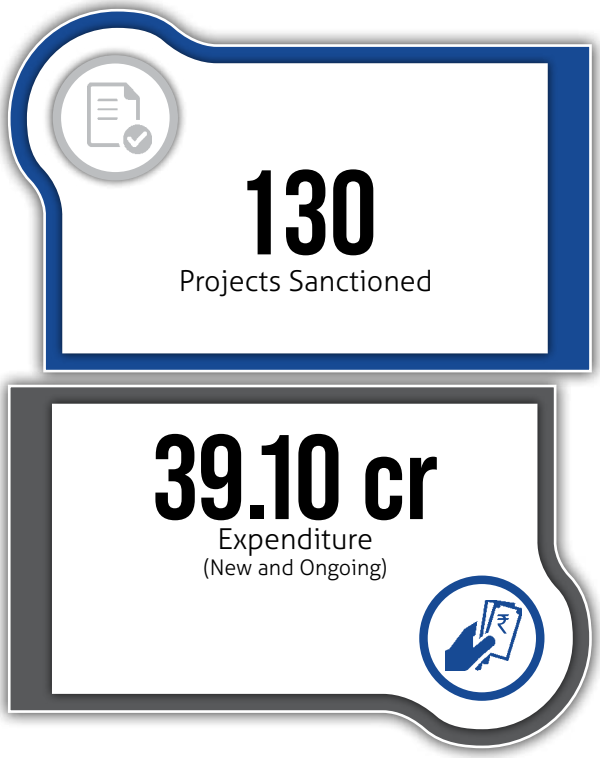
In the reporting period, 130 new projects were sanctioned. The areas supported under CRG – Electrical, Electronic and Computer Engineering are shown in the following figure.



Research Highlights

High performance low voltage flexible organic field-effect transistors for circuit and sensing applications:

High performance flexible OFETs were demonstrated using various optimization techniques with TIPS-pentacene as semiconductor. TIPS-Pentacene/CuPc bilayer was demonstrated for enhancing the photo-sensing spectrum of OFETs (Figure 3.11). Unconventional flexible substrates such as low cost Kapton tape substrate were used to demonstrate high performance OFET devices. Two different kinds of TIPS-pentacene:PS blend based OFETs with hybrid insulating layers of PVP/HfO_2 and PVA/HfO_2, was fabricated using proposed scheme. Maximum field-effect mobility of 0.7 cm2 V-1 s1 was obtained for devices on Kapton tape with ambient storage for 5 months. These devices exhibited very low performance spread under combined effects of ambient exposure and successive electrical stress. Dynamic switching behaviour was observed from the devices in circuit



application, with resistive load inverter circuits (Figure 3.12). Eventually, on the ITO coted flexible PET substrate with Gelatin which is a natural protein as gate dielectric layer, OFET devices were demonstrated which showed potential to be used as humidity sensor and real time breath analyzer (Figure 3.13). These device showed switching behavior as demonstrated using resistive load inverters operated at 5 V. Influence of molecular weight of polymer dielectric on the electrical performance and photo-response of OFETs was investigated reveling crucial relation between concentration and performance (Figure 3.14). The OFET devices can be used as non-volatile memory application by applying the electric pulse under the UV-light photoillumination (Figure 3.15). It was observed that massive memory window could be achieved by applying an electric pulse in presence of UV-light photo-illumination. The transfer characteristics were switched from low-conduction state to high-conduction state and vice-versa by appropriate writing and erasing conditions. For 50 V operation, a significant memory window of more than 45 was achieved. This work was done at Indian Institute of Technology, Jodhpur.

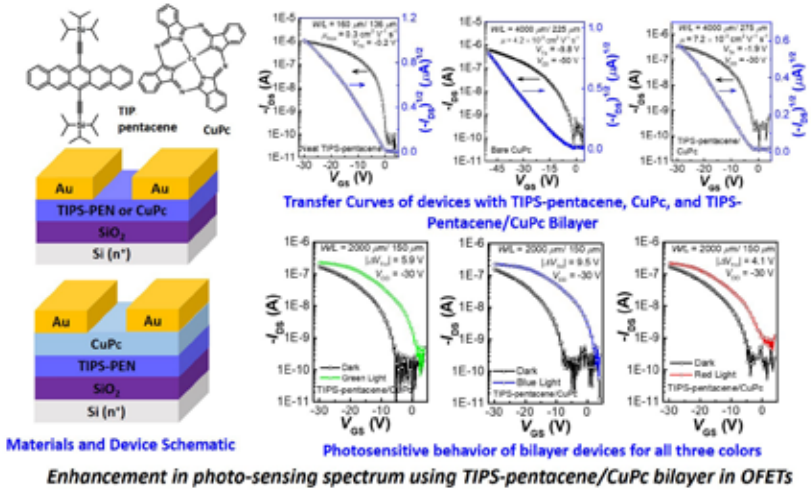


Fig. 3.11: Photo-sensing spectrum of OFETs. The figure also shows the effect of illumination of red, green, and blue light on the transfer characteristics of representative TIPS-pentacene/CuPc bi-layer OFET with W/L ratio of 2000 m/ 150 m.

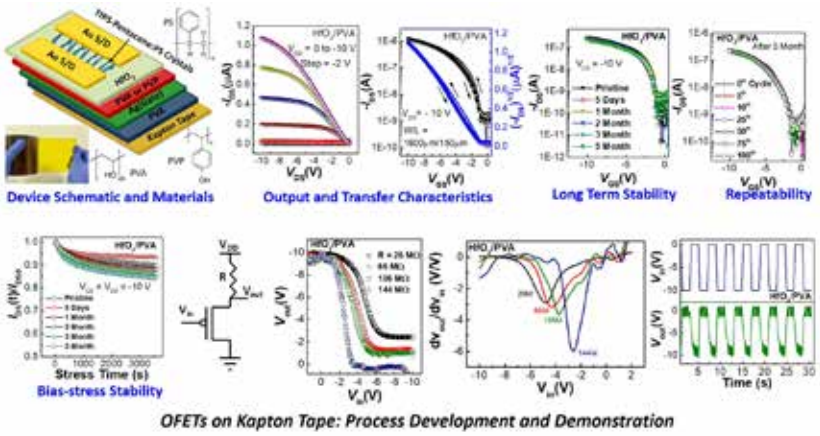


Fig. 3.12: The dynamic response (with RL = 144M) for inverter setup with square wave switching between 0 and -10 V is applied at gate terminal (Vin).

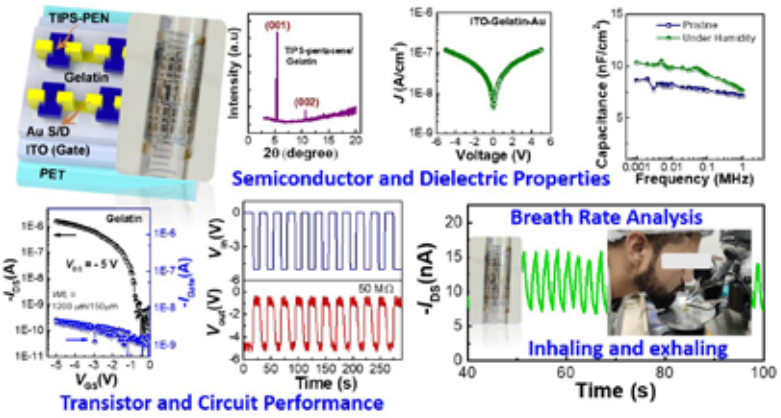


Fig. 3.13: OFET devices on the ITO coted flexible PET substrate with Gelatin

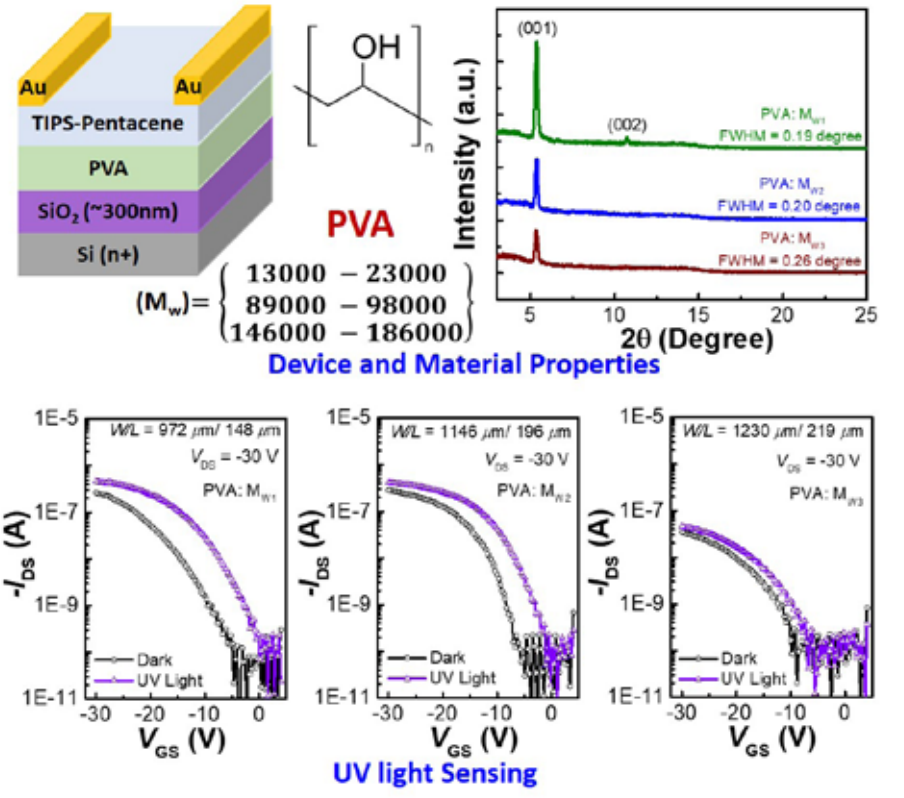
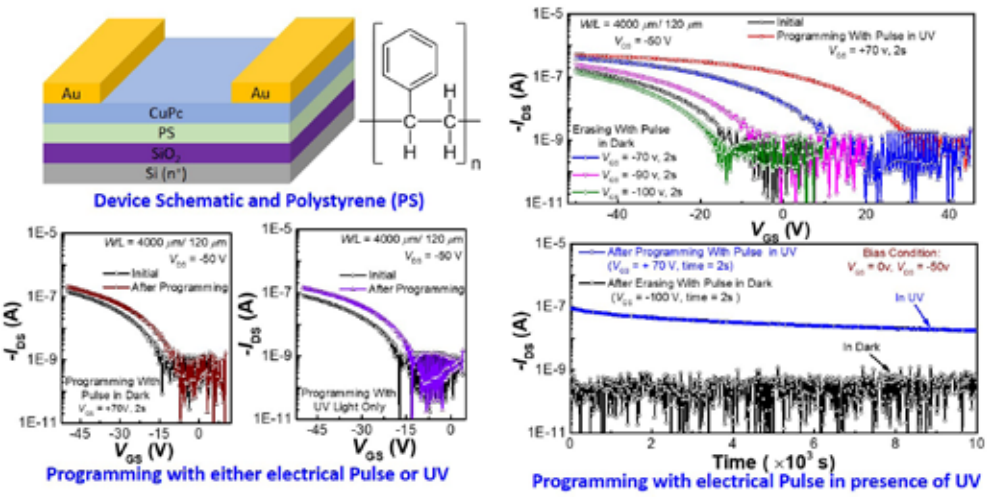


Fig. 3.14: Influence of molecular weight of polymer dielectric on the electrical performance and photo-response of OFETs

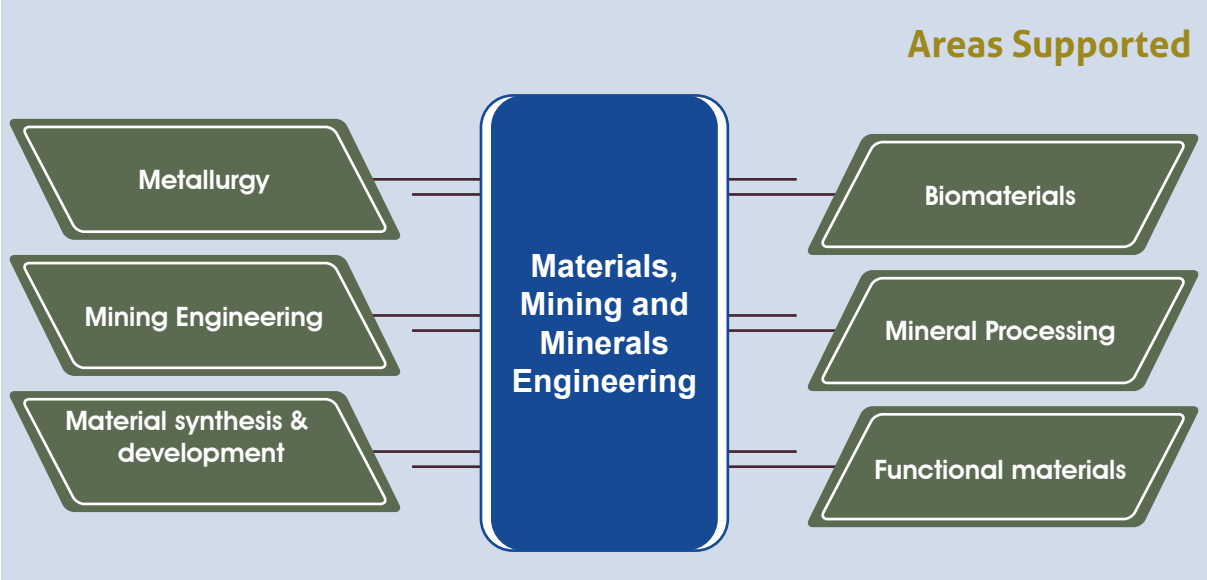


UV Assisted Non-Volatile Memory Behaviour Using Copper (II) Phthalocyanine based OFETs

Fig. 3.15: The OFET devices as non-volatile memory by applying the electric pulse under the UVlight photo-illumination

3.1.1.7 Materials, Mining and Minerals Engineering

In the reporting period, 57 new projects were sanctioned. The areas supported under CRG – Materials, Mining, and Minerals Engineering are shown in the following figure.



Research Highlights

Manipulation of Structure, Composition and Properties of CuO Ceramics and Thin Films to Achieve Near Room Temperature Multiferroism for Device Applications

The investigators at IIT Kanpur investigated the metal-multiferroic-metal (M-MF-M) capacitive devices and conducted electrical, dielectric and ferroelectric characterization to understand the correlations between ferroic and other properties. The two magnetic transition temperatures observed for CuO, indicate the transformation from paramagnetic phase to incommensurate or asymmetrical antiferromagnetic (AF) near highest

Neel temperature (T_{N1}) ~230 K and the order transformation of AF phase to commensurate AF phase at around the Neel temperature (T_{N2}) ~210 K (Figure 3.16). The anomaly in the first-order derivative of dielectric constant near two T_N has been perceived, which is due to the strong correlation between magnetic and dielectric properties. This supports the existence of spin-polaron coupling near Neel temperatures. The temperature-dependent Z″ plots with the frequency range and Cole-Cole plots suggest an strong effect of grain and grain boundaries on electrical conduction. The role grain and grain boundaries are justified through an R|| CPE circuit element with the help of circuit modelling. Electric modulus studies reveal an easy charge transfer for electrical conduction for Fe-doped samples. The high dielectric constant with low loss and high magnetic susceptibility in $Cu_{0.95}Fe_{0.05}O$ indicate its potential for spintronics and multifunctional device applications. Electric modulus studies reveal the easy charge transfer for electrical conduction for Fe-doped samples.

57
Projects Sanctioned

14.51 cr
Expenditure
(New and Ongoing)

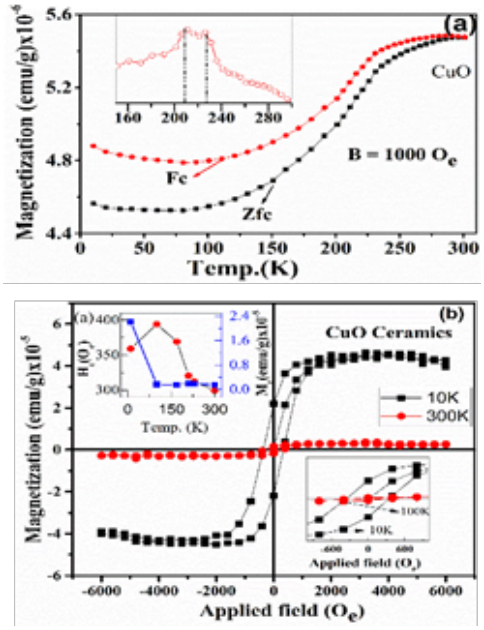
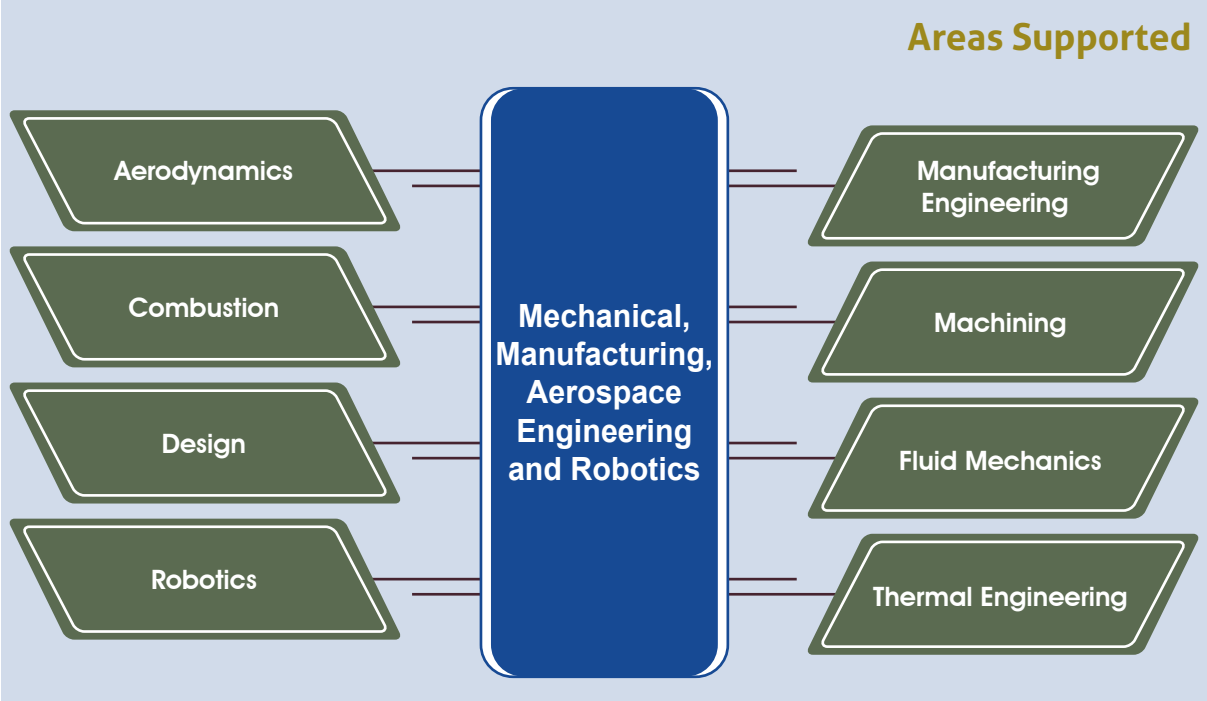


Fig. 3.16: Temperature dependent Magnatization curve at applied field 1000 O_e and (b) Magnetic hysteresis Curve at 10K and 300K for CuO Ceramic.

3.1.1.8 Mechanical, Manufacturing, Aerospace Engineering and Robotics

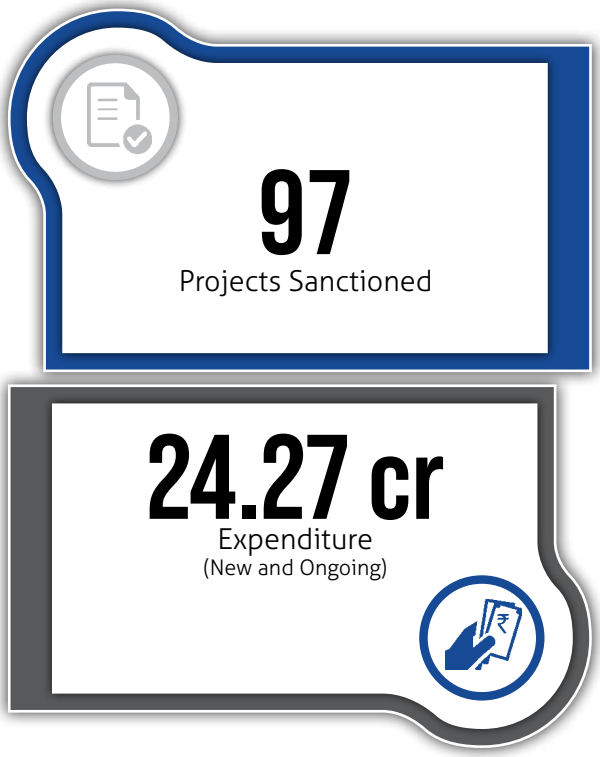
In the reporting period, 97 new projects were sanctioned. The areas supported under CRG – Mechanical, Manufacturing, Aerospace Engineering and Robotics are shown in the following figure.



Research Highlights

Electrothermal Flows for Thermal Management of Electronics

An electrokinetic technique has been developed that continuously manipulates colloidal particles to concentrate into patterned particulate groups in an energy efficient way, by harnessing of the intrinsic Joule heating effects (Figure 3.17). The technique exploits the alternating current electrothermal flow phenomenon which is generated due to the interaction between non-uniform electric and thermal fields. Highly non-uniform electric field generates sharp temperature gradients by generating spatially-varying Joule heat that varies along radial direction from a concentrated point hotspot. Sharp temperature gradients induce local variation in electric properties which, in turn, generate strong electrothermal vortex. The imposed fluid flow brings the colloidal particles at the centre of the hotspot and enables particle aggregation. Further, manoeuvring structures of the Joule heating spots, different patterns of particle clustering may be formed in a low power budget, thus, opening up a new realm of on-chip particle manipulation process without necessitating highly focused laser beam which is complicated and demands higher power budget.



This technique can find its use in targeted cooling of hot spots in microprocessors where colloidal particles with high thermal conductivity can be made to migrate to the hot spots and dissipate the heat generated. If successful, this can be a very efficient dynamic thermal management solution especially for multi-core architecture where the location of the hotspot can change dynamically depending on workload. This work was done at Indian Institute of Technology, Kharagpur.

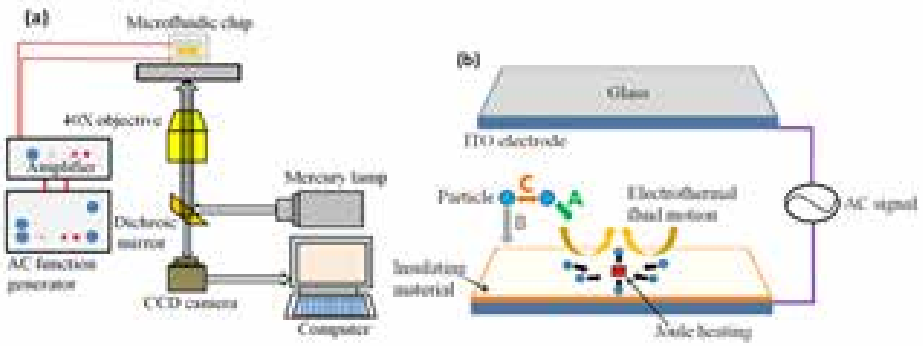
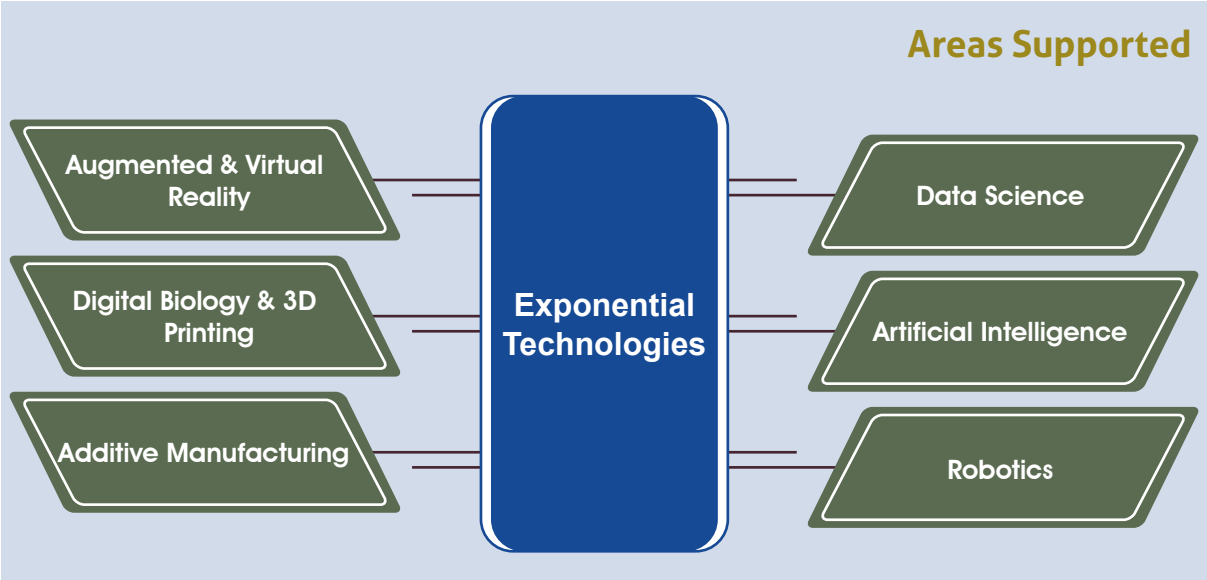


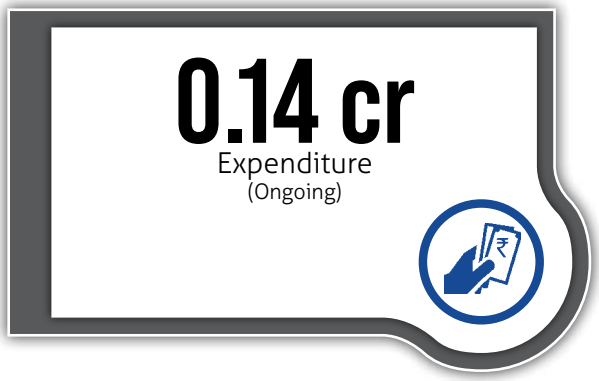
Fig. 3.17: (a) Schematic representation experimental set up; (b) illustration of Joule heating enabled Rapid electrokinetic patterning.

3.1.1.9 Exponential Technologies

The areas supported under CRG – Exponential Technologies are shown in the following figure.



Investigation on Machine Learning approaches for optimisation of process parameters for Additive Manufacturing and accelerated design of patient specific hip implants, based on Finite Element Analysis



The complex nature of laser Directed Energy Deposition (DED) modelling is approached with a different and new way. The DED process has been used to 3D print SS316L as well as Ti6Al4V metal traces on a substrate. The geometry of the trace was analyzed and relevant dimensions of the same are measured using microscopic techniques. The laser DED process parameters and dimensions of the trace will be used as the input for the model.

The experimental campaign of Directed Energy Deposition of SS 316L was performed using

a laser deposition line. A diode laser source, operated in continuous emission, was employed. The arrangement has 5 degrees of freedom. The maximum power delivered by the laser is 2KW. The laser spot size is 1.0±0.2mm. The print head receives the powder from a feeder/hopper with rotating conveyor. Argon gas is used for conveying the powder and as the shielding gas to prevent any chance of oxidation. The chamber is maintained at inert atmosphere. The substrate will be made of mild steel. The laser DED process was performed to produce tracks in the form of single metal deposition along the length, under different process conditions.

The research strategy and approach for the project has been described and shown in the Figure 3.18. Accordingly, the initial 3D printing trials on SS 316L austenitic steel started and the corresponding progress made in that direction will be described in the following sections.

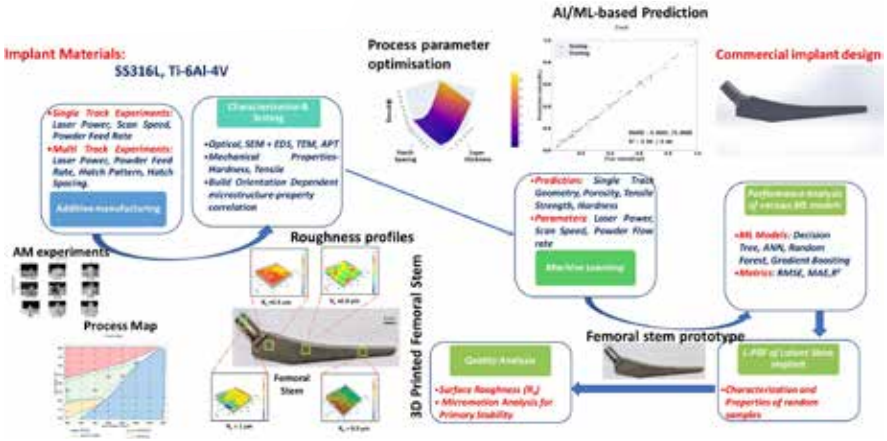
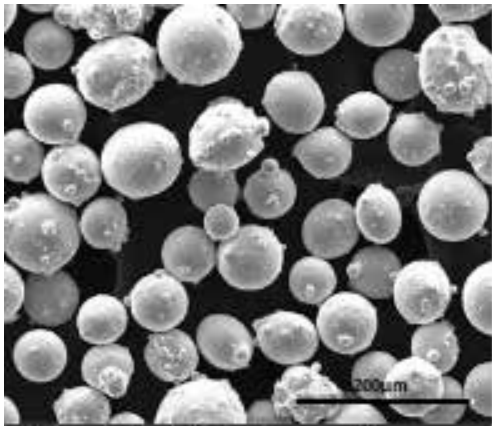


Fig. 3.18: The research methodology for Acetabular shell for hip-joint application

As-received SS316L austenitic steel powder is characterized to determine the shape and morphology (Figure 3.19) by Scanning electron microscopy (SEM). The SEM analysis reveals the particles are spherical and uniform. Small satellite particles can be seen from the SEM images. Particle size distribution is characterized by Laser particle size analyzer (Figure 3.20). The particle size distribution with average particle size (D50) of 60µm observed from the particle size analysis report as depicted in the Figure 3.20. Further the XRD (X-ray diffraction) analysis as shown in the Figure 3.21 confirms the identified phase is ɣ-austenite with FCC crystal structure. This work was done at Indian Institute of Science, Bengaluru.



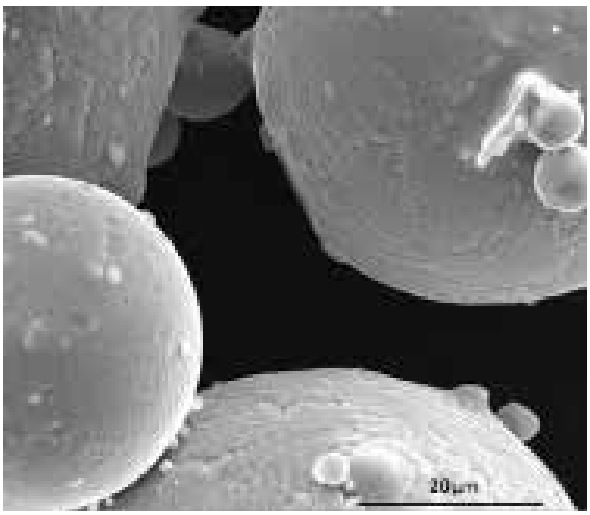


Fig. 3.19: Scanning Electron micrographs of the SS316L

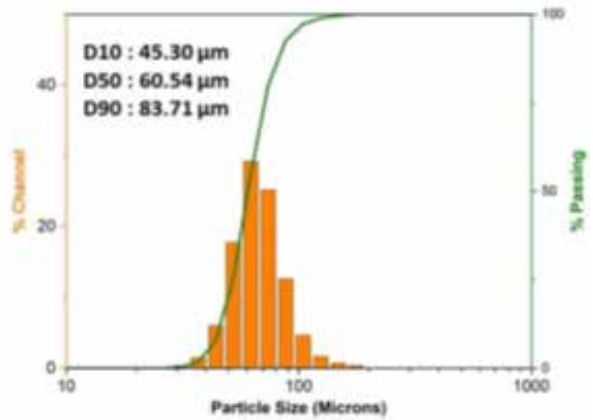


Fig. 3.20: Particle size distribution analysis of the SS316L powder

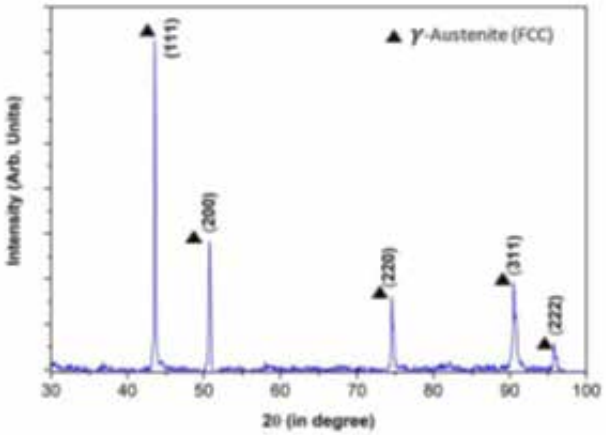
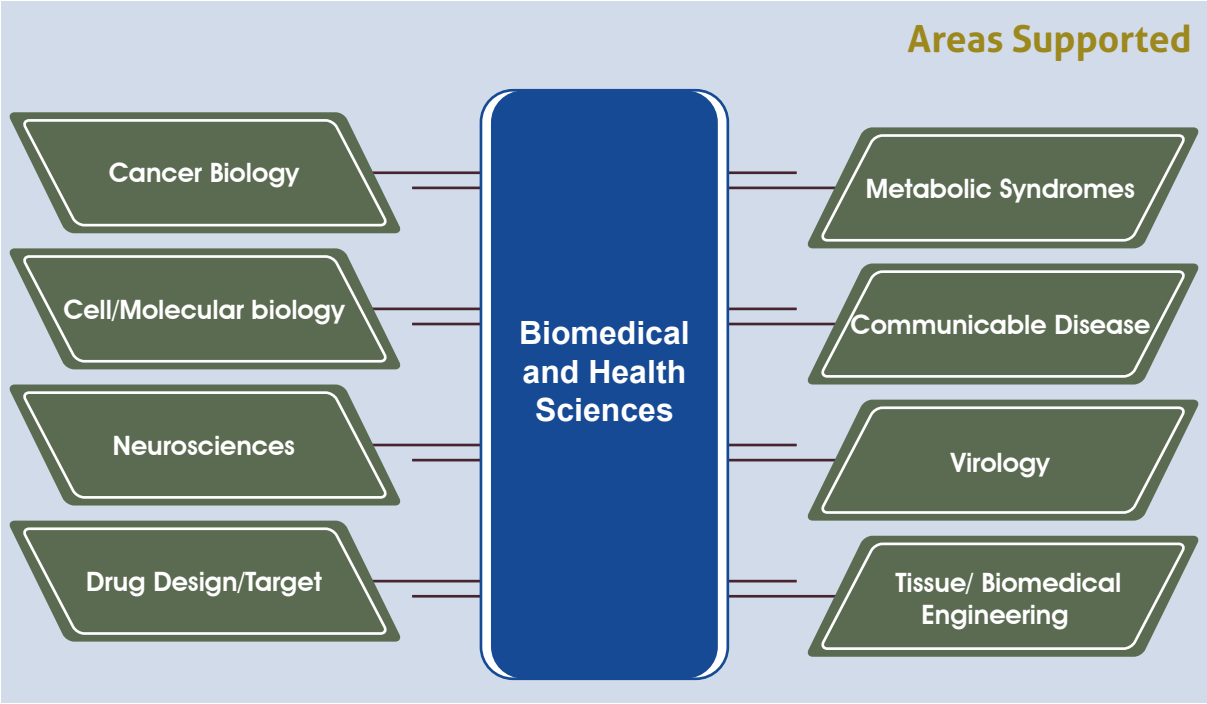


Fig. 3.21: X-ray diffraction pattern of the SS316L powder

3.1.1.10 Biomedical and Health Sciences

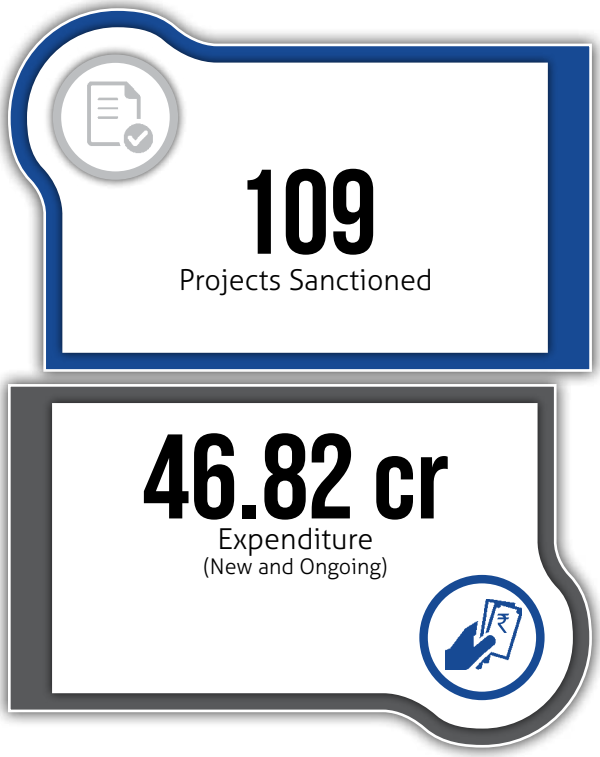
In the reporting period, 109 new projects were sanctioned. The areas supported under CRG – Biomedical and Health Sciences are shown in the following figure.



Research Highlights

Enzyme-Responsive hydrogel for site-specific drug delivery as potential therapy for colitis.

Ulcerative colitis (UC) is the most frequent form of inflammatory bowel disease worldwide and it is characterized by repeated incidents of colonic inflammation and tissue deterioration. Abnormal apoptosis in epithelial cells or coloncytes can disrupt mucosal integrity and barrier function which mainly contributes to the colonic tissue injury. The neutrophil elastase is a major product secreted by stimulated neutrophils which contributes majorly to colonic tissue injury. Treatment with sivelestat (specific inhibitor of neutrophil elastase enzyme) has been reported to prevent colitis in small animal models. However, the usage of sivelestat is limited to due to organ toxicity and irreversible binding to the elastase enzyme.



Project has been initiated to develop enzyme-responsive drug delivery system to deliver the drug only at the site of inflammation within the colon. Site-specific drug delivery will lead to reduce the drug dose and systemic toxicity caused due to other routes of drug administration. Investigators used glycerol monostearate (GMS) to develop hydrogel and showed high biocompatibility and characterized the morphology of the formulation using scanning electron microscope (Figure 3.22 A and 3.22 B).

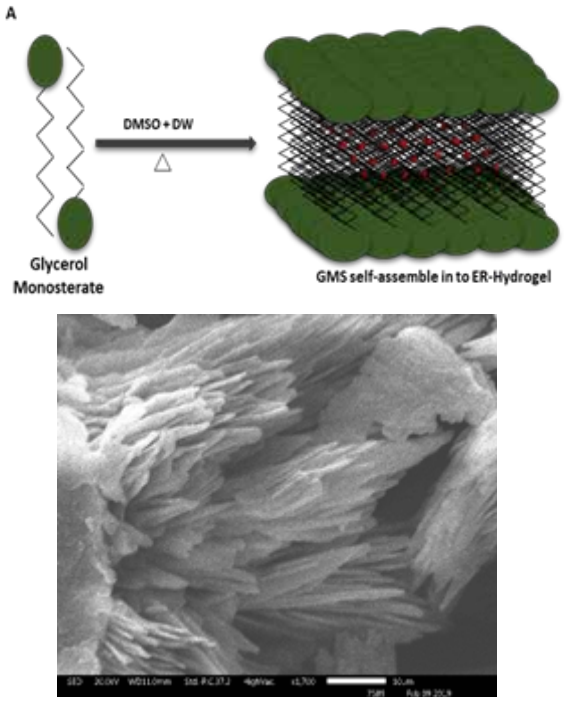
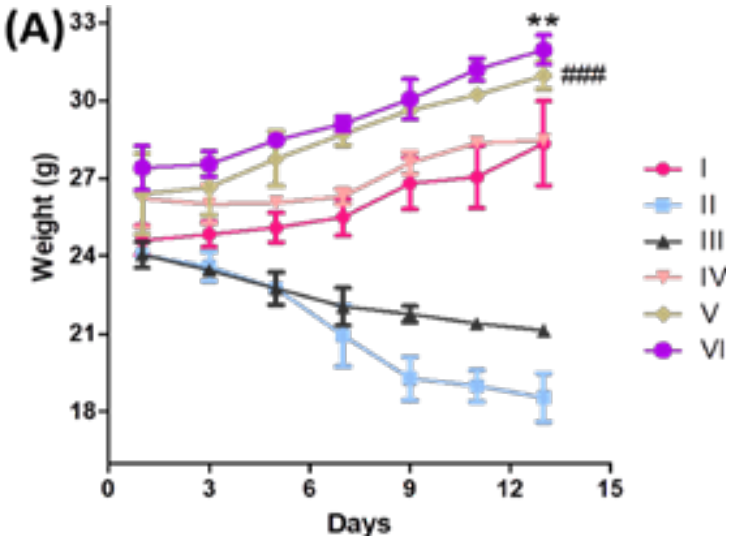


Fig. 3.22: (A) schematic of the self-assembly of GMS into hydrogel. (B) Scanning electron micrograph of CYR61 and Sivelestat hydrogel.

Investigator tested the potency and the therapeutic efficacy of the novel formulation against DSS-induced colitis mice model. Physical examination of animals revealed that DSS-induced animals showed sedentary physical activity, the stool inconsistency with severe rectal bleeding compared to the control group. It has been reported that colonic inflammation leads to the nutritional deficiency and catabolic consequences in the animal body followed by significant weight loss (Figure 3.23 A). DSS group animals showed significant reduction in the length of the colon as compared to the control animals. Upon treatment with budesonide loaded ER-hydrogel (positive drug control) the length of the colon gets restored as close to the control group due to the replenishment of goblet cells followed by refurbishment of colonic mucosa and consequently leading to colon length restoration (Figure 3.23 B).



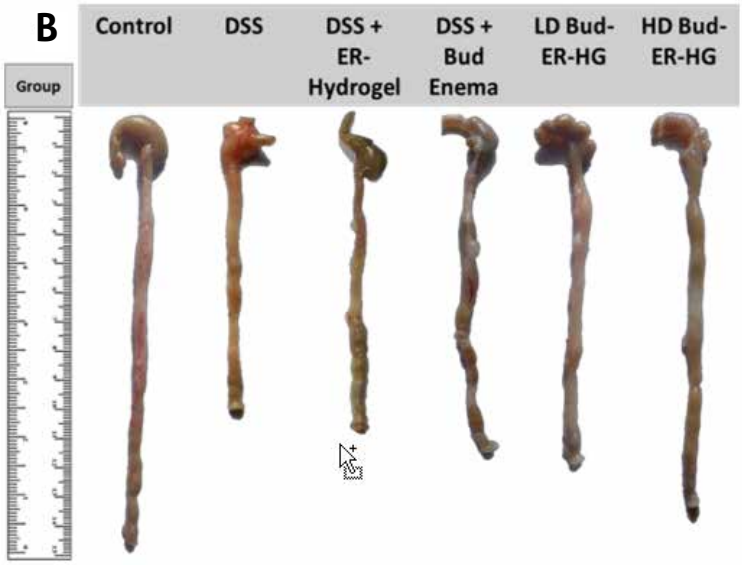
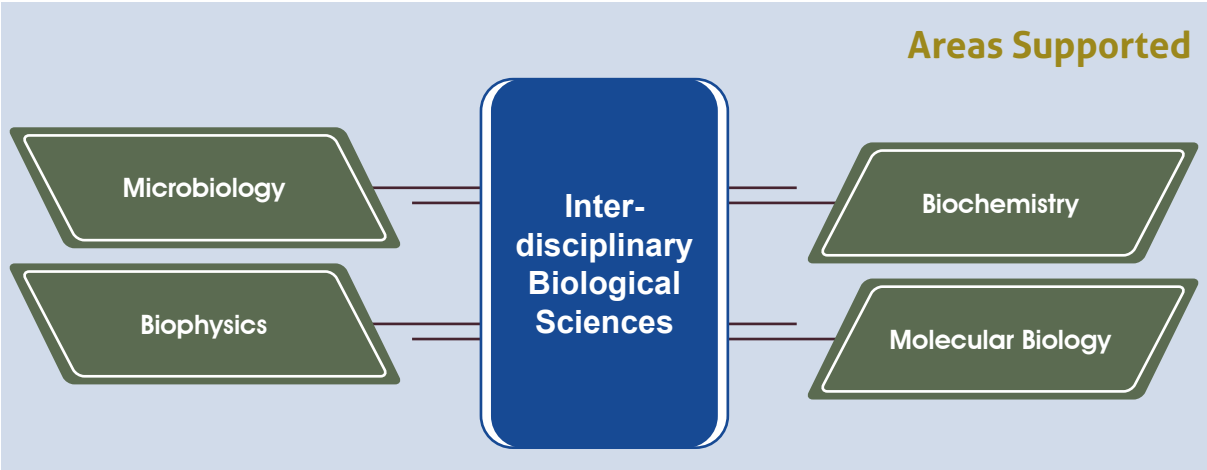


Fig. 3.23: (A) Daily weight variation chart among the groups. I- control; II- DSS-induced colitis; III- DSS+ER-Hydrogel (HG); IV- DSS+ Bud Enema; V- Low Diet-Bud-ER-HG; VI- High Diet-Bud-ER-HG. (B) Representative images of the physical observation of colon length of different groups after the compilation of the study.

Through this study investigator clearly showed that GMS based hydrogel has the potential to translate into the clinic and GMS has been approved by the FDA under the category of Generally recognized as safe compound, which are non-toxic. In future it can be exploited for treatment of colitis. The outcome of the work has been published in reputed peer-reviewed journal. This work was done at Institute of Nanoscience and Technology (INST), Mohali.

3.1.1.11 Interdisciplinary Biological Sciences

In the reporting period, 88 new projects were sanctioned. The areas supported under CRG – Interdisciplinary Biological Sciences are shown in the following figure.



Research Highlights

Maintenance of bacterial genome integrity: Mechanism of action and regulation of the highly conserved Structural Maintenance of Chromosome protein, RecN.

Double-strand breaks (DSB) are a particularly lethal form of DNA damage and, in all domains of life, DNA breaks can be faithfully repaired via homologous recombination. A key step in this pathway involves homology search, where a highly conserved recombinase (RecA/ Rad51) associates with the break site to search for its spatially distant homologous repair partner. The study uncovered a dynamic search process that involves directional translocation of the RecA filament during search. It is also demonstrated that the RecA filament, once formed, rapidly moves in a directional-manner across the length of the cell, undergoing multiple such cell pole-to-pole traversals before completion of search. In concomitant with translocation, the RecA filament also undergoes dynamic remodelling. Thus, the study unravelled three key elements of RecA-mediated in vivo homology search: mobility of a finite segment of RecA, remodelling of the filament and the ability to conduct multiple pole-to-pole traversals (Figure 3.24). This can allow for genome-wide sampling for homology in a robust, yet regulated manner, facilitating repair well within a single generation time of bacterial growth. The study further discovered the mechanistic basis of this RecA mobility. The study discovered, a role for SMC protein, RecN in enabling translocation and dynamic remodelling of the RecA filament during search. This work is being carried out at National Centre for Biological Sciences, Bengaluru.

88
Projects Sanctioned

37.28 cr
Expenditure
(New and Ongoing)

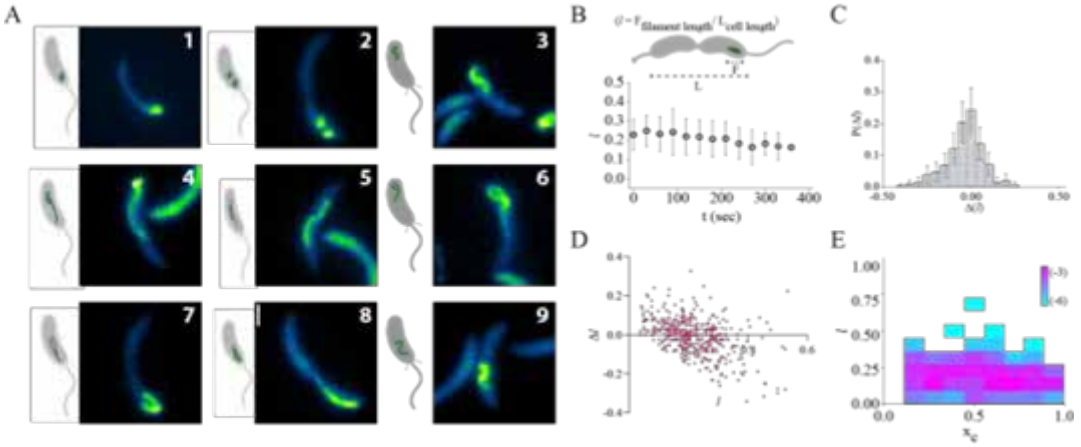
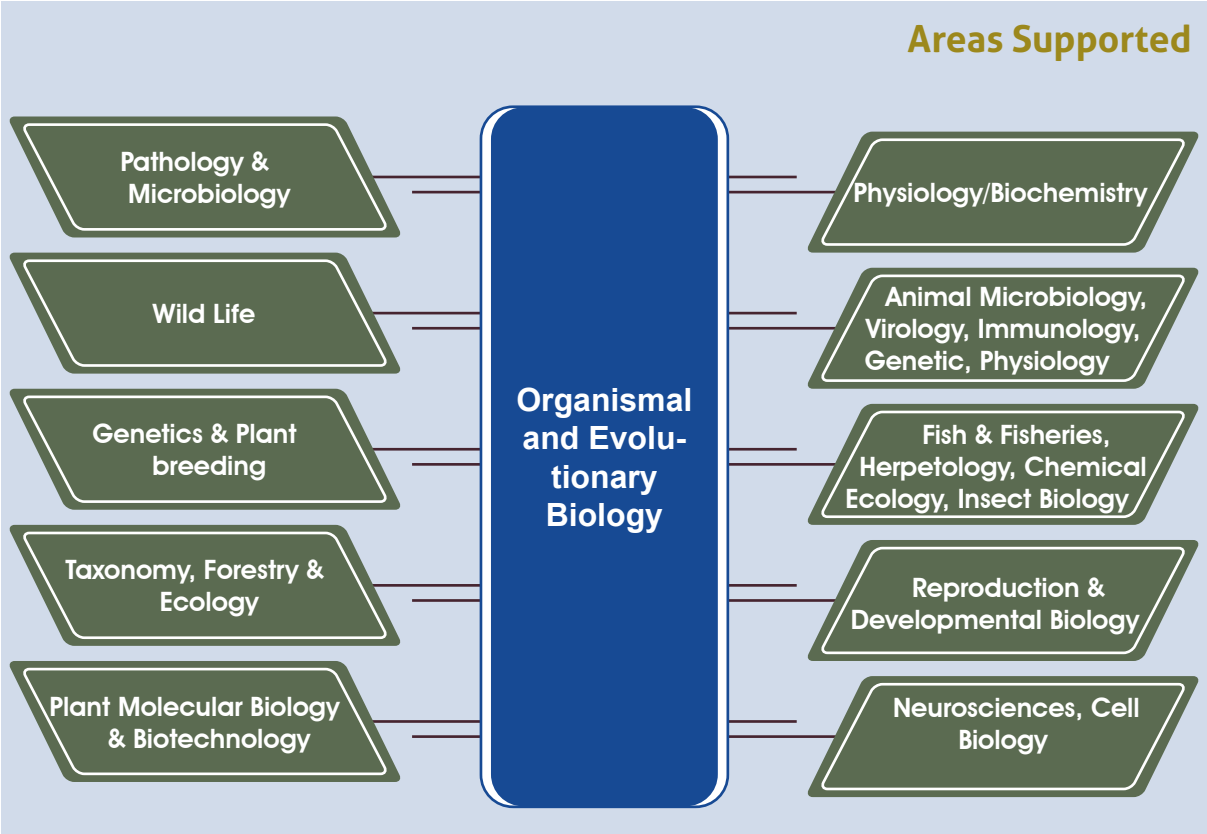


Fig. 3.24: RecA dynamics during homology search and recombination: compact structures of a RecA filament

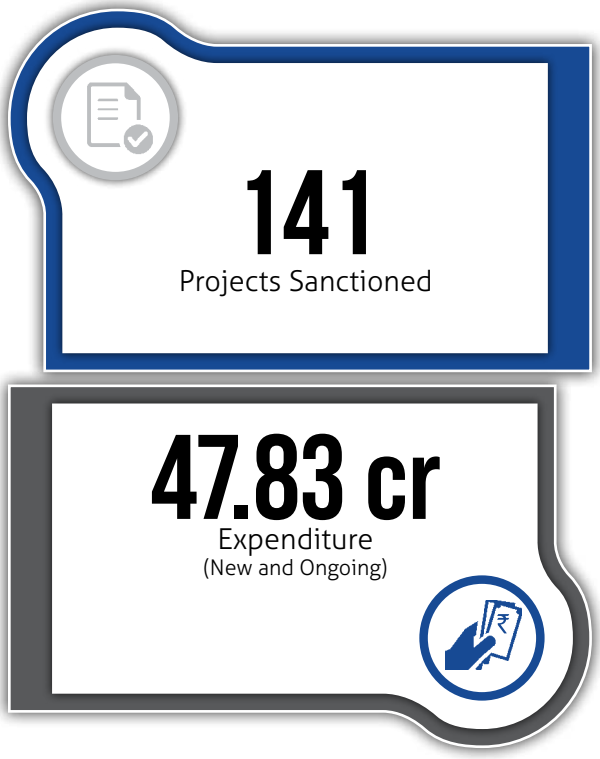
3.1.1.12 Organismal and Evolutionary Biology

In the reporting period, 141 new projects were sanctioned. The areas supported under CRG –Organismal and Evolutionary Biology are shown in the following figure.



Research Highlights

Elucidating the role of wheat ferroportins during cellular iron homeostasis : Regulation of plant iron (Fe) exporter ferroportin (FPNs) has not been addressed till date in crop plants. In this project the investigators are looking for understanding the mechanistic insight for the regulation of the FPN at the post- transcriptional and translational level. Primarily, they have been testing miRNA or UTR mediated regulation of wheat FPN (Figure 3.25). To do that, the first inventory of Fe-deficiency induced miRNA from hexaploid wheat has been provided that showed tissue specific (roots and shoots) expression responses. Multiple candidate miRNAs were identified that could target the wheat FPN1 and exons of the genes encoding for the multi-copper ferroxidase (Laccases) activity in roots. The identified miRNA and FPN are differentially regulated during the Fe deficiency condition. Based on the gene expression analysis, it was noted that FPNs could be involved in maintaining Fe status under its deficiency and excess



condition. Understanding the regulation of wheat FPN will help in understanding the mechanism how cellular Fe levels are regulated in plant tissue. Overall, this project will help in identifying some important components and new regulatory pathways that could be recruited by the plants to cope the changing status of root Fe. This work was done at National Agri-Food Biotechnology Institute (NABI), Mohali.

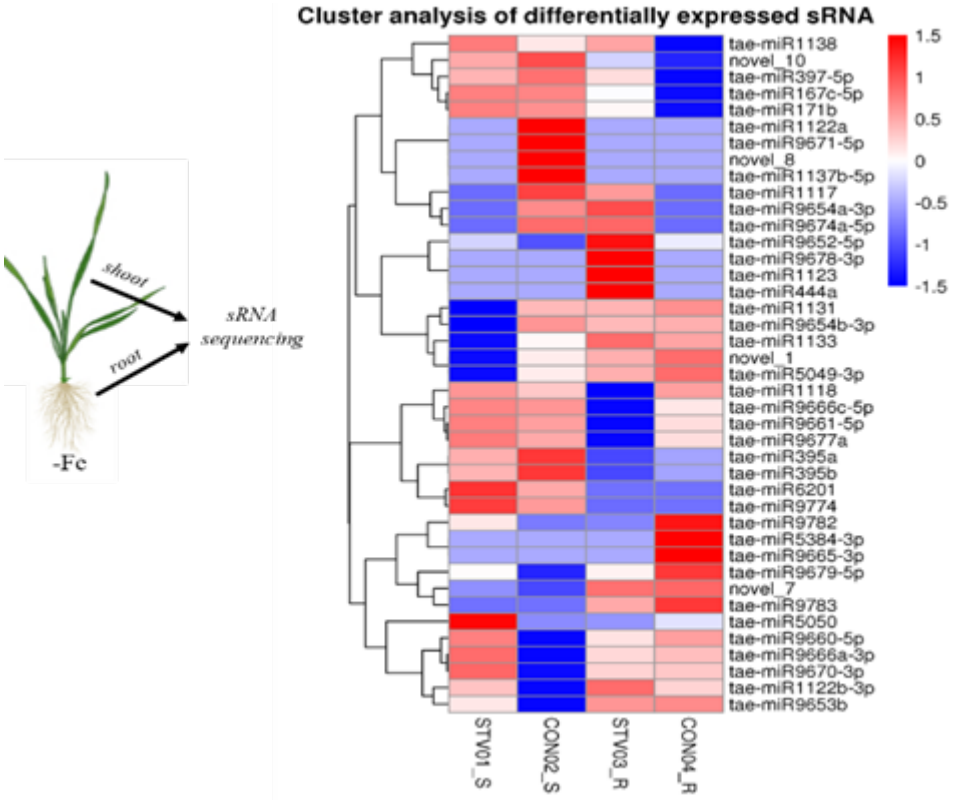


Fig. 3.25: Clustered heatmap for the identified miRNA in the different tissues (roots and shoots) of wheat seedlings exposed to Fe deficiency condition. The identified miRNA was checked for the target against the Fe-regulated genes including transporters (FPN) and ferroxidase activity encoding proteins. (ST_S indicates shoot Fe-starvation; ST_R indicates root Fe-starvation; CON indicates the respective controls.

Biogeography of Eastern Borderland in India: Evidence from Ectotherms

Investigator sampled 17 physiographic units north and south of Brahmaputra River and recorded 147 species of herpetofauna belonging to 72 species of amphibians and 75 species of reptiles. Generated 400 DNA sequences from 225 tissue samples of amphibians (114 samples) and reptiles (111 samples) to answers questions related to systematics and biogeography. Preliminary analysis with agamid lizards support to the hypothesis that Brahmaputra as a biogeographic barrier (Figure 3.26). With the support from this project, investigator discovered three new species and one new genera using integrated taxonomic approach (Figure 3.27-3.29). Investigator also presented a global multilocus DNA sequence phylogeny for 189 named species of Natricine snakes and provided first phylogenetic data for poorly known North-eastern Snakes. This work was done at Wildlife Institute of India, Dehradun.

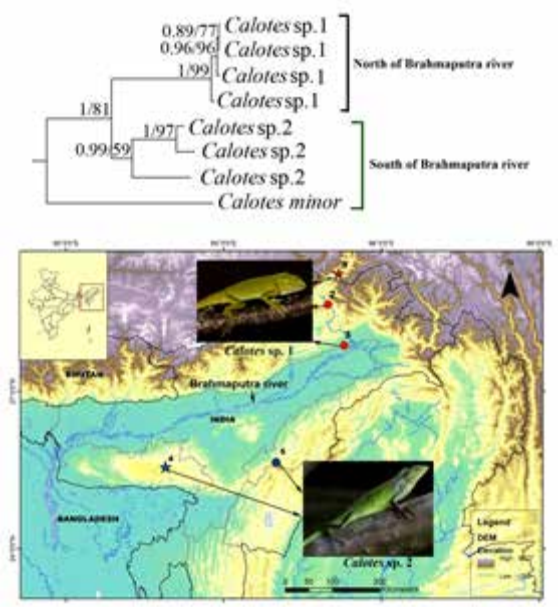


Fig. 3.26: A. Phylogenetic relationship of two *Calotes* species from North and South of Brahmaputra river, **B.** Brahmaputra river showing as geographical barrier for the two species, *Calotes* sp. 1 and *Calotes* sp. 2.

Fig. 3.27: *Micryletta aishani*, A new microhylid frog discovered from Assam.

Fig. 3.28: *Smithophis arunachalensis*, new species of rain loving snake from Arunachal Pradesh.

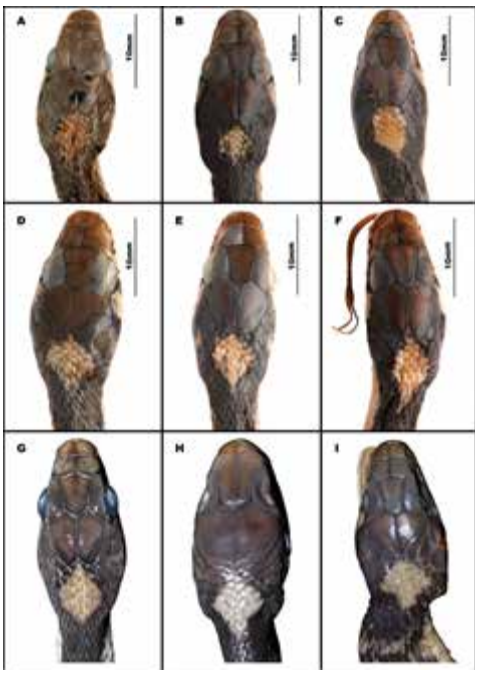
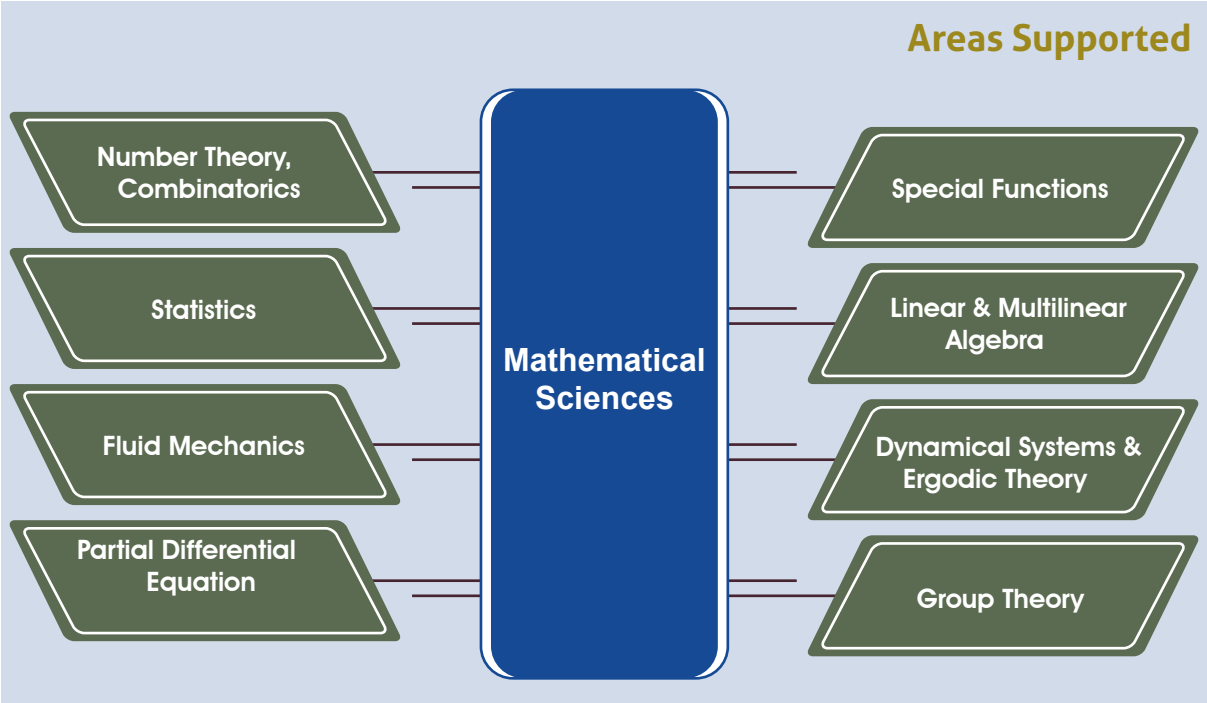


Fig. 3.29: *Rhabdophis bindi*, a new species of snake with a unique neck pattern was discovered from Assam.

3.1.1.13 Mathematical Sciences

In the reporting period, 32 new projects were sanctioned. The areas supported under CRG – Mathematical Sciences are shown in the following figure.

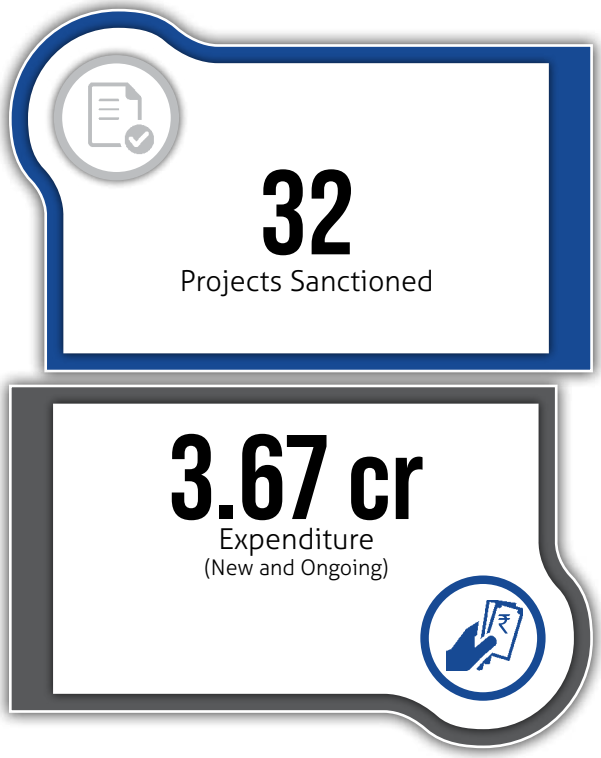


Research Highlights

Emergent dynamics in ecological networks: Spreading of disease and its control:

Disease progression and recovery in a network is a complex process. The study targets a particular situation of disease spreading with a variation in the initial pattern of infected sites in a network, and investigate how a particular pattern of initially infected sites affects the disease spreading with the dispersal of both the infected and susceptible population (Figure 3.30), and if a self-organized recovery process starts at all.

In ecological landscapes, the study explores various possible emergent collective population patterns using a simple ecological network model of all-to-all connected patches where one use a particular type of dispersal process that is controlled by a weighted mean-field diffusion to include the failed migration between the interacting patches. The population dynamics of both the predator and prey has been represented in each patch by a modified Rosenzweig-MacArthur (mRM) model that incorporates an additional effect of habitat complexity. The theoretical investigations on the network dynamics show various complex patterns, namely, 2-cluster, 3-cluster and multicluster states, and chimera states, besides synchrony (1-cluster) and homogeneous steady states (HSS) in a migrating metapopulation



(Figure 3.31). An important observation is that the addition of habitat complexity in the Rosenzweig-MacArthur (RM) model makes qualitative changes in the collective behaviors. This work was done at Jadavpur University, Kokata.

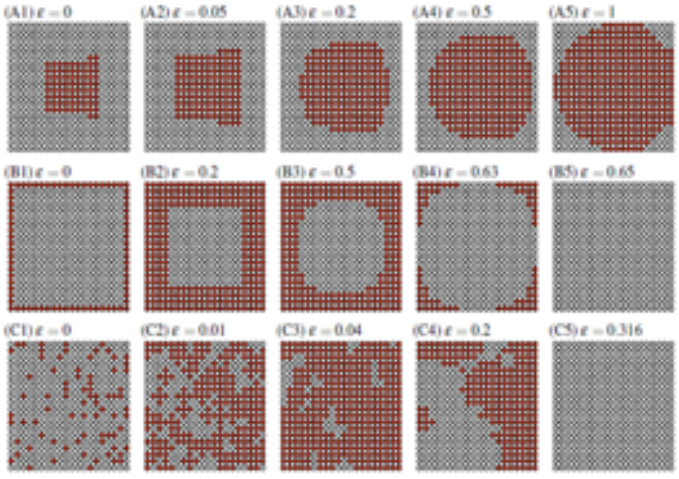


Fig. 3.30: Disease progression in the lattice under different initial distribution. Snaps of the lattice for different values of migration rate, ϵ. Force of infection is considered as 0.002 for infection-free (white circles) and 0.017 for infected nodes (red circles), respectively. Initial distribution of infected patches is 19 % in all cases of initial distributions IC, IP and RDIP represented, respectively, in the first, second and third rows. Each lattice evolves with increasing migration rate and successive snaps after initial transient state are presented row-wise for ICP (A1-A5), IPP (B1-B5) and RDIP (C1-C5).

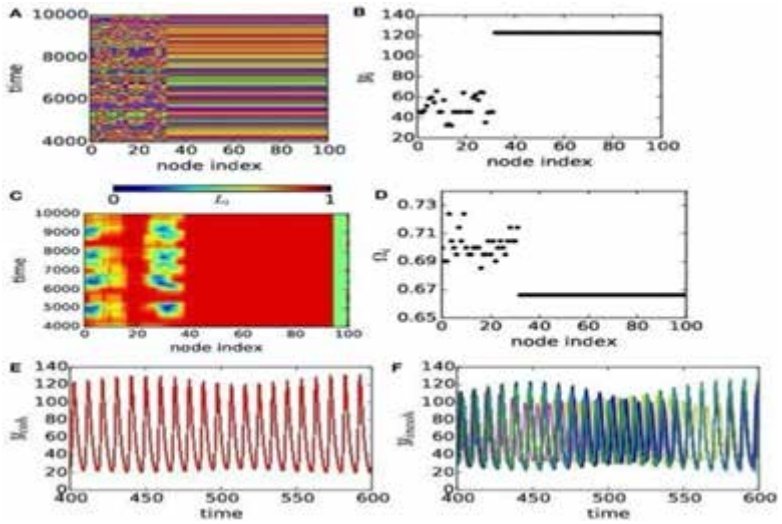
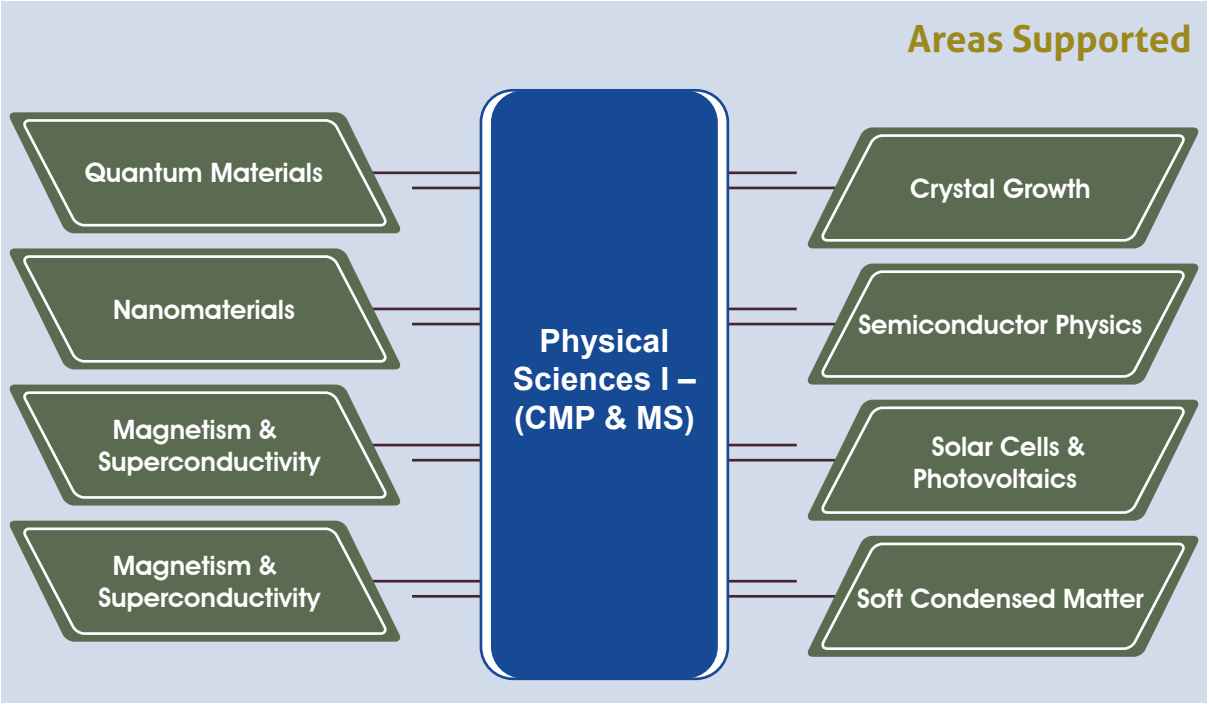


Fig. 3.31: Chimera states for the dispersal rates 0.29 and 0.22. (A) Spatio-temporal plots and (B) Snap shot of predator population. (C) Local order parameter and (D) mean phase velocity. (E) Temporal dynamics of coherent patches and (F) the same for incoherent patches.

3.1.1.14 Physical Sciences I – (CMP & MS)

In the reporting period, 73 new projects were sanctioned. The areas supported under CRG – Physical Sciences I – (CMP & MS) are shown in the following figure.



Research Highlights

Development of Novel Cluster Assembled material from Potential Cluster Motifs: A new insight under density Functional Investigation
Department of Physics:

Critical investigation on the hexagonal series of thallium (Gr. III) pnictides clusters, viz. $(TlX)_{2n+1}H_{2n+4}$ (X=N, P, As; n=1-5) identifies h-TlN ($Tl_3N_3H_6$) cluster as a potential building block for future 2D ultrathin and smart materials, which is further explored to develop 2D ultrathin nanosheets (mono, di and trilayers) of thallium nitride for thermoelectric applications (Figure 3.32). The bilayer TlN nanosheets is observed to have exceptionally better thermoelectric behavior compared to its mono- and trilayer counterparts for upto 800 K. Density functional investigation on various group III magnesium clusters, viz. X_kMg_3 (X=B, Al, Ga, In and Tl; ***k***=1-6) finds X_4Mg_3 (X=B, Al, Ga, In and Tl) units with magic stability and promising for future assembled semiconductor materials (Figure 3.33). Accordingly, 1D B_4Mg_3 assembled nanowire is found to be most promising with direct band gap (of 0.5 eV) and exceptional I-V characteristics and thermoelectric properties. Also, 2D Circular B_4Mg_3 reveal as a narrow direct gap (0.25 eV) semiconductor, mechanically stable and UV active to hold industrial applications. Hexagonal cluster unit based 2D CaX (X=O, S, Se and Te) materials shows outstanding thermoelectric material for 200-1200K with ZT ~ 0.8. The bilayer CaS/CaSe also appears to be a promising multi-time reversible sensor material for environmentally toxic NO_2 gas. This work was done at S. V. National Institute of Technology, Surat.

73
Projects Sanctioned

26.35 cr
Expenditure
(New and Ongoing)

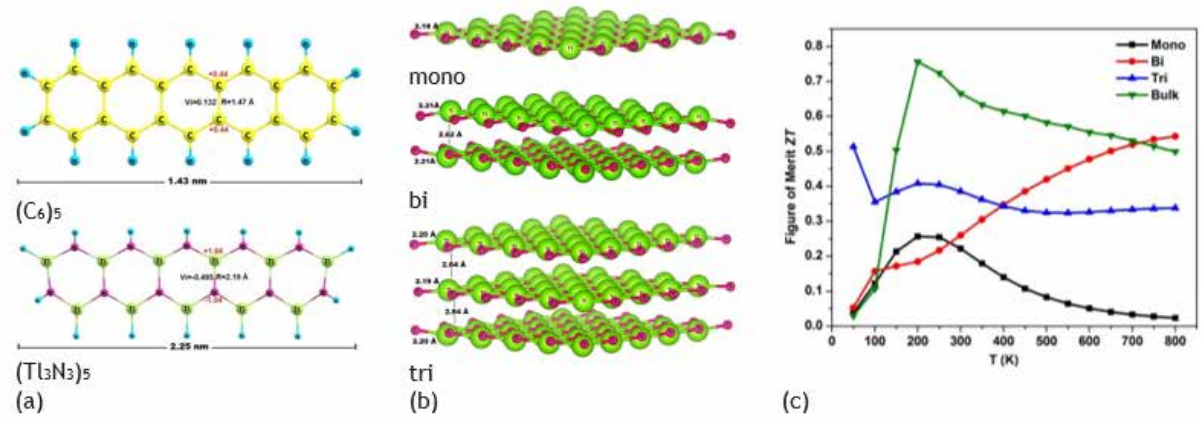


Fig. 3.32: (a) Optimized geometries of polyacene $(C_6)_5$ and hydrogen saturated $(Tl_3N_3)_5$ clusters. Potential energies (*Vi*) of central bridging atoms and their Mulliken charges (in red) are also presented. (b) The optimized structures of 2D thallium nitride nanosheets, viz. Monolayer, Bilayer and Trilayer, and their profile of (c) Figure of merit (ZT) along with bulk counterpart.

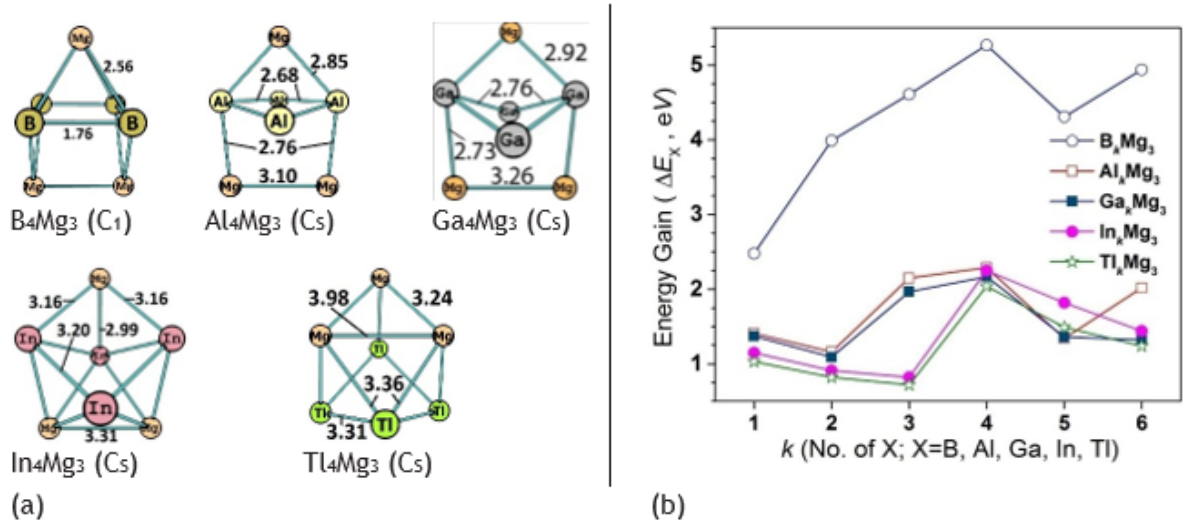
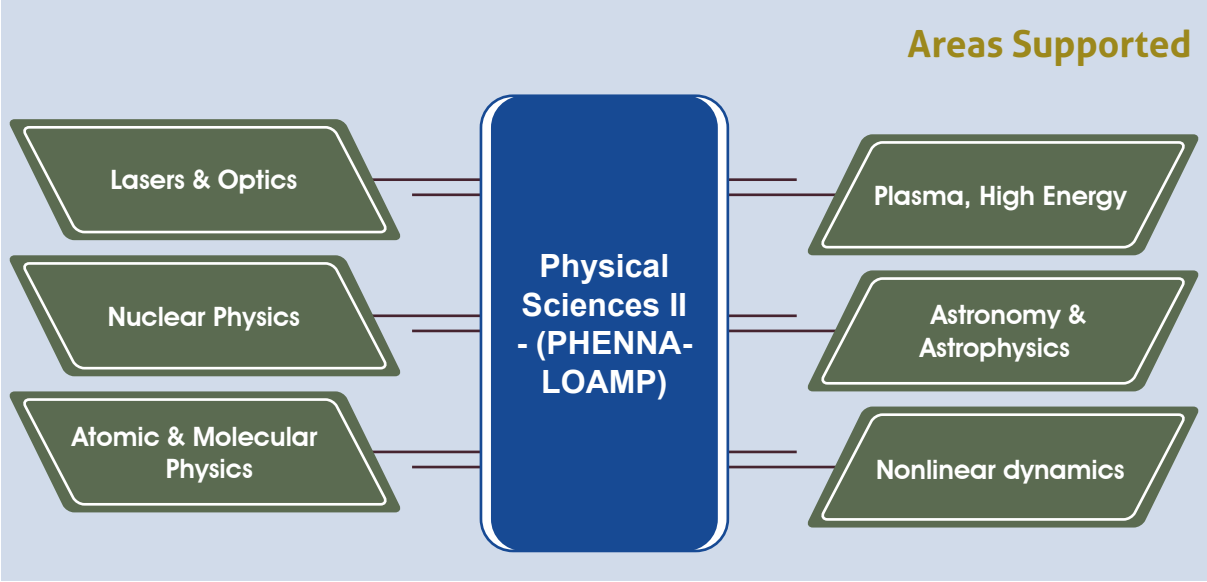


Fig. 3.33: (a) Minimum energy structures of X_4Mg_3 (X=B, Al, Ga, In and Tl) magic clusters and (b) Energy gain (ΔEX) of X_kMg_3 (X=B, Al, Ga, In and Tl; k=1-6) clusters, in adding a X atom to a previous Xk-1Mg_3 cluster.

3.1.1.15 Physical Sciences II - (PHENNA-LOAMP)

In the reporting period, 59 new projects were sanctioned. The areas supported under CRG – Physical Sciences II - (PHENNA-LOAMP) are shown in the following figure.



Research Highlights

Insight from chemical analysis of carbon-enhanced metal-poor stars

A primary objective was to derive observational constraints to the theoretical models of heavy-element nucleo-synthesis. This was accomplished by performing abundance analysis of a selected sample of candidate metal-poor stars. The following have been identified: one normal metal-poor star, 19 Ba stars, 5 CH star, 10 CEMP-s stars, 9 CEMP-r/s stars, and two CEMP-no stars in the sample studied here (Figure 3.34).

A new classification scheme for CEMP-s and CEMP-r/s stars based on the abundances of Ba, La and Eu has been put forward. Based on a parametric model-based analysis, it is confirmed that i-process is primarily responsible for the formation of CEMP-r/s stars (Figure 3.35). The mass of companion (progenitor) AGB stars have been investigated using several diagnostics, such as C, N, O abundances, ratio of heavy s-elements to light s-elements [hs/ls], [Rb/ Zr] ratio and Na, Mg abundances that confirm now invisible low-mass AGB companions for the programme stars. It has beem further identified for the first time, an astrophysical site in the progenitor AGBs where both the i and the s-process nucleosynthesis occur in succession. Ba and CH stars in the used sample are found to be members of the Galactic disk population and majority of the CEMP stars are found to belong to the Galactic halo. This work was done at the Indian Institute of Astrophysics, Bengaluru.

59
Projects Sanctioned

12.29 cr
Expenditure
(New and Ongoing)

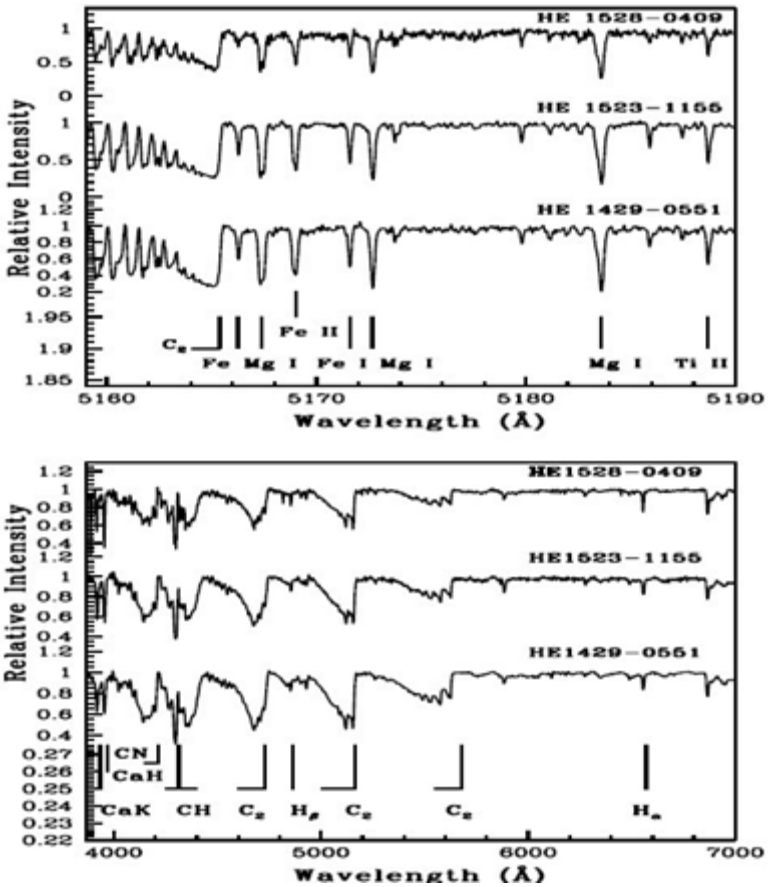


Fig. 3.34: High resolution (upper panel) and low resolution (lower panel) spectra of some of the stars. Neutral and singly ionized lines due to elements such as iron (Fe), magnesium (Mg) and titanium (Ti) can be seen in the upper panel. Carbon molecular bands due to CH, and C_2 are strongly visible in the lower panel.

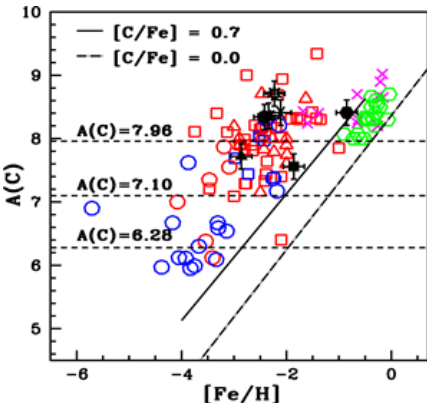
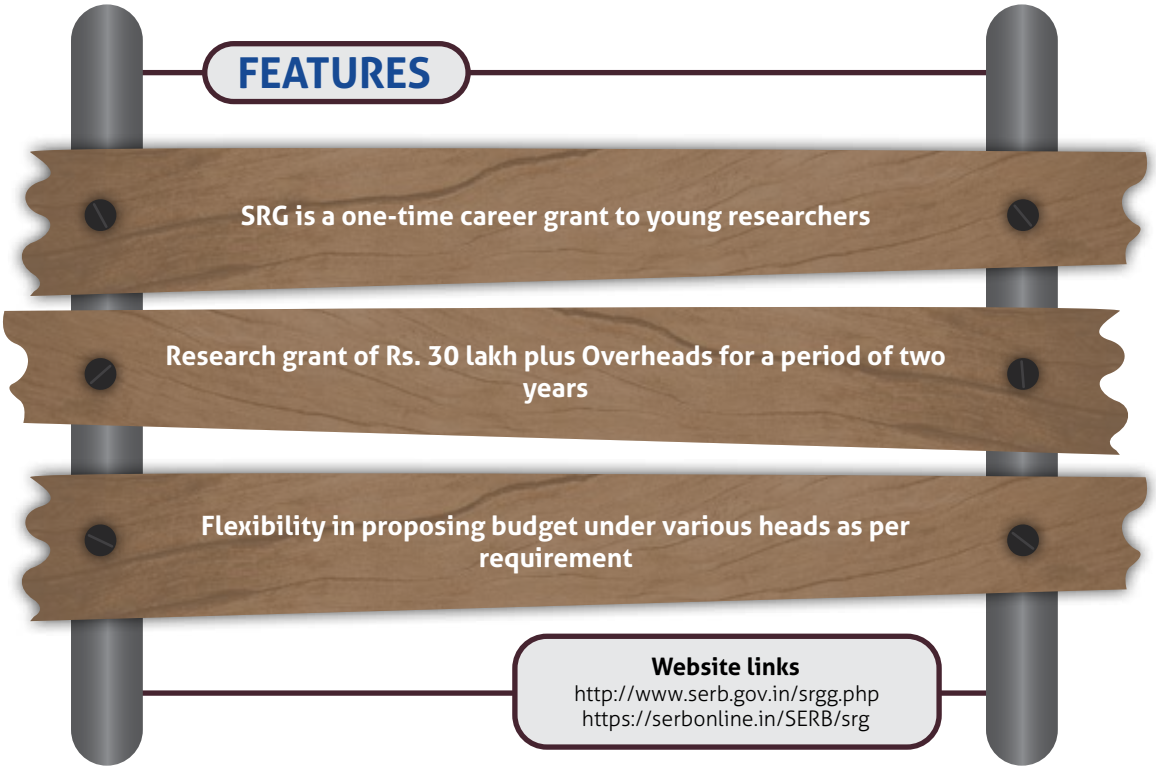


Fig. 3.35: The locations of known CEMP stars in a plot of relative abundance of iron (x-axis) versus that of Carbon (y-axis). The various colored symbols mark the various types of CEMP stars. The stars from this study are in black, with a cross on them, and their location in this diagram implies that these are binary stars, with a companion.

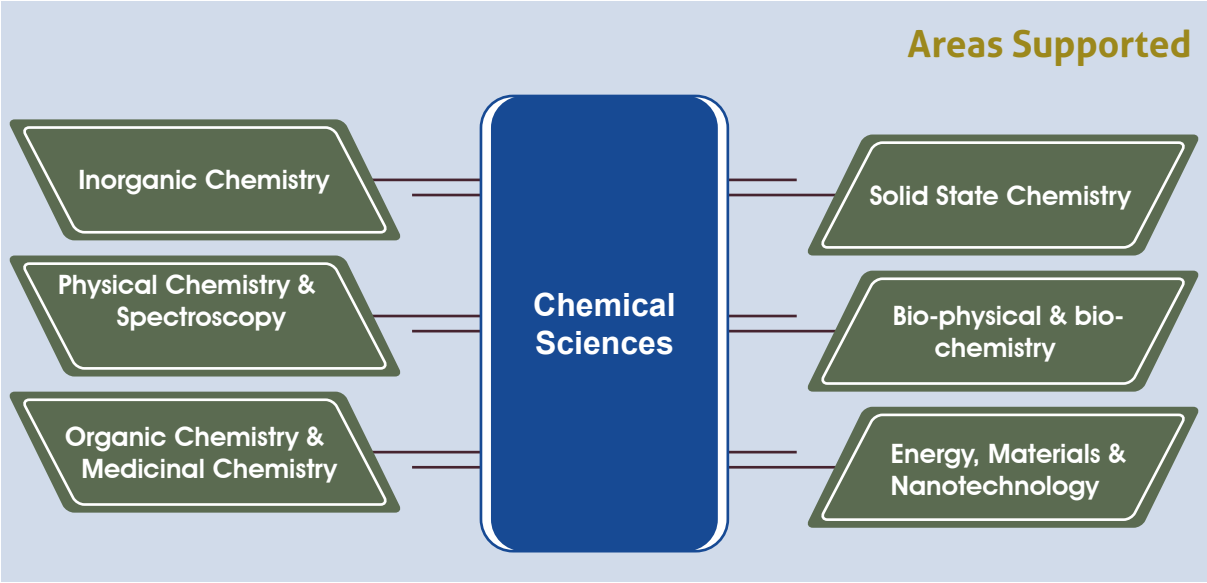
3.1.2 Start-up Research Grant (SRG)

Providing opportunities to the young researchers for pursuing exciting and innovative research in frontier areas of science and technology has always been given prime importance. Start-up Research Grant (SRG) has been launched by SERB for creating R&D platforms for young researchers to build their research career. By this two-year grant scheme, the young scholars get an opportunity to boost their career in their areas of specialization in a new institution or university. This grants helps in establishing the researchers and then moving on to the mainstream core research grant (CRG). The track record and the proposed research plan are the criterion for selection in this scheme. There are five discipline-wise verticals that are guided by individual Expert Committees. Initially, this scheme was launched as Young Scientist Scheme (YSS). Later it was reconstructed into two schemes Early Career Research award (ECRA) and National Postdoctoral Fellowship (NPDF). The ECRA used to offer project grants for young researchers and later it was reconstructed as SRG. The ongoing projects awarded under ECRA and YSS continue to be supported. The research highlights of some of the projects under ECRA, YSS and SRG programmes under various disciplines are provided below.



3.1.2.1 Chemical Sciences

In the reporting period, 55 new projects were sanctioned. The areas supported under SRG – Chemical Sciences are shown in the following figure.

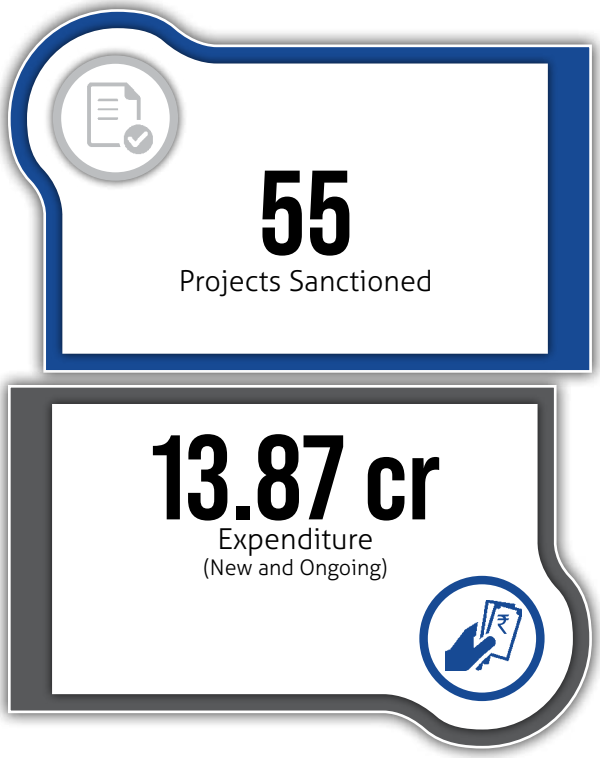


Research Highlights

Exploring Chemotactic and Catalytic Properties of Oligonucleotides for Designing of Self-powered Nanomotors

Studies related to chemotaxis coupled with catalysis has recently been documented for colloidal particles and enzymes, having importance in providing fundamentals of molecular chemotaxis, with application in designing of artificial nanomachines. In a research project supported under the Startup Research Grant (SRG) scheme, a research group studied an unexplored area encompassing phoretic and catalytic behavior of nucleotides and biopolymer (DNA) in different microenvironment, having significance in DNA-nanotechnology, relevant to transport, virus trafficking etc.

The study delineates how different nucleotide-mediated regulation and switching of catalysis towards hydrazone formation or proton transfer reaction can take place over a nanoparticle or vesicular interface simply by 'in situ' modulation multivalent interaction (Figure 3.36 (a)). Subsequently, a spatiotemporal dynamics pattern in the self-assembly behavior of a metallosurfactant from an unorganized assembly has been shown, which is induced by adenosine triphosphate (ATP) and enzymes, alkaline phosphatase (ALP) and hexokinase (HK) (Figure 3.36 (b)). Furthermore, upon monitoring chemotactic drift of calf thymus DNA under microfluidic condition in a gradient of physiologically relevant mono- and divalent salt, it has been found unlike solid colloidal particle,



DNA always moves up the gradient at higher salt concentration. However, their extent is governed by two factors – binding and diffusion of the metal-bound DNA. The localization and spatially confined catalysis of G-quadruplex based catalytic DNAzyme has also been regulated by controlling the gradient of metal ion (Hg^{2+}) inhibitor and non-catalytic aptamer (T9, 9-mer of T-base) (Figure 3.36 (c)). These studies envisage the layout of the reaction-diffusion processes for microscale dynamic organization of 'active' soft matter involving (oligo) nucleotides and DNA. The work was done at Indian Institute of Science Education and Research, Mohali.

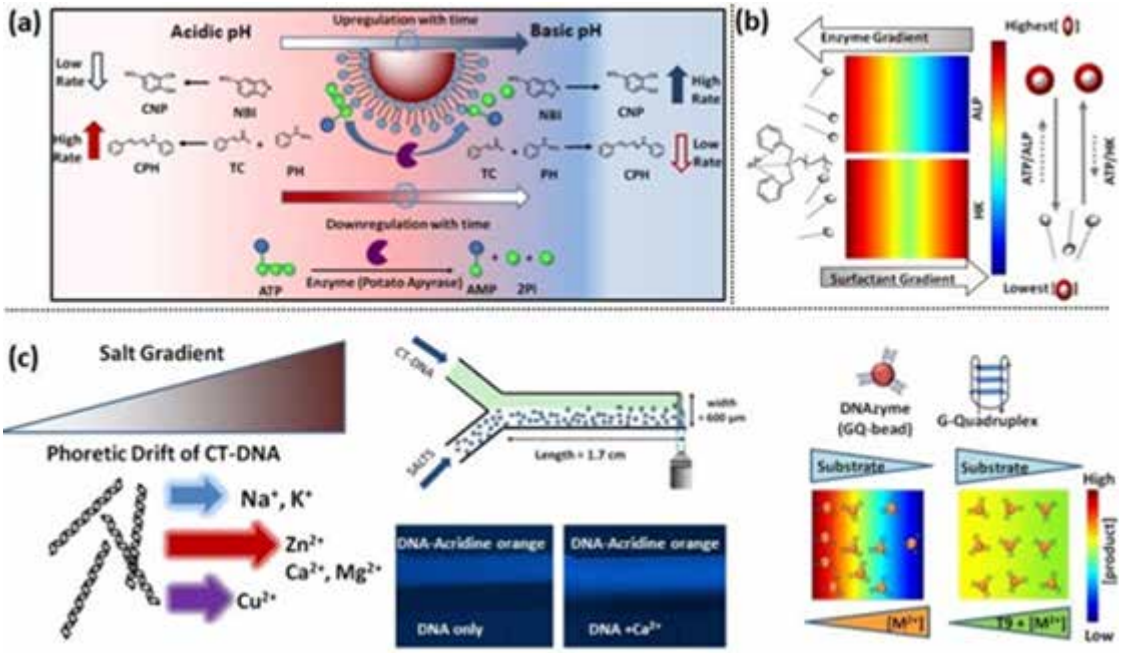


Fig. 3.36: (a) Schematic of nucleotide-mediated catalytic switch; (b) Pictorial representation of spatiotemporal dynamics pattern in the self-assembly behavior of a surfactant from an unorganized assembly, induced by adenosine triphosphate (ATP); (c) Schematically showing chemotactic drift of DNA in a gradient of metal ions in microfluidic environment and regulation of spatial distribution of catalytic G-quadruplex by metal ions and aptamers.

Computational Investigation on the Role of Metals and Side Chain Mutations in Engineered Myoglobins

Engineering enzymes for non-natural reactions presents an exciting domain in biocatalysis. Major success in engineering enzymes has come from directed evolution methods. A successful example is the use of haem enzymes to catalyze carbene transfer reactions. These important reactions that are used to construct C-X bonds have also witnessed tremendous success in homogeneous catalysis where metal-porphyrins are used. However, achieving high levels of chemo-, regio-, and stereocontrol with Fe has been a challenging task. To circumvent this issue in enzymes, Fe has been replaced with Ir for a C-H insertion reaction. While the approach is quite successful, the understanding at the molecular level is very limited. The investigators, used Density Functional Theory (DFT) methods to shed light on the improved reactivity of Ir metal over Fe in the C-H insertion reaction catalyzed by heme enzymes (Figure 3.37).

The study showed that the improved reactivity of Ir systems is not due to the conventional stronger metal-ligand overlap, but due to a lower distortion in the metal-porphyrin ring system. Additionally, study also showed how computational methods can be used in deciding the best metal-ligand combination for a catalytic transformation. For instance, how changes in the axial ligand from methyl to chloride to imidazole changes the rate determining step of the catalytic cycle were explored. For another C-H insertion reaction, the study explored how a change in metal causes a shift in the mechanism as in Ir-porphyrins, which follow a concerted carbene transfer whereas Ru adopts a radical pathway. These computational insights would be highly useful in designing new catalytic systems, and can be extended to other carbene transfer reactions. The work was done at Indian Institute of Science, Bengaluru.

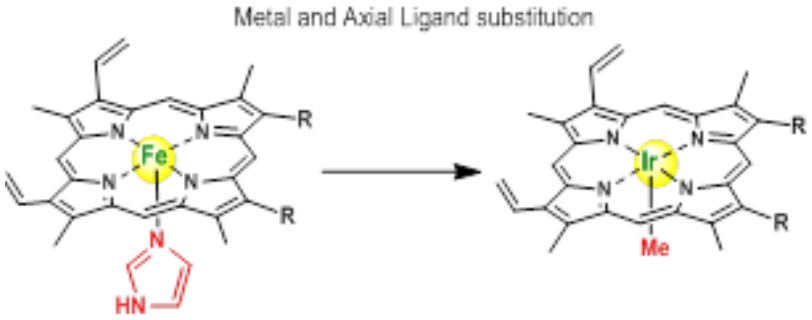
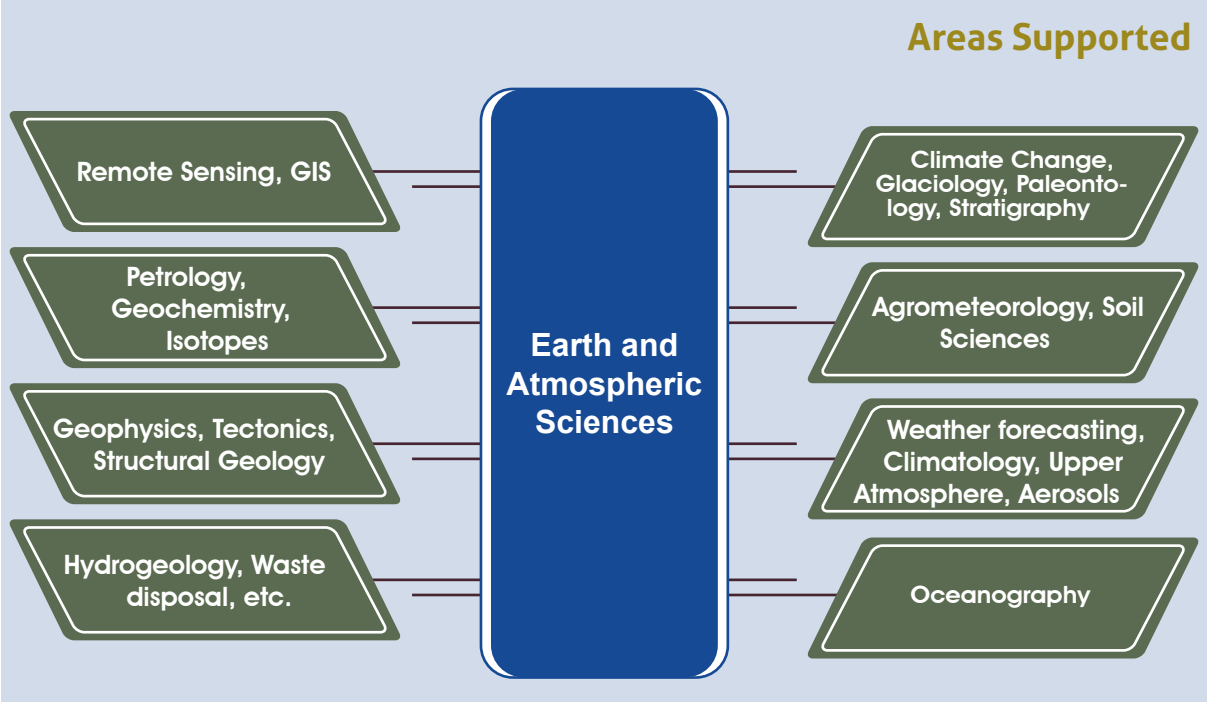


Fig. 3.37: Choosing the best metal-ligand combination using DFT methods

3.1.2.2 Earth and Atmospheric Sciences

In the reporting period, 25 new projects were sanctioned. The areas supported under SRG – Earth and Atmospheric Sciences are shown in the following figure.



Research Highlights

Tracing the impact of Late Cenozoic climatic transitions on the erosion rates of Himalaya

Most of Earth's surface processes that transport sediment are influenced by climate changes. For example, more rainfall enhances surface runoff and river sediment transport capacity, and colder temperatures expand glaciers at the expense of river networks. Many researchers think that late Cenozoic cooling and the alteration of glacial and interglacial periods during the Quaternary were accompanied by changes in continental erosion.

However, quantifying erosion rates in the geological past is challenging, and previous studies reached contrasting conclusions. In this study, the paleoerosion rates have been estimated by measuring the concentration of in situ-produced cosmogenic radionuclide ^{10}Be in Siwalik sediments shed from Himalaya. The ^{10}Be concentration of exhumed older foreland basin sediment integrates its entire exposure history: exhumation via erosion through the near-surface, sediment transfer by rivers to the foreland, near-surface residence during progressive burial as a sedimentary deposit, and eventual re-exposure following basin inversion. In this study, the ^{10}Be concentrations acquired during hillslope erosion in the past by sequentially constraining the ^{10}Be production during these multiple stages of production and accounting for the ^{10}Be decay using magnetostratigraphy-derived ages of sediment deposition, have been reconstructed. The paleoerosion rate data is supplemented with ten modern catchment-averaged erosion rate estimates using ^{10}Be abundances in sands from the Yamuna trunk stream and tributaries near the mountain front. Our reconstructed erosion rates show a quasi-cyclic pattern with a periodicity of ~1 million year and a gradual increase toward the present (Figure 3.38). It is suggested that both patterns—cyclicity and gradual increase—are unrelated to climatic changes. Instead, it has been proposed by the investigators that an emergent phenomenon related to tectonic accretion of material to the Himalaya, resulted in changes of its topography that were accompanied by changes in erosion rates. Our study is amongst the first that documents cyclic erosion rates that could plausibly be linked to the tectonic evolution of orogenic wedges, and may thus change the way erosion histories are interpreted globally. This work was done at Indian Institute of Science Education and Research, Kolkata.

25
Projects Sanctioned

4.85 cr
Expenditure
(New and Ongoing)

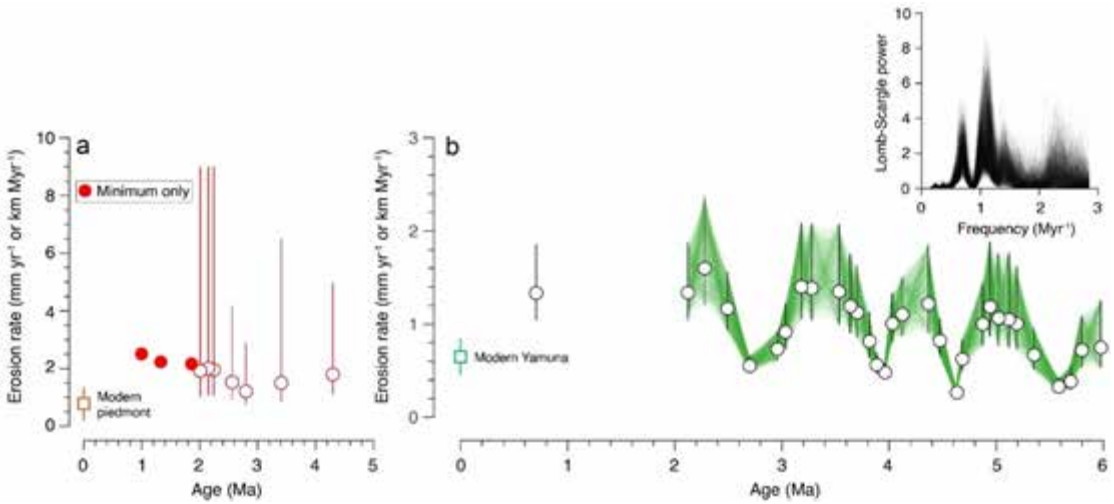
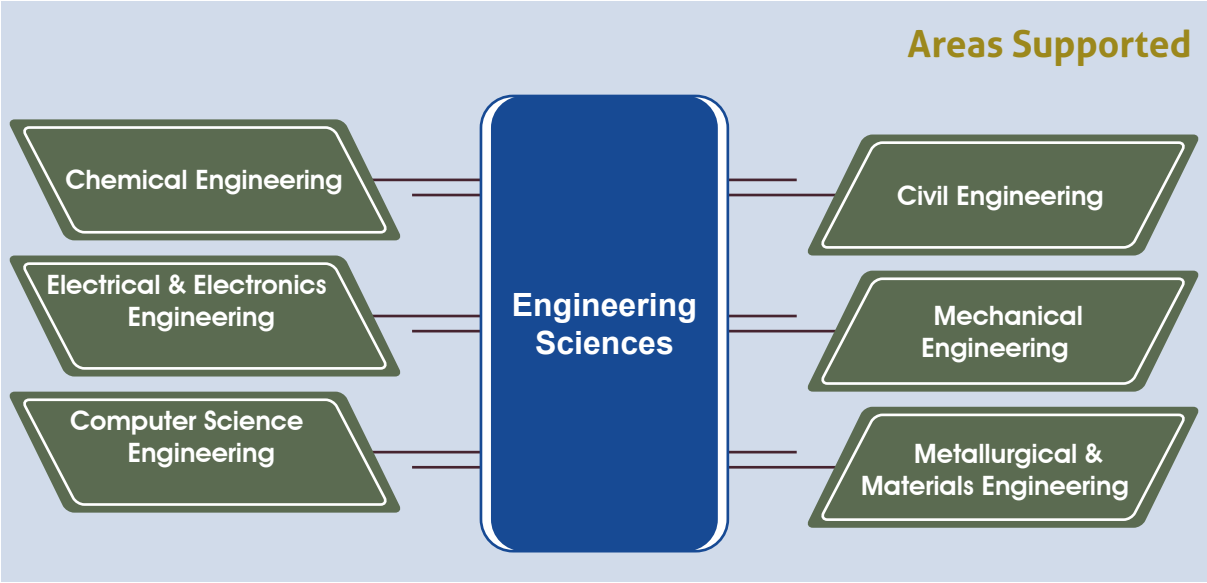


Fig. 3.38: Erosion rates reconstructed from cosmogenic-isotope data plotted against sediment depositional age, showing ~1-Myr periodicity and increase in rates towards the present. Green lines show results of Monte Carlo uncertainty modelling. Inset shows the Lomb-Scargle periodogram computed from the erosion rate data.

3.1.2.3 Engineering Sciences

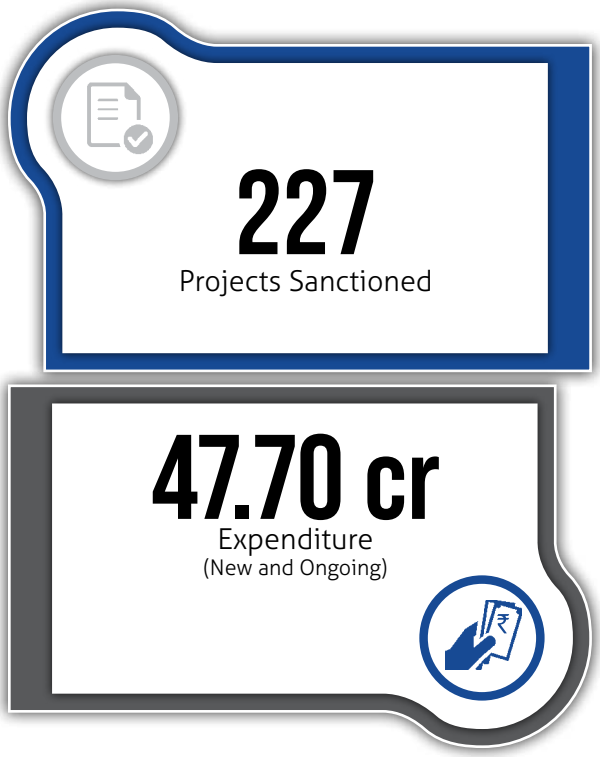
In the reporting period, 227 new projects were sanctioned. The areas supported under SRG –Engineering Sciences are shown in the following figure.



Research Highlights

Design of Single-band and Dual-band Transmission-type Linear to Circular Polarization Converter

In this project design of transmission type linear to circular polarization converters have been carried out. The desirable features of FSS to act as Transmission Type Linear to Circular Polarization Converter is as follows: (I) Transmission Magnitude: Transmission magnitude (|S21|) is expressed in decibel (dB), and for FSS to transmit effectively, it is essential to ensure the transmission magnitude is close to 0 dB, the acceptable amplitude level is -3 dB. (II) Transmission Phase: The phase difference between two orthogonal components of transmitted the signal from FSS should be 90 degrees or an odd integral multiple of 90 degrees. The unit cell of the proposed polarization reconfigurable converter (PRC) consists of two metallic printed half-hexagonshaped structures, as shown in Figure 3.39. The front, back, and perspective views of the proposed unit cell are respectively shown in Figure 3.39 (A-C).



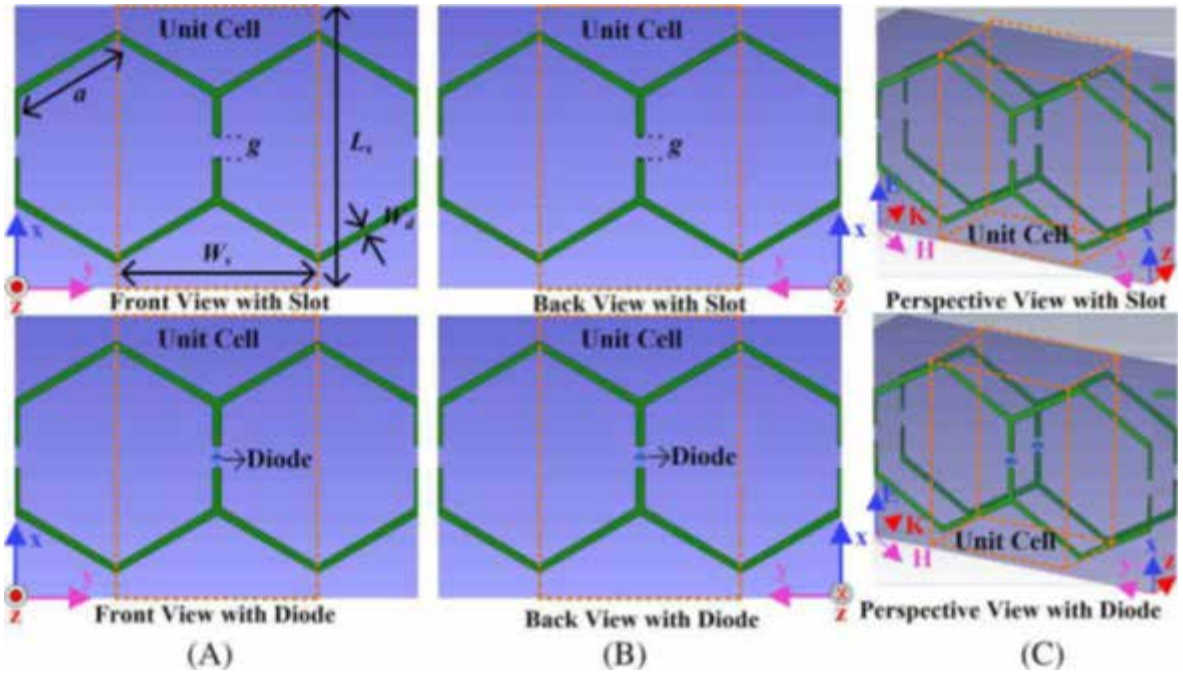


Fig. 3.39: Proposed unit cell of the polarization reconfigurable converter (A) front view, (B) back view and (C) perspective view. Ws = 9.25, Ls = 13, a = 5.34, g = 1, and Wd = 0.34 (all dimensions in mm)

In order to improve the transmission through the converter, the basic unit cell is printed on both the sides of a dielectric constant of 2.2 and a loss tangent of 0.0009. The slot length "g" in the middle of the cell plays an important role in the functioning of the cell. A linearly polarized (LP) microstrip patch antenna is fabricated through the standard photolithographic procedure. A 6 × 6 array of the proposed PRC is also fabricated and is used as a superstrate at the height of lambda/3 from the patch antenna. The reflection coefficient (S11) measurement of the fabricated antenna with PRC is done using the MS2028C Vector Network Analyzer from Anritsu. All the Axial Ratio (AR) measurements were conducted experimentally in an anechoic chamber using N9010A EXA (X-Series) Signal Analyzer from Keysight Technologies. The PIN diode is turned ON by providing a bias voltage of 0.91 V; in this state, the PRC transmits an LP wave, and the AR of the antenna is above 15 dB both in simulations and measurements representing the linear polarization of the antenna. However, if the PIN diode is turned OFF by giving a 0 V bias voltage, the PRC transmits a CP wave. In the OFF state of the diodes, the minimum AR measured is around 0.86 dB, representing the circular polarization of the antenna. Therefore, the polarization of the antenna can be controlled by the working state of the diodes. To ensure that the PRC is illuminated with a 45 degree polarized incident wave, the PRC elements are rotated 45 degrees clockwise to the patch antenna. The simulated and measured gain of the antenna without PRC is around 6.53 dBi and 8.53 dBi with PRC. The increase in gain can be attributed due to the formation of the Fabry-Perot cavity in the antenna with the PRC. Furthermore, 1 x 4 and 2 x 2 patch antenna arrays are fabricated and are integrated with the 9 x 9 array of the PRC. The integrated system giving rise to polarization reconfigurable antenna arrays is measured for reflection coefficient, far-field patterns, axial ratio, and gain using PNA N5224B. Dual-Band Linear to circular polarization converter: The unit cell of the proposed dual-band linear to circular polarization converter is shown in Figure 3.40. The structure comprises a single-dielectric substrate layer with dimensions along the x- and y-directions as wx = 3.90 mm and wy = 3.72 mm, respectively. The material of the substrate is chosen as 60 mils thick Diclad 880 with a relative permittivity of 2.2 and a loss tangent of 0.0009. The metallic split rings with the strips are printed on both sides of the substrate to improve the transmission. The conducting material for all metallic strips is 35 m thick copper. The performance of the converter can be shaped by appropriately adjusting the geometrical parameters. This work was done at Indian Institute of Technology, Jammu.

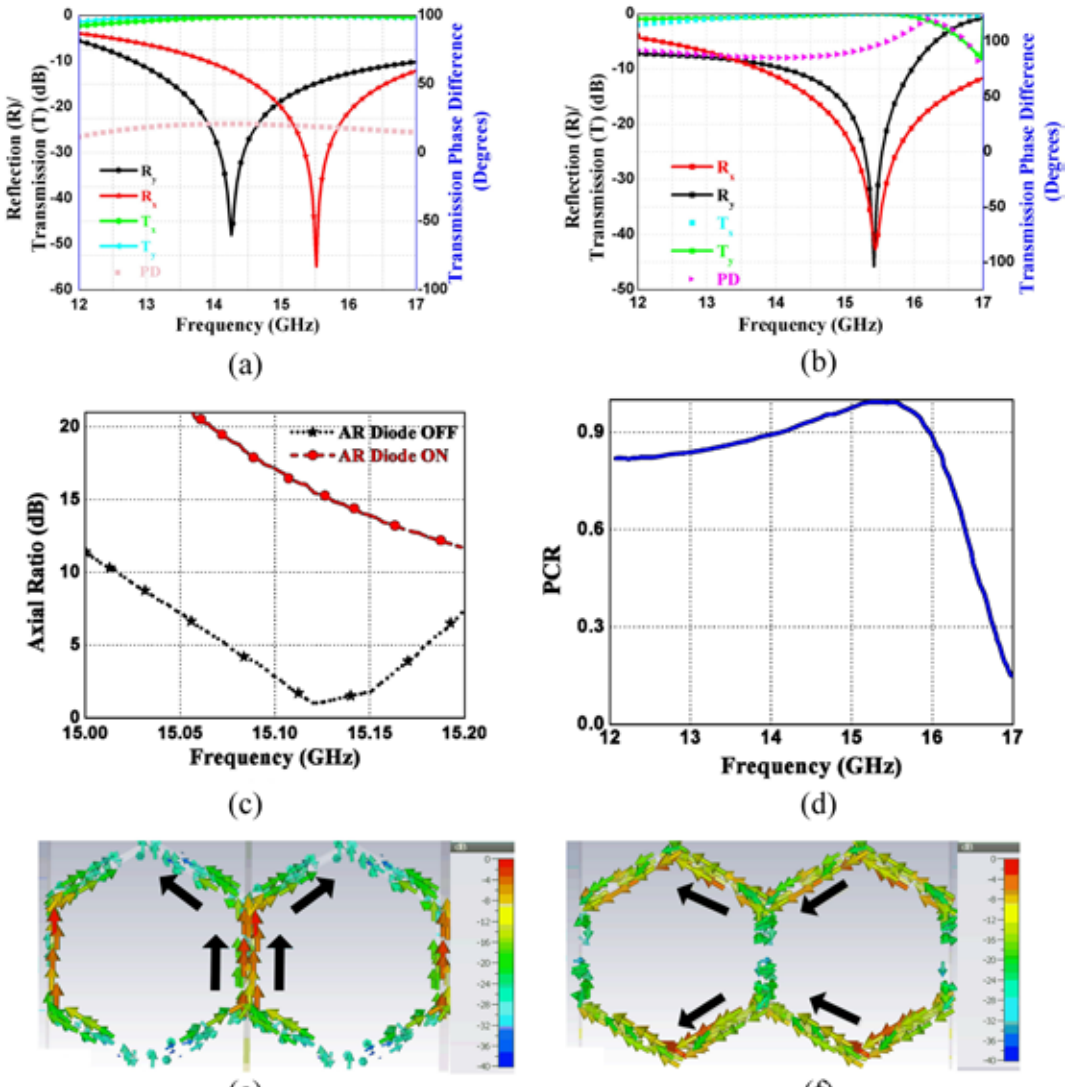


Fig. 3.40: Plot of reflection/transmission coefficient and transmission phase difference of polarization reconfigurable converter (PRC) for (A) g = 0 (Diode ON) (B) g = 1 (Diode OFF), Rx, Ry is reflection and Tx, Ty is transmission for x- and y-polarized incident wave respectively, PD is phase difference between Tx and Ty. (C) Axial ratio (AR) for g = 0 (Diode ON) and g = 1 (Diode OFF). (D) Polarization conversion efficiency (PCR). Surface current (E) g = 0 (Diode ON) and (F) g = 1 (Diode OFF) protection and fault buffer data acquisition 4) a

Proximal Femoral Locking Plates (PFLP): Biomechanical Exploration of Design Variants for North Eastern (NE) Population

The custom-made fixture was introduced in order to provide sufficient distal constraint one-third along the shaft from the distal end while tilting the bone laterally by 10° in the frontal plane and by 10° dorsally in the sagittal plane. The set up was initially calibrated with a minimum load which was then increased quasi-statically upto 2kN at a constant displacement rate of 5 mm/min. A 7-hole DHS plate (Figure 3.41a) was also designed and virtually fitted with five screws (1 proximal locking and 4 dynamic) (Figure 3.41(c,d)). A comminuted fracture, simulated as two-part fracture gap of 20 mm, was created in the subtrochanteric region of the implanted femur (Figure 3.41(b,d)). Linear elastic, isotropic and homogenous material properties were applied to cancellous bone, whereas orthotropic material properties were applied to the cortical bone based on the data provided by the manufacturer. The material for the plate and screw was considered to be stainless steel (SS). Poisson's ratio for all material was set as 0.3. In order to simulate the locking behaviour of the screws, the interface between the proximal locking screws and the bone, however, was considered to be bonded under all conditions. Screw plate interface was

assumed to be bonded for PFLP fixation to mimic the locking plate characteristic whereas it was assumed to be in contact for DHS fixation with coefficient of friction set as 0.3. In both models, distal dynamic screws were assumed to be in contact with bone having coefficient of friction set as 0.3. The interface between the bone and plate were assumed to be bonded under all condition. The interface between the cortical and cancellous bones is considered bonded as well. It may be noted that by defining bonded interface in an FE simulation, the geometry was treated as though it was perfectly connected, like one solid piece. Hence, no relative movement, frictional or otherwise, is allowed at the interface. Augmented Lagrange Method with standard (surface-to-surface) contact behaviour was considered as contact algorithm. For convergence, the penalty stiffness and penetration tolerance were set as 10 and 0.1, respectively. A mesh size study was carried out to check the numerical convergence of the cortical model (intact) using three different FE meshes containing ~70,000, ~150,000 and ~520,000 elements respectively, and a comparison of their predicted von Mises stress. The maximum difference in peak von Mises stress was predicted to be 5% between the coarse and the medium meshes, and 2% between the medium and fine meshes. Therefore, considering the computational efficiency and accuracy, the medium sized mesh was judged to be sufficiently accurate. The work was done at Indian Institute of Technology, Guwahati.

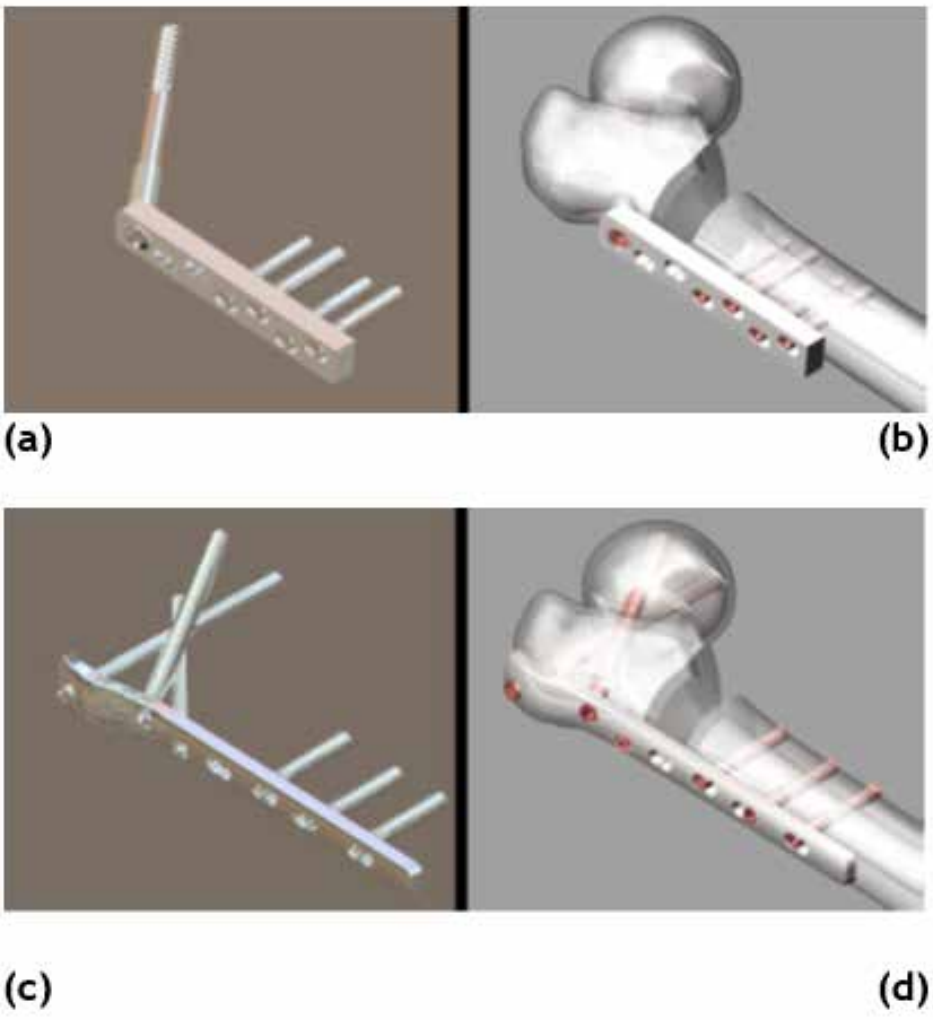
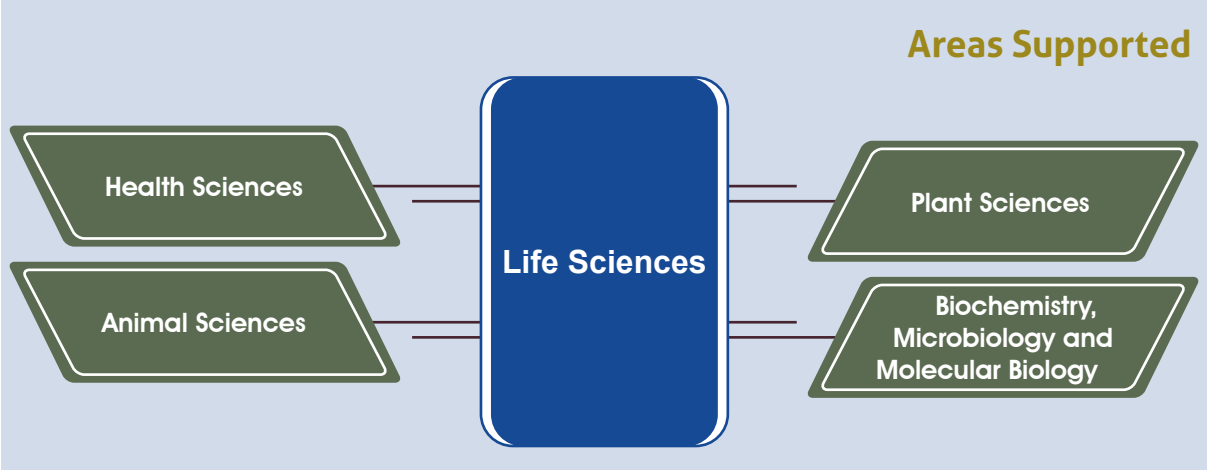


Fig. 3.41: Rendered CAD models of the implants and the implanted femur with a simulated non-comminuted subtrochanteric fracture gap of 20 mm: (a) DHS, (b) DHS fixated femur, (c) PFLP and (d) PFLP fixated femur.

3.1.2.4 Life Sciences

In the reporting period, 130 new projects were sanctioned. The areas supported under SRG – Life Sciences are shown in the following figure.



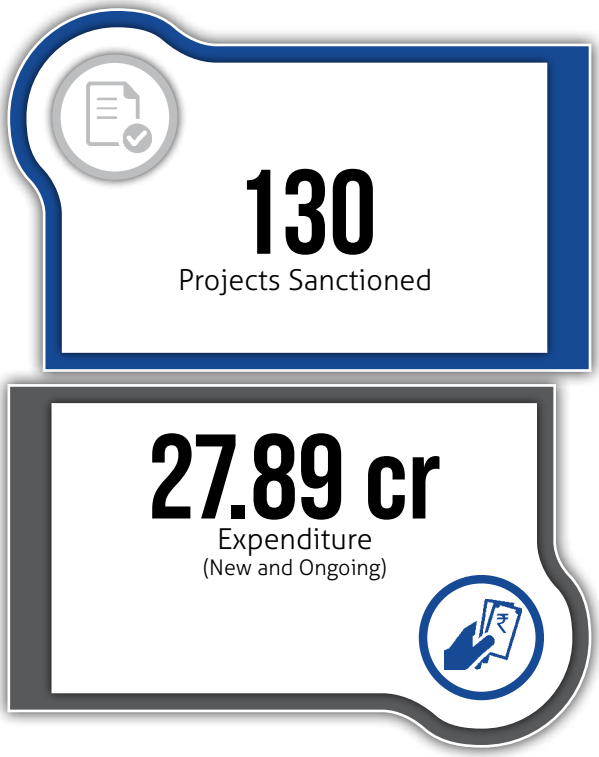
Research Highlights

Molecular characterization of flavonol biosynthesis in banana: Towards development of flavonol enriched banana

Three R2R3 MYB transcription factors were characterized as flavonol specific activator from banana: In our *in silico* analysis three putative R2R3-MYB-type flavonol specific regulators were identified in *M. acuminata.* Three homologous R2R3-MYB proteins MaMYBFA1, MaMYBFA2 and MaMYBFA3 were identified as candidate flavonol specific regulators. The phylogenetic analysis indicated, that all three candidate proteins cluster in the same clade together with functionally proven flavonol specific regulatory proteins from diverse plant species (Figure 3.42).

MaMYB transcription factors are differentially expressed in various tissues of banana. The transcript level of the three identified MYB genes in different tissues of banana like young leaf, pseudo stem, bract, root, unripe peel, unripe pulp, ripe peel and ripe pulp by qRT-PCR have been quantified. It has been found that the expression level of all three MYB genes were highest in bract tissue. Whereas, their expression was significantly lower in other vegetative tissues like young leaf, pseudo stem, root etc. Fruit tissue, which is the edible part of the plant, have least expression. One of the identified genes, *MaMYBFA2,* was expressed in ripe peel tissue as compared to other two MYB genes.

Assessment of the regulatory specificities of MaMYB proteins: To analyze the transactivation



potential of MaMYB and to test its functionality, a PEG-mediated co-transfection based transient expression system using protoplasts of the *A. thaliana* At7 cell line has been utilized. This system allows co-transfection of effector and reporter constructs for quantification of GUS activity, which after normalization, was taken as a measure of promoter activation. The effector construct harbors MaMYB ORF fused with uidA ORF (GUS). The responsiveness of the effector

construct was tested with the promoter (reporter construct) of structural genes involved in the flavonol biosynthesis in *A. thaliana*. Apart from these reporters, *AtDFR* promoter to test whether the identified regulatory protein activates anthocyanin biosynthesis has been utilized. It has been found that MaMYBFA2 and MaMYBFA3 could transactivate promoters of biosynthetic genes like CHS, CHI, F3H, and FLS where MaMYBFA1 couldn't. Both have highest transactivation potential for F3H promoter. They also activated CHS, CHI and FLS promoters. Interestingly, they couldn't activate DFR promoter, which are rete-limiting enzyme for anthocyanin biosynthesis. AtMYB12 and ZmP also showed similar function as MaMYBFA2 and MaMYBFA3 (Figure 3.43). It has been confirmed that these two MYB genes, MaMYBFA2 and MaMYBFA3 have the potential to regulate flavonol biosynthesis.

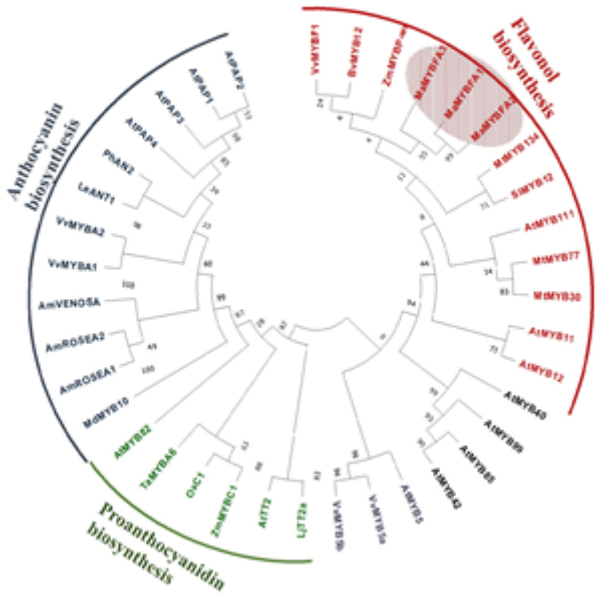


Fig. 3.42: Identification of candidate Banana R2R3-MYB flavonol regulators. The depicted R2R3-MYB proteins were classified into three major groups as flavonol-, anthocyanin- and proanthocyanidin biosynthesis specific regulators using landmark flavonoid specific R2R3-MYBs from different plant species. The phylogenetic tree was constructed using MEGA X. MtMYBs are highlighted by red ovals.

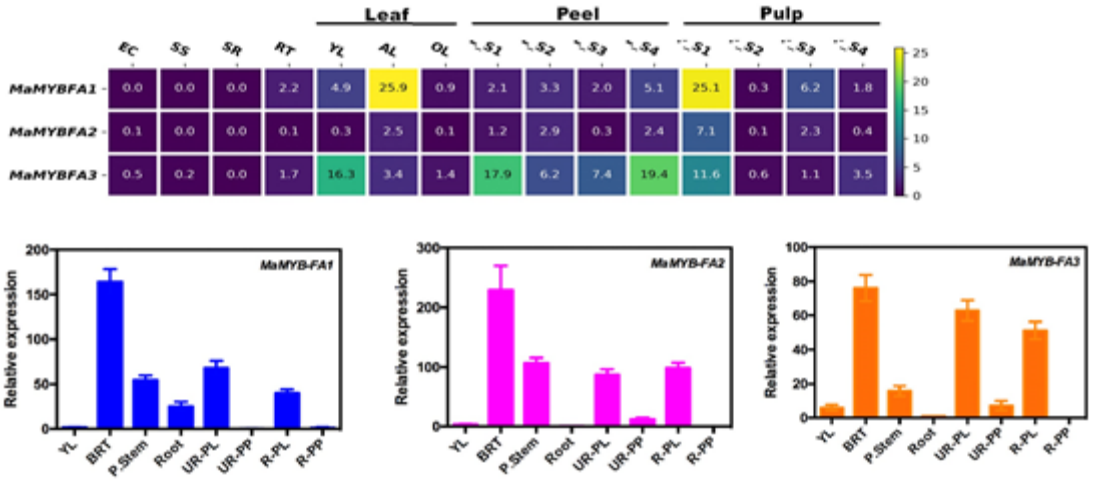


Fig. 3.43: Tissue specific expression of MaMYBFA genes. Publically available RNA-seq data sets were explored to analyse expression of MaMYBFA genes in embryogenic cells (EC), seedling shoot (SS), seedling root (SR), root (RT) and different developmental stages of leaf (young, adult and old), peel (stage 1 to stage 4 (S1 to S4)) and pulp (stage 1 to stage 4 (S1 to S4)) organs/tissues. A heatmap of gene expression levels is given on the basis of FPKM values (a). Quantitative real time expression analysis of MaMYBFA genes in different organs of banana

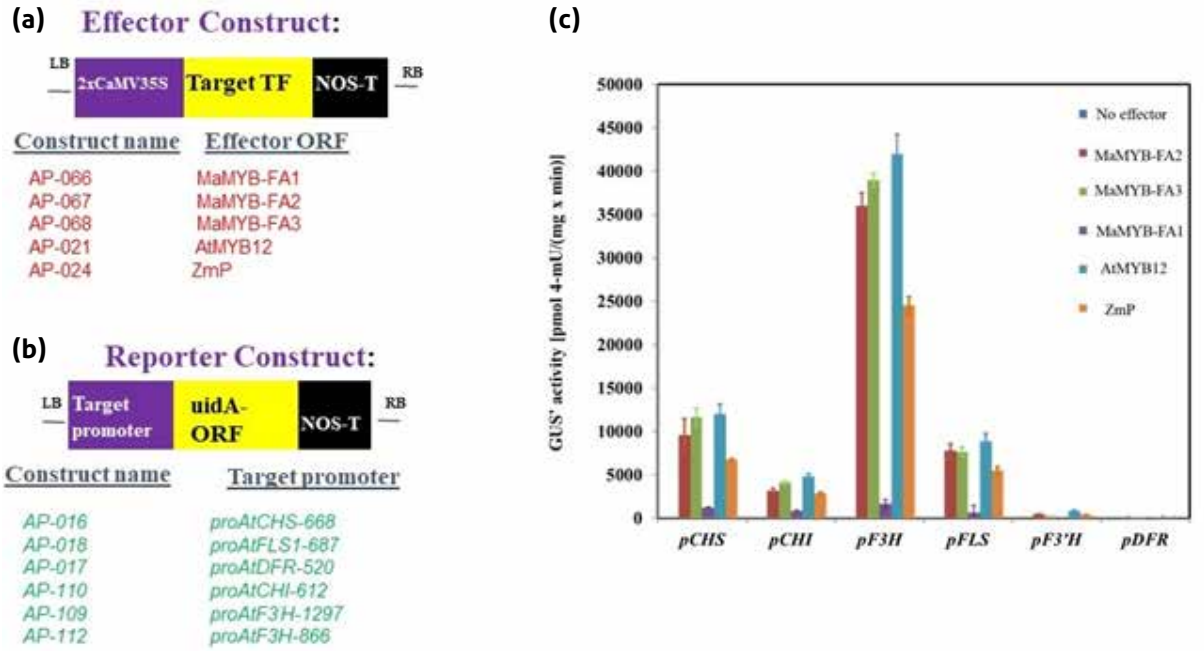


Fig. 3.44: Co-transfection analysis in At7 protoplasts indicate in vivo regulatory potential of MaMYBFA on A. thaliana flavonol biosynthesis gene promoters. Schematic representation of the effector and reporter constructs used. Fragments of Arabidopsis flavonoid biosynthesis gene promoters (reporters) were assayed for their responsiveness to the effector MaMYBFA expressed under the control of the CaMV 35S promoter (a & b). Results from co-transfection experiments in At7 protoplasts. The figure shows promoter activity (mean GUS activity) resulting from the influence of the effector protein on different reporters (c)

MaMYBFA2 and *MaMYBFA3* complement the flavonol-deficient phenotype of an *A. thaliana myb* mutant: To further validate the in planta function of MaMYBFA1-3 as a flavonol regulator, the MaMYBs under the control of double CaMV35S promoter in a flavonol-deficient regulatory multiple myb mutant of *A. thaliana.* has been over-expressed. The transgenic *A. thaliana* seedlings were analysed by high performance thin layer chromatography (HPTLC) fingerprint for their ability to reconstitute flavonol glycoside accumulation. The HPTLC analysis showed clear differences between WT (Col-0), mutant line, and different MaMYBFA1-3 complemented lines. The over-expression of MaMYBFA2, and MaMYBFA3 promoted the accumulation of various quercetin and kaempferol derivatives (Figure 3.44) in the multiple myb mutants. However, MAMYBFA1 over-expression could not restore flavonol synthesis in flavonol deficient mutant (Figure 3.45). Taken together, the complementation analysis suggested that MaMYBFA2 and *Ma*MYBFA3 functions as flavonol regulator in planta. The anthocyanin pigmentation in the MaMYBFA1-3 complemented seedlings has also been anayzed. Visual inspection of sucrose-induced anthocyanin pigmentation in norflurazon-bleached seedlings showed no indication of accumulation of anthocyanin pigments suggesting that MaMYBFA1-3 do not have the potential to activate anthocyanin biosynthesis in *Arabidopsis*. Above experiments proves that MAMYBFA2 and MaMYBFA3 are the functional regulator of flavonol biosynthesis in banana. More detailed functional study through expression and metabolite analysis will be done in native system to validate functional aspects of these candidate genes. This work was done at National Institute of Plant Genome Research, New Delhi.

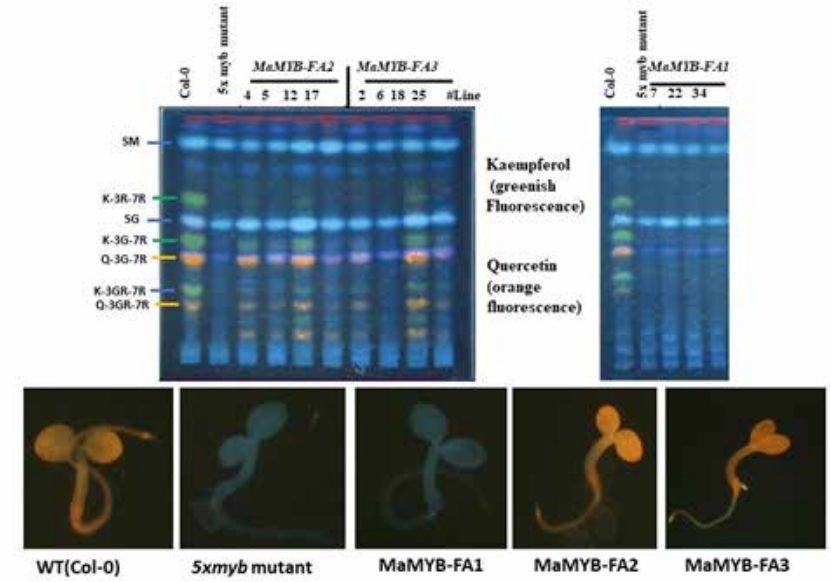


Fig. 3.45: MaMYBFA2 & 3 restores the flavonol-deficient phenotype of a regulatory multiple *A. thaliana myb mutant*. HPTLC of methanolic extracts of T2 seedlings of independent transgenic *A. thaliana* lines containing T-DNA insertions construct in the flavonol- and anthocyanin-deficient multiple myb mutant background. Flavonol glycosides were detected by DPBA staining and visualization under UV illumination. Green fluorescence indicates different derivatives of kaempferol and orange fluorescence indicates the presence of quercetin derivatives. K3R7R, kaempferol-3-o-rhamnoside-7-o-rhamnoside; K3G7R, kaempferol-3-o-glucoside-7-o-rhamnoside; Q3G7R, quercetin-3- oglucoside-7-o-rhamnoside; K3GR7R, kaempferol-3-o-glucorhamnosid-7-Orhamnoside; Q3GR7R, quercetin-3-o-glucorhamnosid-7-orhamnoside (a). Phenotypic characterization of WT, mutant and MaMYBFA complementation lines of norflurazon bleached, DPBA stained seedlings, showing orange fluorescence flavonol pigments (b).

Investigating auxiliary functions of HSP110 in malaria causing parasite *Plasmodium falciparum*

Assessing the changes in the mRNA levels and protein levels PfHSP110 and its co-chaperones during different stress conditions: Changes in the cellular levels of PfHSP110 and its co-chaperones were evaluated through real- time PCR (RT-PCR) and through western blotting. The parasite was exposed to different proteotoxic stress conditions (proteasomal, mitochondrial and nuclear stress). Initially phenotypic/ morphological changes were observed through giemsa staining. For instance, MMS treatment resulted in loss of chromatin integrity, while FCCP resulted in compaction of parasite, and Mg132 resulted in vacuole formation (Figure 3.46). At mRNA levels, significant upregulation in PfSHP110 level was observed upon proteasomal (Mg132) and mitochondrial (FCCP) stress (Figure 3.47). Using in-house generated polyclonal antibodies, the protein levels of PfHSP110 and its co-chaperones (PfHSP70 and cytosolic type-I HSP40) were assessed through western blots (Figure 3.48). Though, the mRNA levels were significantly increased upon stress conditions, but the concomitant upregulation in their respective levels could not be found. This could be due to saturating endogenous levels of HSPs in the parasite.

This work was done at CSIR – Central Drug Research Institute, Lucknow.

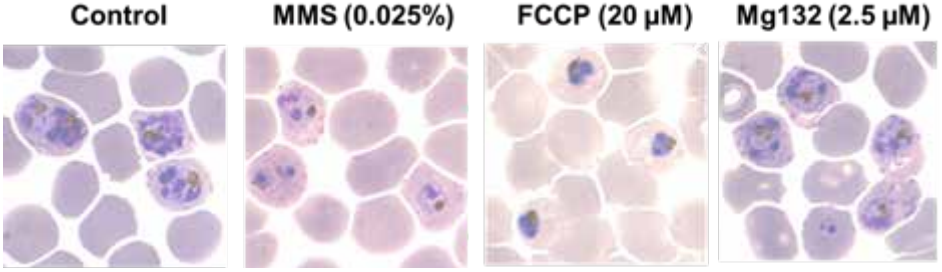


Fig. 3.46: Giemsa stained parasites (PF3D7) after different proteotoxic stress conditions. Parasite was exposed to different stress (nuclear, mitochondrial and proteasomal stress). Stress was given at early trophozoite stage and harvested after 6h treatment.

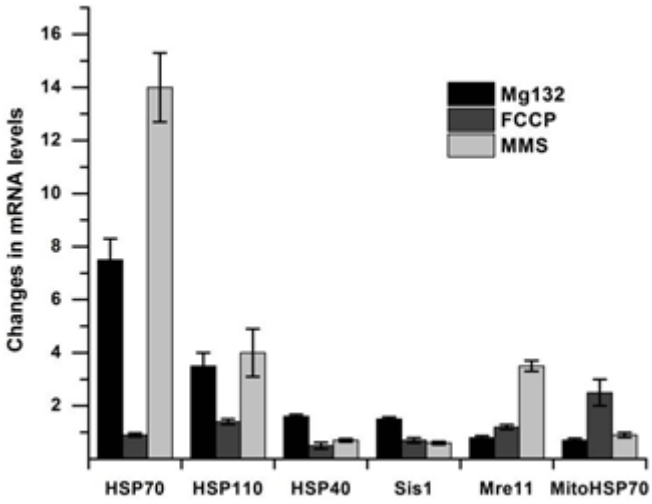


Fig. 3.47: Assessing the changes in the transcript levels upon exposure to proteasomal (2.5 μM Mg132), mitochondrial (20 μM FCCP) and nuclear stress (0.025 % MMS). Parasite was exposed to different stress conditions in early trophozoite stage and harvested after 6h treatment. Mre11 is used as a positive control for DNA damage and mito-HSP70 is used as a control for mitochondrial stress.

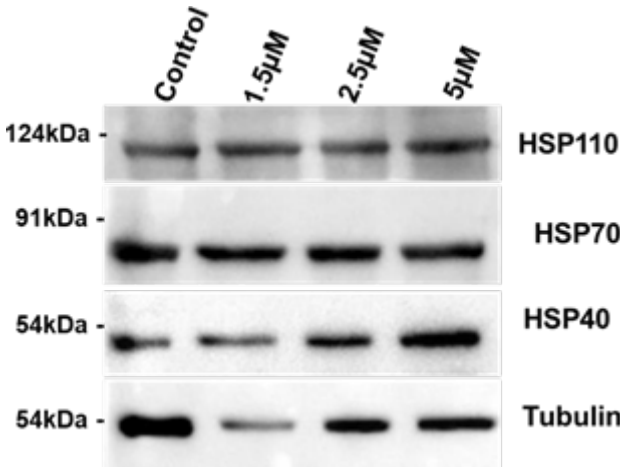


Fig. 3.48: Western blot analysis of protein levels of PfHSP110 and its co-chaperones levels in human malaria parasite upon exposure to proteasomal stress at early trophozoite stage. Detection is done using polyclonal antibody raised in rabbit.

Deciphering the mechanism of bioengineered substrate driven epithelial-to-mesenchymal transition: Implications in breast cancer therapy

Fabrication and characterization of electrospun nanofibers of varying topography: Nanofibers of varying topography i.e. random and aligned, were generated by the process of electrospinning. Process parameters for electrospinning were as follows: voltage: 10kV, flowrate: 1 ml/hr, distance between the tip of the needle and the collector: 18 cm and 21 G needle. For aligned nanofibers, the speed of the rotating mandrel was 5000 rpm while for random nanofibers, the speed of the rotating mandrel was 500 rpm. Figure 3.49 (a) and 3.49 (d)shows the scanning electron micrographs depicting successful fabrication of random and aligned nanofibers. The degree of alignment was further confirmed by Image J software; the results demonstrated that the aligned fibers were oriented in a particular angle confirming their unidirectionality/alignment or anisotropic nature (Figure 3.49 (b) and 3.49 (c)). In case of random nanofibers, the fibers were oriented at multiple angles, confirming their randomness (Figure 3.49 (e) and 3.49 (f)). The fiber diameter for both aligned and random nanofibers were found in the range of 200-300 nm (Figure 3.49 (g)). In summary, nanofibers of varying topography, i.e., random and aligned were successfully generated and characterized. The work was done at All India Institute of Medical Sciences, Bhopal.

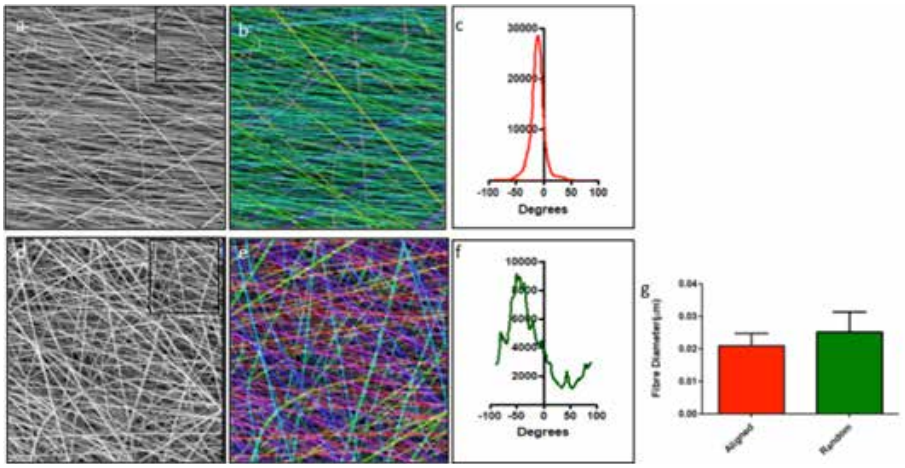


Fig. 3.49: Representative scanning electron micrographs of (a) aligned and (d) random polyhydroxybutyrate/gelatin scaffolds generated by electrospinning. Colored and graphical representation of fiber orientation in (b,c) aligned and random (e,f) nanofibers. (g) Graphical representation of nanofiber diameter of aligned and random nanofibers as calculated by ImageJ software.

Characterization of breast cancer seeded on nanofibrous scaffolds of varying topography

Following the successful synthesis of electrospun nanofibers, breast cancer cells (MDA-MB-231) were seeded on aligned and random nanofibers. In order to promote cell attachment, PHB was mixed with gelatin (since gelatin provides cell attachment sites) prior to electrospinning. The results of the viability study demonstrated that viability of breast cancer cells increased as a function of time (Figure 3.50 (a)). Figure 3.50 (b) demonstrates live/dead staining (FDA/PI) of breast cancer cells on substrates of varying topography. While there was minimal cell death on these substrates corroborating with the MTT data, there were morphological differences in the cells when grown on these substrates. This was well depicted by scanning electron micrographs of breast cancer cells-seeded substrates (Figure 3.51). Elongated morphology of breast cancer cells was observed when seeded on aligned nanofibers as compared to random nanofibers. These results are in line with previously reported studies which demonstrated that spindle shaped cells have been shown to be associated with epithelial-to-mesenchymal (EMT) like phenotype, a critical step in cell invasion and metastasis.

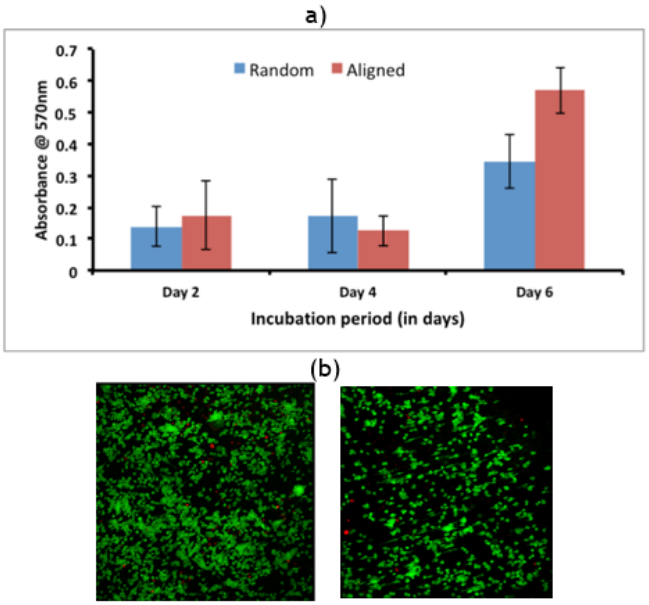


Fig. 3.50: (a) Viability of MDA-MB-231 cells (breast cancer cell lines) as a function of time on substrates of varying topography (random and aligned), as shown by MTT assay (b) Photomicrographs depicting live/dead staining of breast cancer cells seeded on substrates with varying topography (Left: random nanofibers, Right: aligned nanofibers)

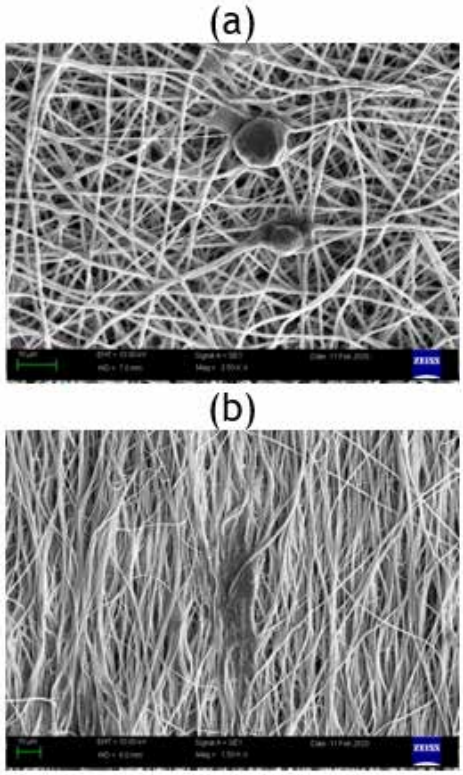


Fig. 3.51: Scanning electron micrographs demonstrating morphological differences of breast cancer cells when seeded on substrates with (a) random and (b) aligned morphology.

Following the proliferation and morphological characterization of breast cancer cells seeded on scaffolds of varying topography, the cells were tested for EMT markers vimentin and MMP1; it was observed that the cells seeded on aligned nanofibers demonstrated upregulation of EMT markers such as vimentin, fibronectin, twist and MMP-1 as compared to cells on random nanofibers (Figure 3.52). Upregulation of these markers in breast cancer cells on substrates with aligned orientation demonstrates that the cells are undergoing EMT-like transition as well as enhanced metastasis on these substrates. Therefore, these substrates can be a useful model to recapitulate the metastatic behaviour of cancer cells. Future studies in this project will use these substrates to elucidate the role of various developmental pathways in modulating breast cancer metastasis. This work was done at All India Institute of Medical Sciences, Bhopal.

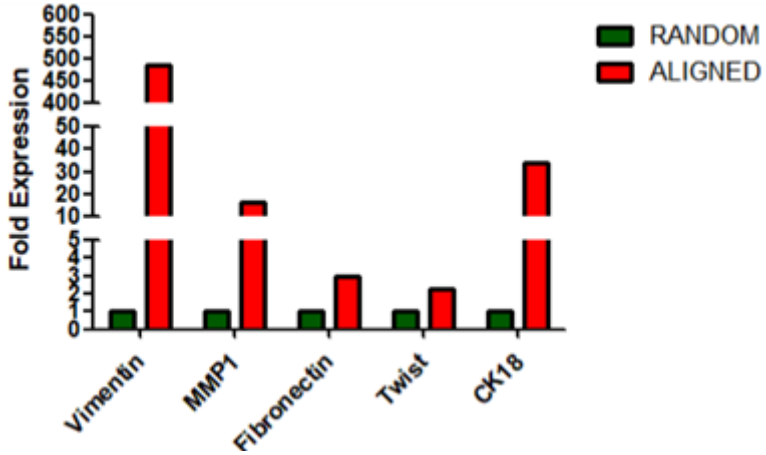
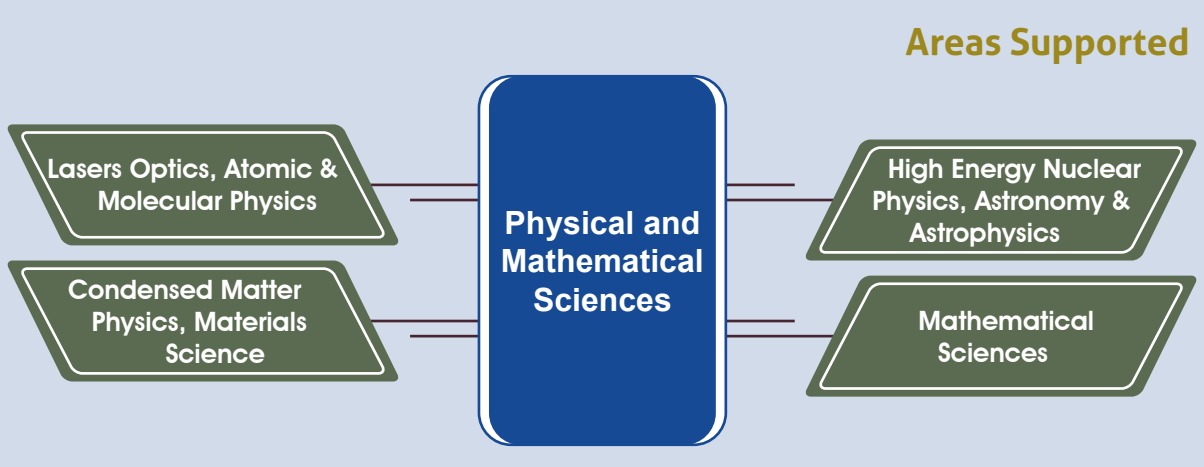


Fig. 3.52: Vimentin, MMP1, fibronectin, twist and cytokeratin 18 (CK18) expression levels in breast cancer cells seeded on random and aligned nanofibrous substrates as assessed by real-time PCR. Expression levels are normalized to 18s rRNA as well as to the expression of various markers in breast cancer cells when seeded on random nanofibers.

3.1.2.5 Physical and Mathematical Sciences

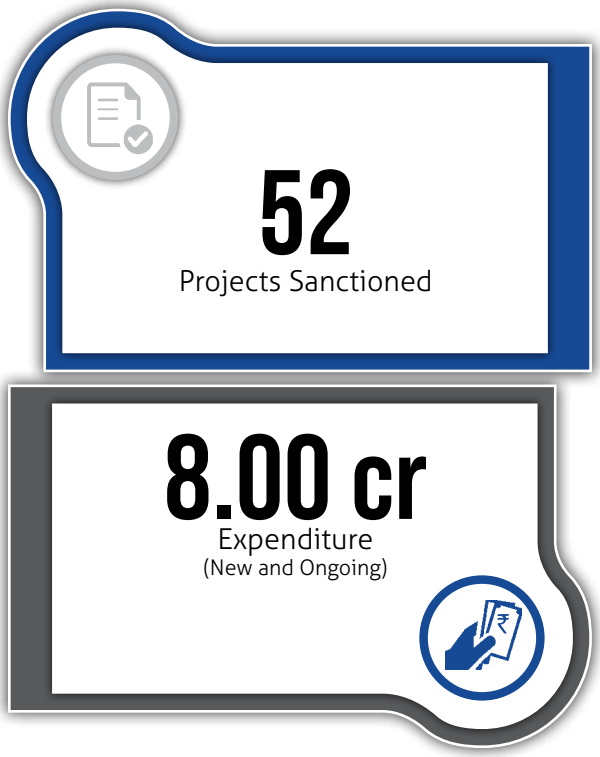
In the reporting period, 52 new projects were sanctioned. The areas supported under SRG – Physical and Mathematical Sciences are shown in the following figure.



Research Highlights

Low mass star formation in diverse environmental conditions

Star formation confines the origin of stars and planetary systems, and acts as a principal-agent in galaxy formation and cosmic evolution. Although several studies suggest uniformity in the solar neighborhood, observational evidence for its non-universality in extreme environments in the Milky Way as well as in external galaxies has been claimed.



A systematic, high sensitive observational analysis of a sample of 9 young clusters under diverse environmental conditions in the outer Galaxy has been performed using the deepest near-IR photometry available (Figure 3.53). The sample clusters selected are diverse in terms of their stellar density, UV radiation strength from the massive stars and Galactocentric distance. After structural analysis and field decontamination, an unbiased, uniformly sensitive sample of pre-main-sequence members of the clusters down to brown-dwarf regime are obtained. The lognormal fit to the IMF of nine clusters gives the mean characteristic mass of 0.32±0.02 solar mass and sigma of 0.47±0.02 (Figure 3.54). IMF obtained has been compared with that of low- and high-mass clusters across the Milky Way. Any systematic variation in IMF with respect to the radiation field strength, stellar density as well with Rg are verified and the analysis conclude that there is no strong evidence for environmental effect in the underlying form of IMF of these clusters. This work was done at Indian Institute of Science Education And Research, Tirupati.

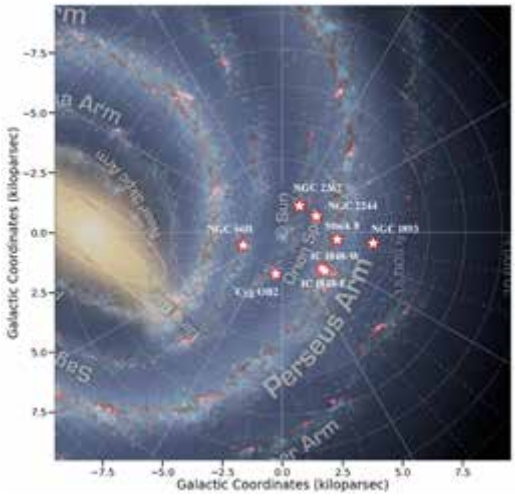


Fig. 3.53: Spatial distribution of the clusters in the study with respect to the Sun and the Galactic centre. Ro (distance of the Sun from the Galactic centre) is taken to be 8.34 kpc (See Damian B., MNRAS, 2021, 505, 2557 for details).

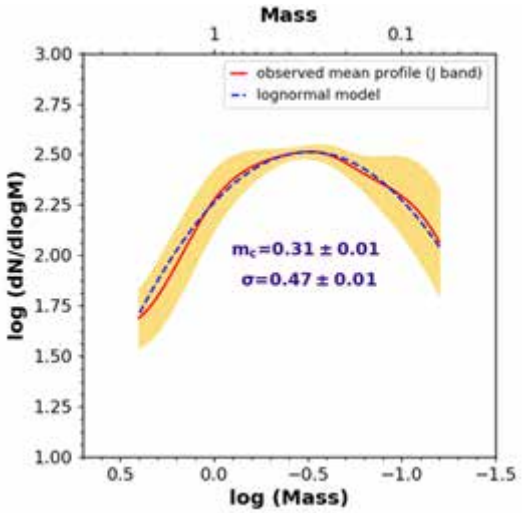


Fig. 3.54: Mean IMF of all the clusters in the study including the nearby young cluster IC348 (red curve) derived using J-band magnitude. Blue dotted curve is the log-normal fit to the distribution and the fitting parameters are mentioned in the figure, which agrees for a universal IMF. The shaded region marks the 1 sigma deviation from the mean (See Damian B., MNRAS, 2021, 505, 2557 for details).

Theoretical studies of quantum phase transitions of dipolar bosons in frustrated and flatband lattices

In this study, the signatures of repulsively bound bosonic pairs in a multi-body interacting Bose-Hubbard model have been obtained in both one- and two-dimensional lattices using the DMRG and CMFT approaches. The Bose-Hubbard model studied in the presence of a staggered magnetic flux on a two-leg ladder lattice and have shown that the presence of alternating flux in the system leads to the appearance of a staggered current superfluid phase. Topological phase transition of bound bosonic pairs has been investigated in the context of interacting Su-Schrieffer-Heeger (SSH).

The ground state phase diagram of a non-locally coupled dipolar bosonic system have been obtained in a bilayer optical superlattice by considering bosons in one layer to be of softcore in nature and separately allowing two and three body hardcore constraints on the other layer. Further quantum walk of interacting defects were studied on top of an uniform bosonic Mott insulator at unit filling in an one dimensional graph to predict the phenomenon of quantum walk reversal (Figure 3.55). The investigation has

been further extended to study the re-entrant localization transition in a quasi-periodic double-well lattice which arise from the competition between lattice topology and quasi-periodic disorder in the system (see, Figs. 3.56-3.58). This work was done at Indian Institute Of Technology, Guwahati.

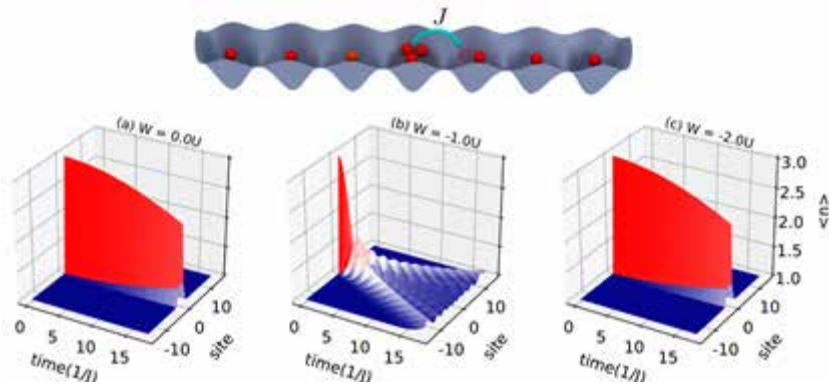


Fig. 3.55: Quantum walk reversal of Mott-Insulator defects in one dimension with multi-body interactions

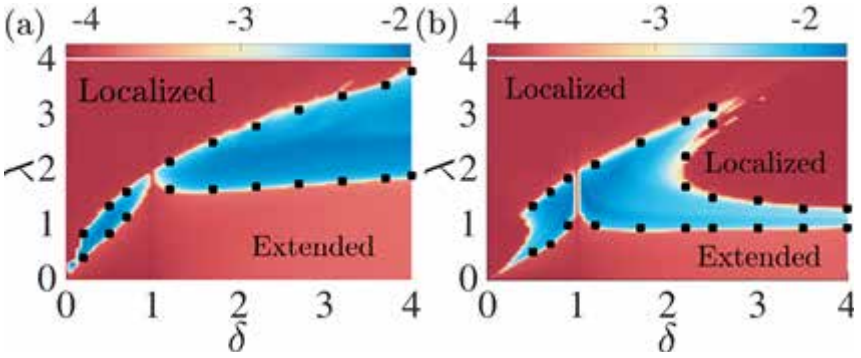


Fig. 3.56: (a) Phase diagram of disordered Su-Schrieffer-Heeger (SSH) model with uniform disorder. (b) Re-entrant localization transition in the Su-Schrieffer-Heeger (SSH) model with staggered disorder.

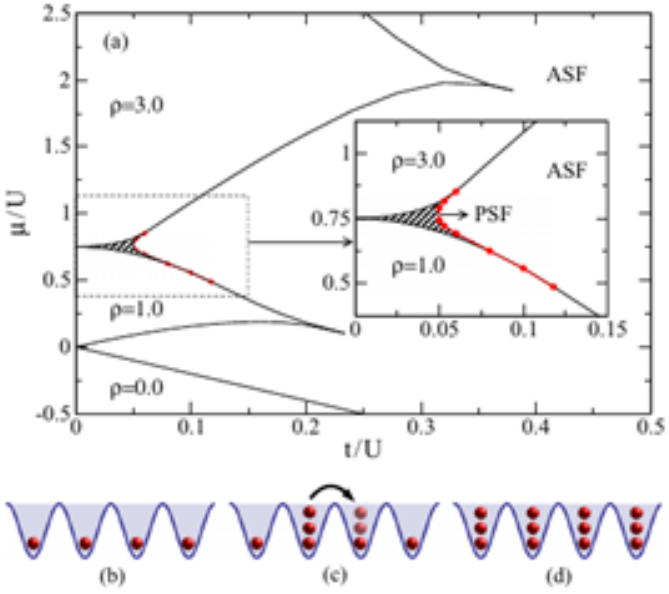


Fig. 3.57: Signatures of repulsively bound pairs in optical lattices

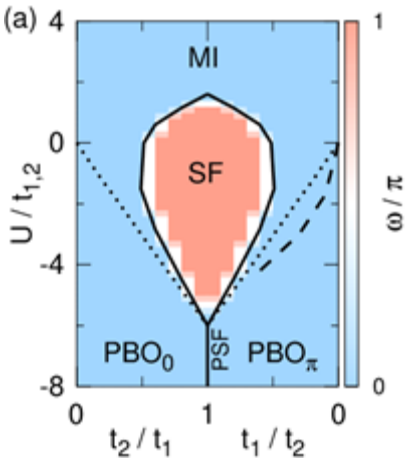
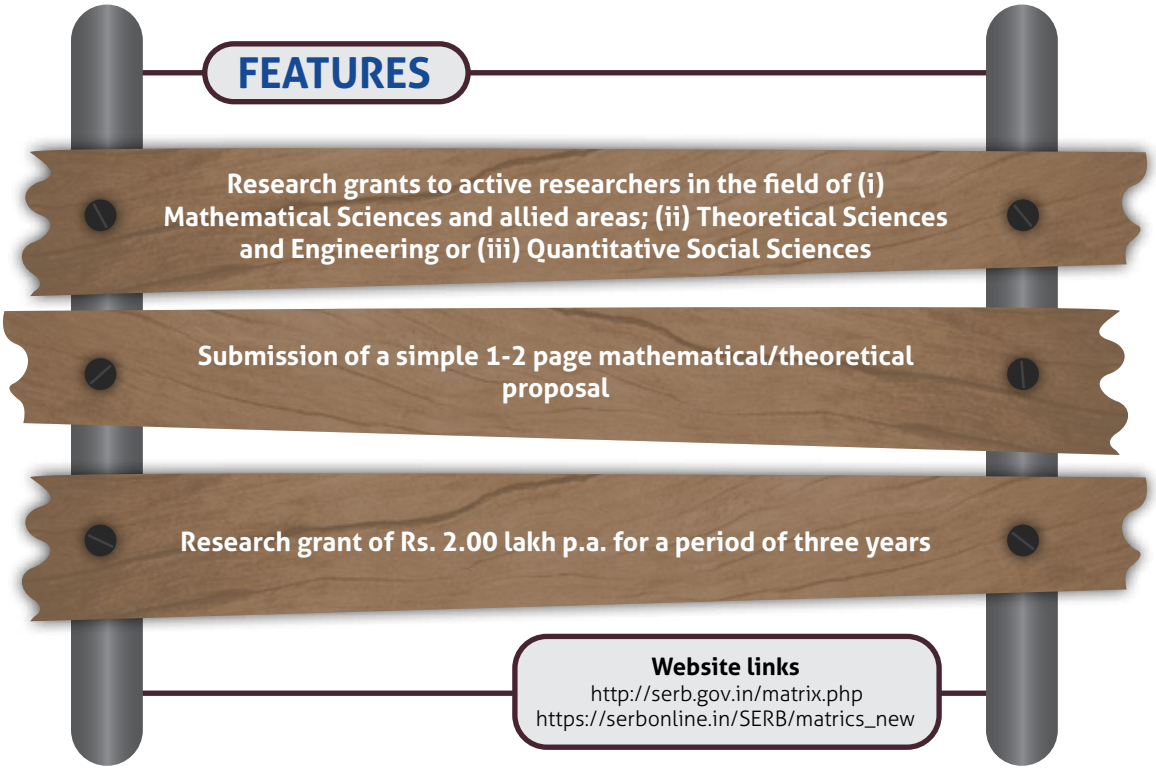


Fig. 3.58: Topological properties of bound bosonic pairs in one dimension.

3.1.3 MATRICS

MATRICS Scheme is aimed to provide fixed grant support to active researchers with good credentials in Mathematical Sciences, Theoretical Sciences and Quantitative Social Sciences. The main attribute of this scheme would be a simple submission of a concept note. The funding provided would cater to the specific needs of Mathematical/Theoretical Sciences research. During the reporting year, a total of 955 proposals had been received and 186 proposals were sanctioned.



Research Highlights

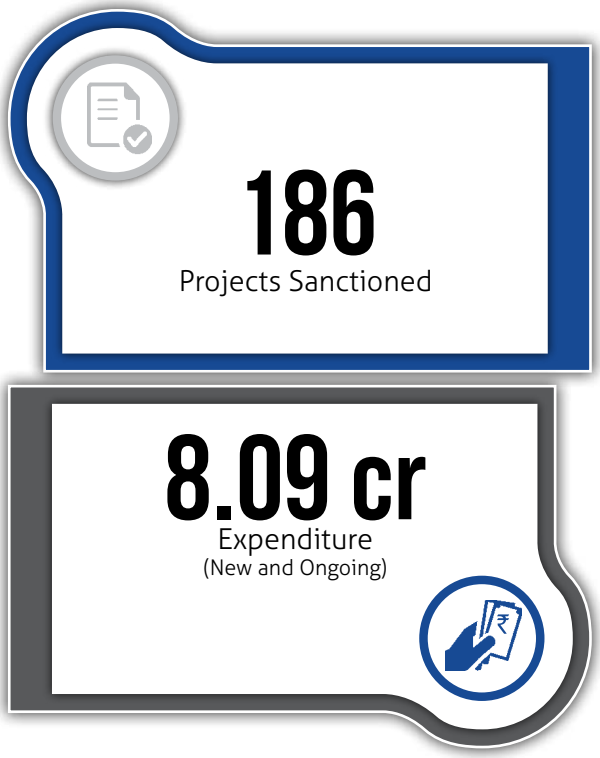
Understanding Error Surfaces of Deep Neural Networks

Understanding the success of deep neural networks (DNNs) still remains a mystery despite its vast success across applications ranging from aerospace to agriculture to healthcare. The study here has shown that the deeper understanding of error surfaces of deep neural network (DNN) models and their trajectory over the training process provides opportunities to develop more generalizable models in future. Choosing mini-batches wisely while training DNN models found to be a very effective strategy to train these models to be more generalizable.

A novel method (DANTE) for training neural networks using the alternating minimization principle has been introduced. DANTE provides an alternate perspective to traditional gradient-based back propagation techniques commonly used to train deep networks. It utilizes an adaptation of quasi-convexity to cast training a neural network as a bi-quasi-convex optimization problem. It has been shown that for neural network configurations with both differentiable (e.g. sigmoid) and non-differentiable (e.g. ReLU) activation functions, alternations can be performed effectively. DANTE can also be extended to networks with multiple hidden layers. In experiments on standard datasets, neural networks trained using the proposed method were found to be promising and competitive to traditional backpropagation techniques, both in terms of quality of the solution, as well as training speed. This work was done at Indian Institute of Technology, Hyderabad.

A class of multi scale problems from random dynamical systems

Small noise limit analysis has the potential to unravel many interesting phenomenon associated with random dynamical systems. In this study simultaneous small noise limit of a slow fast diffusion given by the solutions of a certain stochastic differential equation has been investigated. The small noise limit of the slow diffusion process has been characterized as a solution of an ill posed ordinary differential equation in the sense of Fillipov.



The study has been further extended to examine optimal controls for both finite horizon and ergodic control problems by considering their small noise perturbations that render them non-degenerate diffusions and hence the corresponding HJB equation is well-posed in the classical sense, with an associated verification theorem. The main contribution is the ergodic control of degenerate diffusions where no satisfactory results are available even regarding the existence of optimal controls. Hence one can prove the existence of optimal control beyond the asymptotically flat controlled diffusions.

Mean field stochastic differential games has been studied with ergodic cost and dynamics given by controlled possibly degenerate or asymptotically flat diffusions. Study of mean field games with degenerate state dynamics is first of its kind and small noise perturbation analysis has been used to investigate the problem. This work was done at Indian Institute of Technology, Bombay.

3.1.4. Industry Relevant R&D (IRRD)

Industry Relevant R&D (IRRD) scheme aims to utilize the expertise available in the academic institutions and national laboratories to solve industry specific problems for larger benefit of the society. It was launched in 2015-2016. The joint proposals by academic and industry partner are supported in this scheme. The scheme is set to be revamped.

Website links
http://www.serb.gov.in/irrd.php
http://serbonline.in/SERB/IRR

0.35 cr
Expenditure
(Ongoing)

Research highlights of project supported under the older version of IRRD scheme is provided here.

Design and Development of Embedded Vision based System for Yoga Therapy

The study attempted to extract every respiration cycle of a person along with the duration of inhalation and exhalation using RGB-D videos under minimal movement. Individuals can consciously control their breathing rate by monitoring the bio-signals and their performance indicators. The data is acquired in an indoor environment with nominal lighting conditions with the user seated at a distance of 2-6 feet from the depth camera (Figure 3.59). Studies have shown that the chest and abdominal wall movement corresponds with the inhalation and exhalation of the human respiratory system. This fact is exploited in selecting a region of interest for depth-based respiration measurement. CUBEMOS Skeleton tracking SDK is used for tracking the joints of the user from the required region of interest (ROI) in every frame. The technique that helps to extract breathe signal from ROI and the algorithms that provide insight into every breath cycle are presented. Real-time visualization of each breath cycle data of the user results in generating insights for an effective breath session. Hence, a biofeedback game was developed based on the 4-2-4 breathing cycle to guide users regulate their breath in every cycle. The gamified setup was tested for a 4-2-4 guided breathing and the extracted signal (Figure 3.60) indicates the durations of respiration and breath retention for the 4-2-4 breathing exercise captured by the proposed method. The highlighted regions in red represent the time duration in which inhalation and exhalation were detected and the time duration in which breath is retained is depicted between the highlighted regions. This work was done at Vellore Institute of Technology, Vellore.

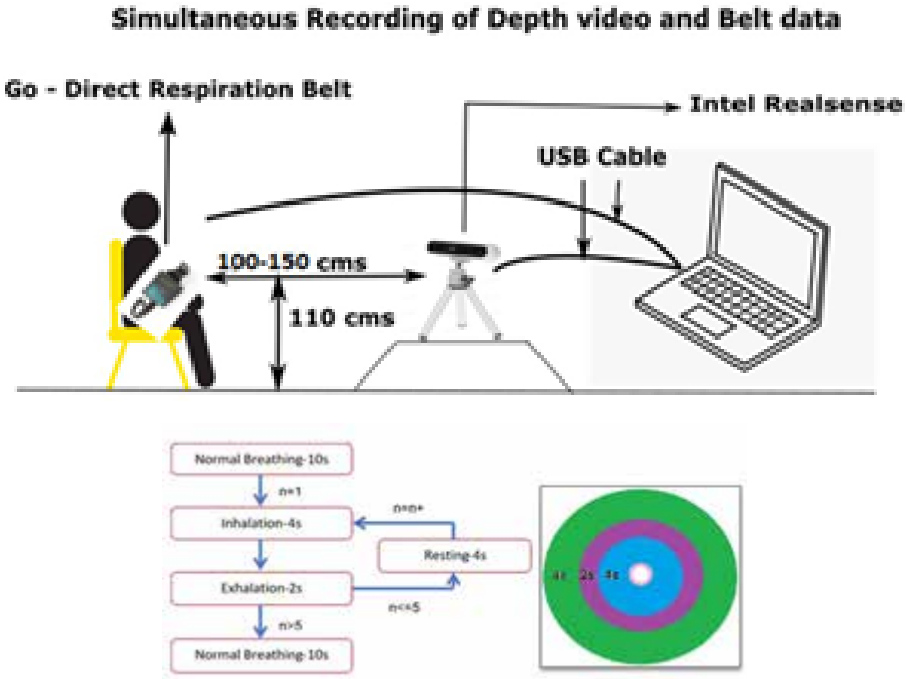


Fig. 3.59: Data acquisition setup for RBG-D video and respiration belt and Flow Diagram for guided 4-2-4 breathing and Gamified Visual feedback where each circle grows outwards based on the users' breathing pattern

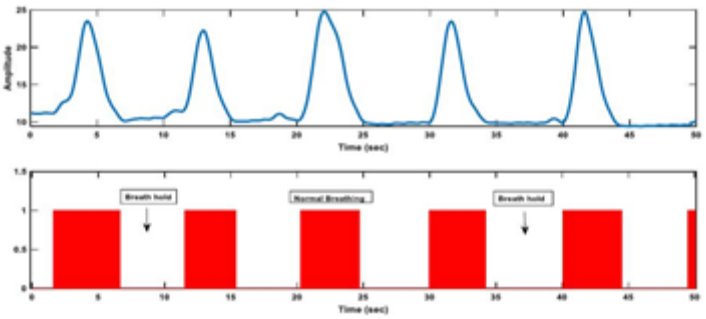


Fig. 3.60: Respiration signal from Guided Breathing exercise and estimated breath cycle time duration and breath retention time duration

3.1.4.1 Fund for Industrial Research Engagement (FIRE)

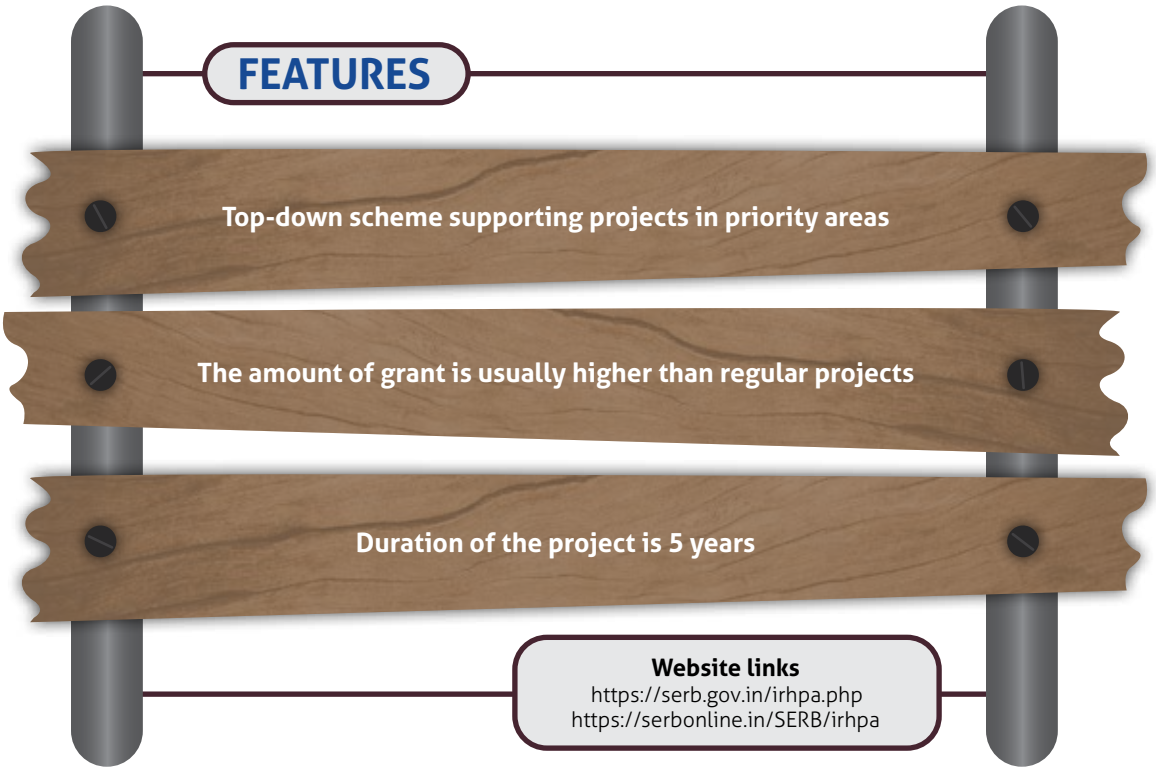
SERB intensely pursues different means to engage with industry to address the gap between knowledge economy that is driven by fundamental research and commercial economy driven by the market. This led to initiation of a programme called FIRE under IRRD. The program, Fund for Industrial Research Engagement (FIRE), intends to address the challenges in the research and innovation space in India, by creating an ecosystem that would accelerate the growth in the research work with national impact and drive the R&D landscape efficiently and effectively.

SERB signed a Letter of Intent (LoI) with a group of semiconductor industries, namely, Applied Materials India Private Limited, Intel Technology India Private Limited, Mentor Graphics (Sales & Services) Private Limited, NXP India Private Limited, Texas Instruments (India) Private Limited to create a research fund with the objective to collaborate on research problems that can have a ground-breaking impact on a large scale over the next five years. The partnership focuses on national and global problems and will fund high quality research with maximum industry impact potential, at a national scale with 50:50 monetary fund sharing.

3.2 PROMOTING INNOVATION

3.2.1 Intensification of Research in High Priority Areas (IRHPA)

The scheme Intensification of Research in High Priority Areas (IRHPA) was launched to provide major funding support in high priority areas where multidisciplinary, multi institutional expertise may be required. The goal of the scheme is to strengthen scientific footprints of our nation in international scenario. For this purpose, SERB makes a national call for seeking proposals after identifying the priority areas. Various Core Groups, Centers of Excellence and National Facilities in frontline and emerging fields of Science and Engineering have been set up in academic institutions and national laboratories by significant contributions from this scheme. This scheme has thus helped in augmenting the R&D capabilities of the country in priority areas and several projects have been sanctioned under this scheme.

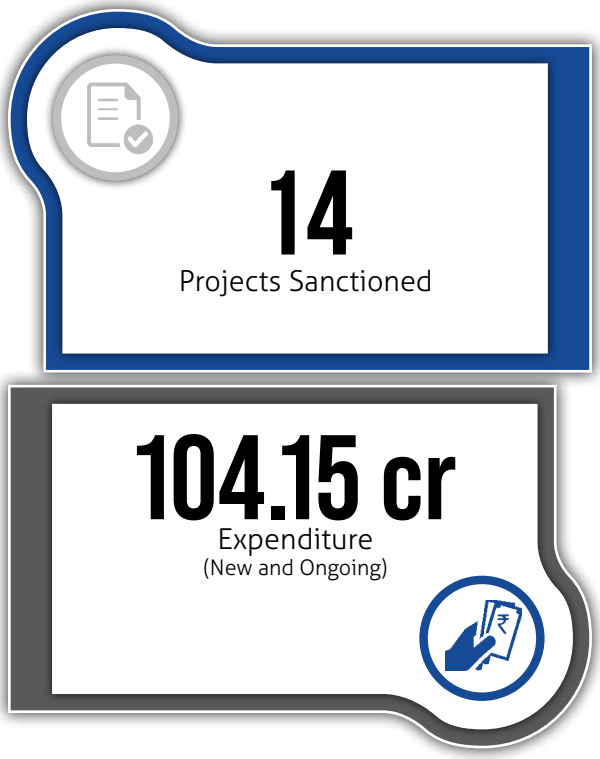


SERB Centre for Energy Transformation and Storage

A healthier, resilient and sustainable environment can be offered to the citizens of any society only when the Clean Energy is abundantly available. For this purpose, it is essential that the use of fossil fuels and emissions be reduced judiciously. It is therefore required to enhance the research and innovation in various segments of energy transformation so as to upscale the economic transitions and propel national growth. Therefore, it is must that the long-term solutions for sourcing sustainable energy by developing indigenous technologies in this area be taken up actively. It has been felt that there is an urgent need to explore opportunities for smart energy transformation, storage and management to offset our dependence on conventional energy, provide stable power to off-grid areas, and support the EV revolution.

With this mission, SERB has invited proposals with three specific areas of interest for the upcoming Centres for Energy Transformation and Storage namely, Electrochemical energy storage systems for micro-grid installations, Technologies for utility-scale high-capacity batteries, and Transparent photovoltaics for devices and surface integration.

A call was made in this respect and a total of 64 proposals were received. After due consideration,



stringent review and selection process by the expert committee and the empowered committee, board has sanctioned to setup five IRHPA Centres for Energy Transformation and Storage facilities at IIT Kharagpur, IIT Mumbai, IIT Kanpur, IISc Bengaluru and IIT Roorkee with a total outlay of 45.94 crores as below:

Title	Centre of Excellence on Energy Aware Urban Infrastructure
Institution	Indian Institute of Technology, Kharagpur

Title	Sustainable Technology for Smart Off-Grid Renewable Energy Transformation and Electrochemical Storage Management
Institution	Indian Institute of Technology Bombay, Mumbai

Title	Centre for Rechargeable Energy Storage Systems for Augmenting Transportation and Electrification (CREATE)
Institution	Institute of Technology, Kanpur

Title	Centre for Electrochemical Energy Storage: Design, Development, Fabrication and Evaluation of Utility-Scale High-Performance Batteries
Institution	Indian Institute of Science, Bengaluru

Title	Development of Transparent Perovskite Devices for Building Integrated Photovoltaics (TRADE)
Institution	Indian Institute of Technology, Roorkee

SERB National Biosafety Level-3 facilities

SERB felt an urgent and timely need to create state of the art BSL 3/ABSL 3 facilities to promote R&D activities in the frontiers of drug discovery, diagnosis, novel vaccine investigation, and to investigate and handle the new, emerging, infectious and opportunistic pathogens that cause contagious diseases to human, plants, livestock, wildlife etc. Therefore, SERB has speeded up to establish National Biosafety Level (BSL 3/ABSL 3) infrastructure facilities for handling infectious pathogens, build capacity to provide support for programmes of national priority and provide surge capacity to respond expeditiously to epidemics / pandemics. An important point is that these facilities will be made available to start-ups and MSMEs to contribute to the development and validation of their efforts in antimicrobial drugs, vaccines, and diagnostics product pipeline. There will be no overlap with the already existing facilities created through other programs while developing these standalone national facilities.

A call was made to establish such National Biosafety Level-3 facilities and a total of 34 proposals were received. After due consideration, stringent review and selection process by the expert committee and the empowered committee, board has sanctioned to setup four IRHPA Biosafety Level-3 facilities at IISc Bengaluru, IIT Kharagpur, Central University of Rajasthan Ajmer and IISER Tirupati with a total outlay of 38.44 crores as below:

Title	Biosafety-level 3 facility to enhance infrastructure for Viral/Fungi- TB coinfection research and zoonotic diseases/pandemic preparedness
Institution	Indian Institute of Science, Bengaluru

Title	Establishing a State-of-the-Art Hybrid BSLIII Facility at IIT Kharagpur to facilitate Fundamental Research and Development of Diagnostics and Therapeutics against Class III pathogen caused viral and bacterial diseases
Institution	Indian Institute of Technology, Kharagpur

Title	Creation of ABSL-3 facility at CURAJ under Rajasthan bio-cluster for infectious diseases, therapeutics and diagnostics
Institution	Central University of Rajasthan, Ajmer

Title	Establishing a Regional Biosafety laboratory (BSL -3) at Tirupati for research and diagnostics in infectious diseases: tuberculosis and virology
Institution	Indian Institute of Science Education and Research, Tirupati

SERB - Centre(s) for Antibody Engineering

Creation of state-of the art research infrastructure is critical to SERB's efforts in supporting fundamental research, through its high priority programs. SERB has responded to the urgent need to ramp up national R&D efforts by bringing technical partnerships and collaborative know-how from researchers across academic and research institutions, biotech, and pharmaceutical companies.

Antibodies have emerged as a major alternative to conventional therapeutics agents and antibody- based products account for majority of the FDA approved drugs and therapeutic molecules. Considering the limitations associated with conventional translation methods, synthetic antibody generation utilizing phage display-based approaches have assumed more significance in meeting the current challenges in discovery, diagnostics, and therapeutics. Considering this scenario, SERB has initiated efforts to advance research in antibody technology by establishing integrated antibody engineering platform(s) in India through R&D centres. The vision of these centres is to drive innovative and interdisciplinary collaborative research in recombinant antibody engineering and build critical infrastructures for technology driven solutions.

A call was made to establish such Centre(s) for Antibody Engineering and a total of 35 proposals were received. After due consideration, stringent review and selection process by the expert committee and the empowered committee, board has sanctioned to setup three IRHPA Centres for Antibody Engineering facilities at IIT Chennai, IISER Mohali and IISER Bhopal with a total outlay of 21.62 crores as below

Title	Centre for Antibody Engineering: Infrastructure and Development of Technologies for Pre-clinical evaluation, Product establishment and Platform integration for Onco-theranostic applications
Institution	Indian Institute Of Technology, Madras Cancer Institute Chennai

Title	Centre for Antibody Engineering: Centre for Immuno-Diagnostics/ Therapeutics Veneering technologies (CIVET)
Institution	University Of Delhi, South Campus, New Delhi Indian Institute Of Science Education And Research, Mohali

Title	Precision Antibodies Engineering Centre (PACE)
Institution	Indian Institute Of Science Education And Research Bhopal National Centre For Cell Science, NCCS, Pune King George Medical University, Lucknow

Out of these three centres, Precision Antibody Engineering Centre (SERB – PACE) is one such project supported under the SERB – Centre for Antibody Engineering, under the IRHPA program. The antibody conjugates offer one of the most promising and rapidly growing segments for directed therapeutics. The global supply chain of key components of antibody-drug conjugates (ADCs) is gaining momentum. However, the structural complexity of these molecules presents the most significant roadblock, both in their synthesis and analysis. This factor alone accounts for most of the translational failures. The key targets of this project is the development of antibody conjugates for targeted imaging-guided surgery and directed cancer chemotherapeutics (Figure 3.61). The project involves researchers from three institutions – Indian Institute of Science Education and Research (IISER) Bhopal, National Centre for Cell Science, Pune and King George Medical University, Lucknow, and aims to explore solutions for modular and selective antibody engineering. The project aims to develop a technological platform for synthesis of

homogeneous antibody-conjugates, and explores capacity-building for the multi-milligram scale synthesis of such libraries. Analytical capabilities to generate pre-clinical data will be strengthened to support the national needs in the field. The project also aims to develop antibody-based biologics by meeting the demands of their property regulation through bioconjugation. For example, homogeneous and precise PEGylation could regulate circulation half-life without impacting the antigen-binding specificity or antibody-dependent cellular cytotoxicity pathway.

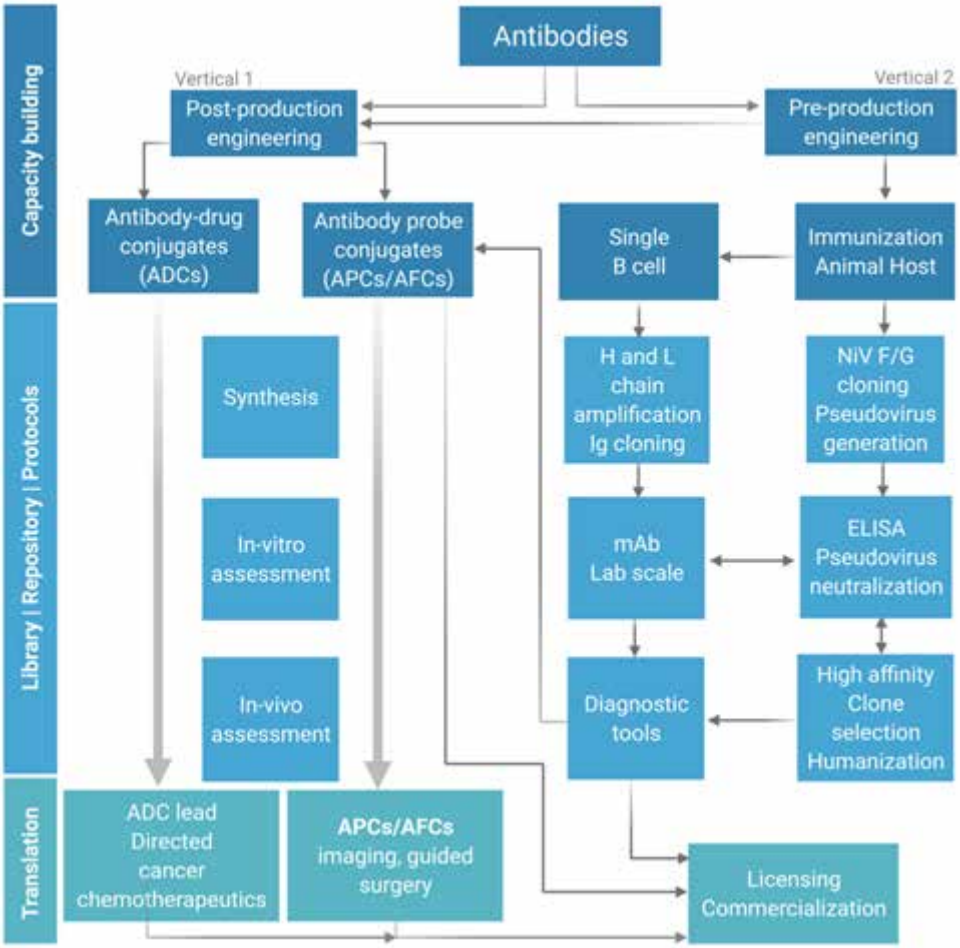


Fig. 3.61: Proposed Work Flow for SERB – Precision Antibody Engineering Centre

IRHPA- 3D-Bioprinting

3D bioprinting for ENGineering Biomimetic Tissues and Organoids for personalized MEDicine (ENGinMED)

Human studies, critical for developing new diagnostics and therapeutics which are limited by ethical and logistical issues and hampered due to intrinsic differences between rodent models and human biology. Advent of three-dimensional culture techniques facilitated to grow the human liver in laboratory condition and to study the various biochemical process at the physiological and pathological condition and also opens the avenues for exploring the plausible therapeutic applications for various liver disease.

In the current project one of the aims is to characterize the Decellularized Extra Cellular Matrix (D-ECM) based bioink for fabricating the mini liver organoids. Investigators used caprine D-ECM as an active component in the bioink that could mimic the niche characteristics of the native liver tissue as well as to support the growth of liver cells. The obtained decellularized liver tissue (as stated in the methodology section; Figure 3.62 (B) was characterized for the removal of cellular and DNA content. SEM imaging of the

native and decellularized tissue demonstrated complete removal of cells as compared to the native liver as shown in Figure 3.62(C). The samples were also histologically analyzed via hematoxylin and eosin (H&E) staining and DAPI staining (Figure 3.62(C)). Further, biochemical quantification of glycosaminoglycans (GAGs) content in the decellularized tissue as performed in comparison to the native tissue. GAG estimation demonstrated retention of matrix components compared to the native liver. Native liver demonstrated higher absorbance to that of native liver as on decellularization matrix components become more exposed to enzymatic digestion yielding into better absorbance values as shown in Figure 3.62(D).

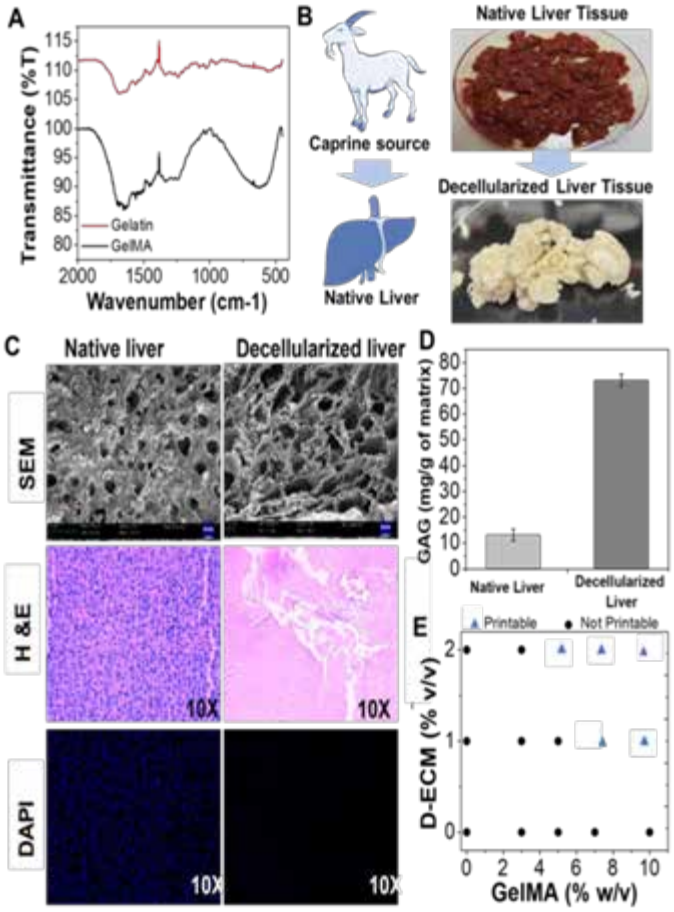


Fig. 3.62: Characterization of liver specific bioink materials.

Design and characterization of bioactive 3D bioprinted mini-liver lobules: To mimic the native lobule architecture, investigator used AutoCAD software and designed the hexagon lobule. As shown in the Figure 3.63 the final printed construct will utilize dual extruder bioprinting technique where extruder 1 will be used to print the hepatocyte laden part and extruder 2 will print the endothelial cell laden part.

Using GelMA/PEDGA as base material with/ without decellularized matrix solution fabricated the constructs using HepG2 cells. Analyzed the pore structure of 3D printed constructs by SEM as shown in Figure 3.64 (A) and the pore size was in range of 700µm. Using bright field microscopy investigator clearly showed 3D printed acellular and cell laden constructs (after fixation in 4% PFA) in Figure 3.64 (B). Further Investigators assessed the biocompatibility and evaluation of the 3D bioprinted constructs for proliferation and differentiation ability at various time points. These findings laid a base for translation of the fabricated 3D bioprinted constructs and biomaterial links towards animal studies and pre-clinical trials. This work was done at Indian Institute of Technology, Kanpur.

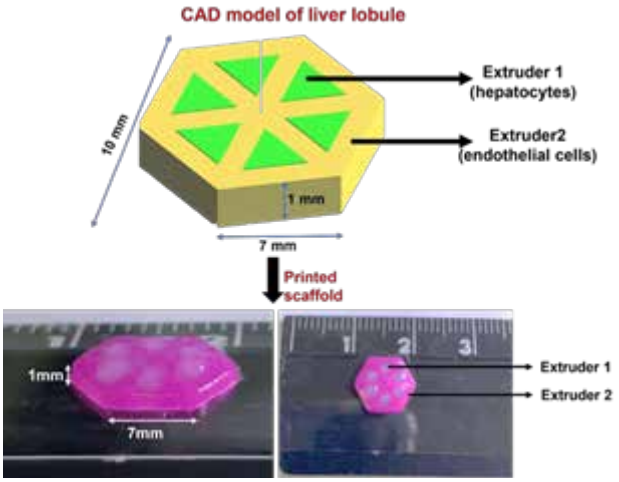


Fig. 3.63: CAD model design to mimic the native liver lobule architecture.

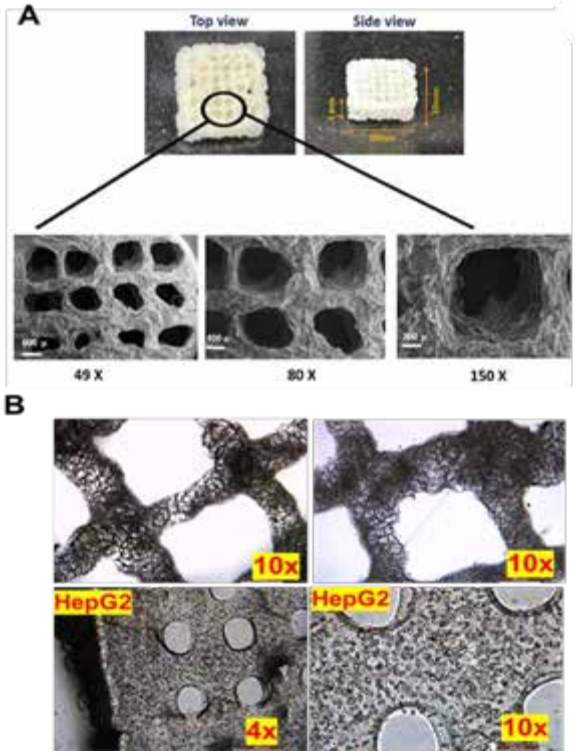


Fig. 3.64: Characterization of 3D bioprinted liver constructs.

IRHPA Drug Discovery for neglected Diseases

Multimodal Approaches to Develop Potential Therapeutic Leads Targeting Molecular Hot Spots of Duchenne Muscular Dystrophy for Clinical Trial

The objective of the project is to develop Potential Therapeutic Leads of Duchenne Muscular Dystrophy Disease. The research team of three institutions such as IIT Jodhpur, DART Bengaluru and AIIMS Jodhpur are involved. The research team has made significant progress, such as (i) design of library of effective agonist molecules (Figure 3.65), (ii) synthesis, purification and characterization of more than 50 agonist molecules using NMR and HPLC (Figure 3.65) and synthesis of bulk quantity (5 Kg) of generic version of a utrophin agonist molecules followed by its characterization by NMR and purity by HPLC (Figure 3.66), (iii) tablet formulation of generic version of utrophin agonist molecule completed, for the development of affordable therapeutics

(Figure 3.67), (iv) necessary requirements for seeking clinical approval from DCGI are in progress, (v) received approval from DCGI to DART Bengaluru for conducting a multi-centric clinical trial on Antisense oligonucleotide (AON) based exon skipping in DMD patients, (iv) AON targeting exon 51 has been successfully synthesized and characterized, and (v) design and synthesis of new molecular tags for improving of bioavailability of AON lead has been initiated (Figure 3.68).

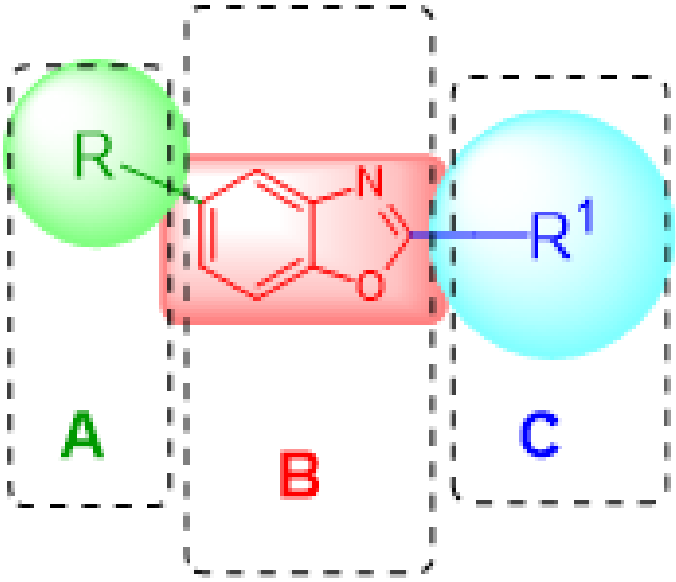


Fig. 3.65: Designed structural scaffold of agonist molecules with variable substitution for different libraries

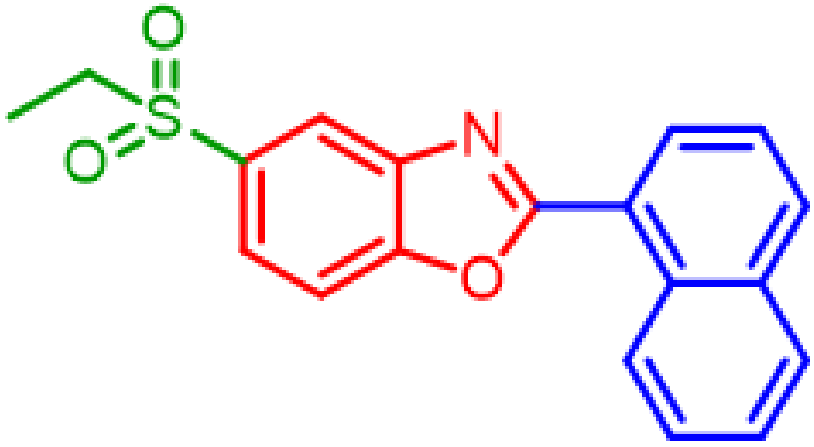


Fig. 3.66: Synthesized, purified and characterized by NMR of generic version of utrophin agonist

Fig. 3.67: Oral dispensable formulation of generic version of utrophin agonist

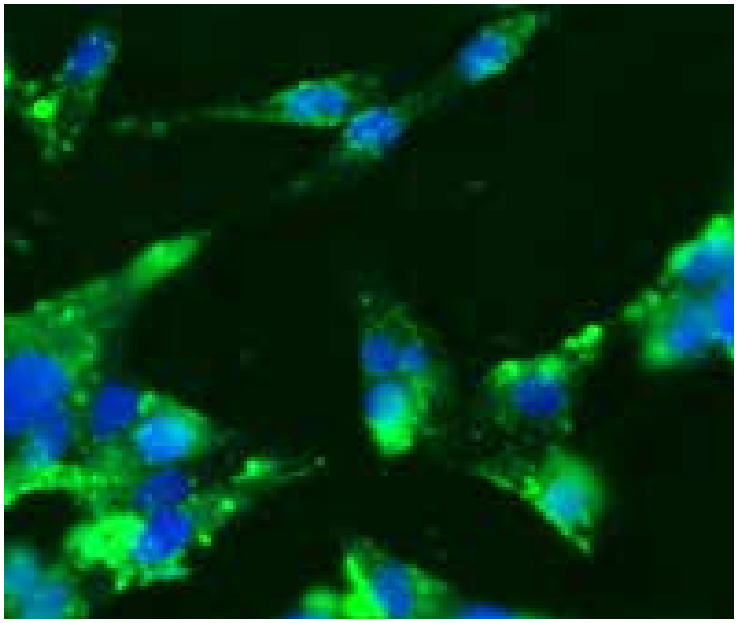


Fig. 3.68: Snapshots of cell penetration of molecular tag designed for improving bioavailability of AON

A multi-targeted approach encompassing fundamental and applied studies towards drug discovery for Leishmaniasis

Kala azar is the second deadliest parasitic disease caused by Leishmania donovani. It is a tropical disease of poor, and hence it is largely ignored by the scientists around the world. There is no vaccine that is available for the prevention of the disease and the available therapeutics revolve around different treatment regimens which have problems relating to efficacy, adverse side effects and exhorting costs. A group of researchers from JNU, New Delhi has developed novel drugs which are highly effective in combating the kala azar disease. These drugs are inspired from the simple sugars and peptides from the biological systems which increase their bioavailability and reduce any side effects. The preclinical data on

animal testing has also demonstrated decreased parasite load in the visceral organs of the mice further establishing the therapeutic potential of these drugs. Moreover, the efforts were also made to enhance the efficacy and reduce the cost of a known drug, Amphotericin B. This drug has also recently been repurposed for black fungus disease post COVID-19. The Amphotericin B is given in liposomal formulation to increase the efficacy and improved treatment outcomes. However, this greatly increases the price of the drug. The group has developed a novel delivery platform using nanoerythrosomes that specifically targets the drug to the visceral organs and provide improved therapeutic efficacy in animal model. Since the nanoerythrosomes were prepared from the expired red blood cells, they demonstrate an effort to reduce the wastage and cost of final delivery vehicle. This work comes under several national initiatives of the Government of India such as Innovate India, Make in India and Swasth Bharat. The anti-leishmanial properties of the identified drugs can be seen in the accompanying (Figure 3.69).

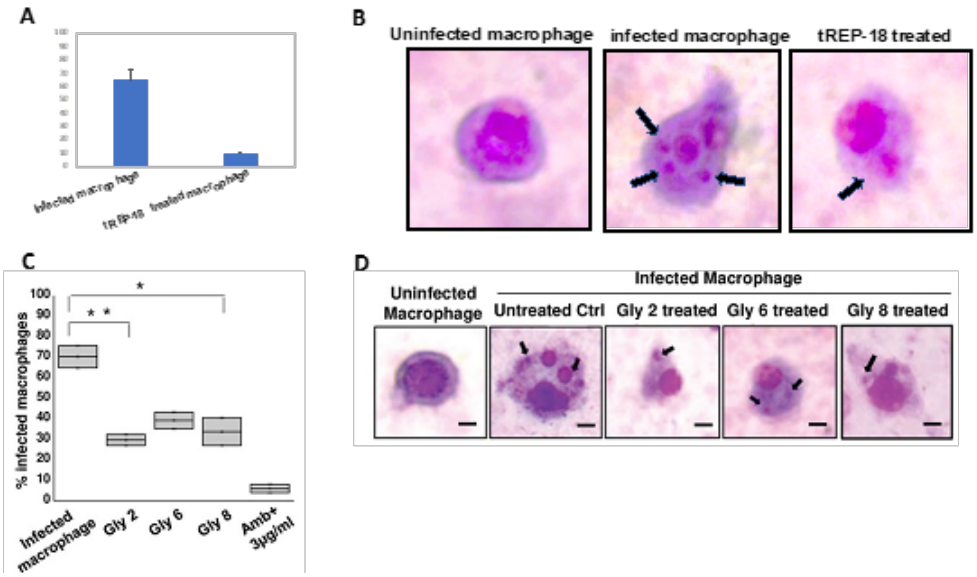


Fig. 3.69: Demonstrates the anti-leishmanial properties of the identified drugs. (A) Geimsa stained images representing impact of peptide drug treatment on *L. donovani* amastigote infection to macrophages; (B) Bar graph illustrates percentage of infected macrophages in the presence and absence of peptide drug. (C) Glycoside-treated and untreated Geimsa-stained macrophages infected with L. donovani amastigotes. (D) Percentage of infected macrophages in the presence and absence of glycoside treatment.

IRHPA Emergent property of Nanoscale matter

Rapid, room-temperature, and solution-based routes are developed for designing and fabricating organic and inorganic material based broadband and infrared photodetectors

Self-Powered Organic Broadband Photodetector: Tuning dark current in donor and small acceptor molecules (PM6:Y6) by controlling the active layer thickness and charge transport layer. The optimized active layer thickness and charge transport layer can reduce leakage current and trap-assisted recombination. The device with optimized parameters can achieve lowest dark current density of (1.70±0.67) $x10^{-10}$ A/cm^2. Temporal photoresponse (rise and fall time) of the optimized PM6:Y6 devices to 10Hz to 100KHz square-wave modulated at 405 nm illumination is ~1.5-2.0 µs is represented in Figure 3.70.

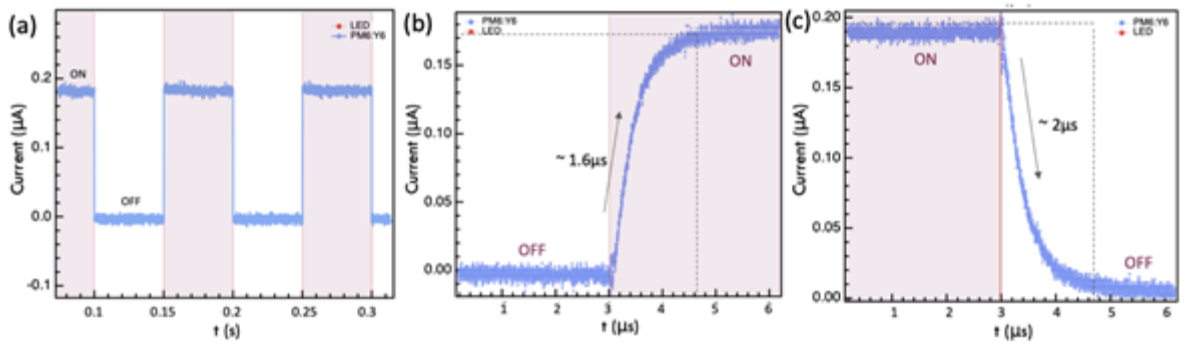


Fig. 3.70: Temporal photoresponse of PM6:Y6 devices (a) at 10Hz (b-c) rise and fall time respectively.

Quantum Dot-Bulk Silicon Heterojunction based Infrared Photodetector: Design and fabricate novel $CuFeSe_2$ and $AgFeS_2$ colloidal Quantum Dot films using colloidal synthesis. Device architecture is created by spin-coating colloidal solution on the substrate. Fourier Transform Infrared Spectroscopy (FTIR) analysis of the films was performed to check the material's characteristic properties. Device response is monitored in response to IR light excitation on the device (Figure 3.71) and device performance is evaluated based on measurement of leakage current and other parameters. The research work was carried out at Indian Institute of Science, Bengaluru.

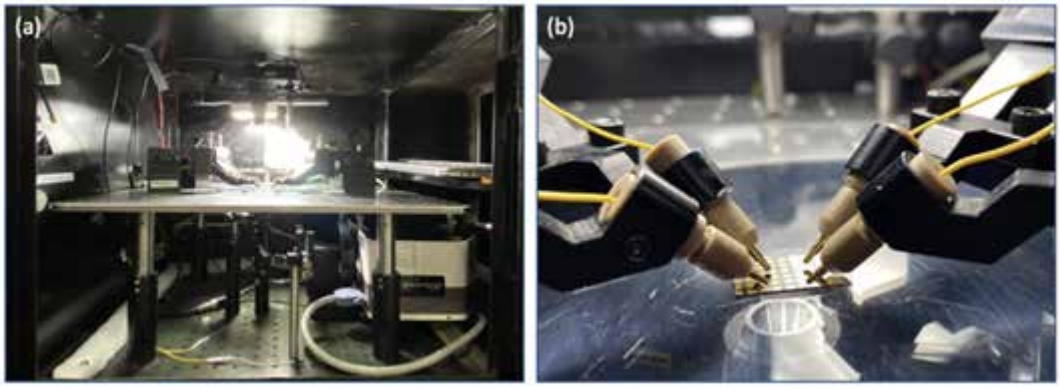


Fig. 3.71: Probe station Measurement Setup with optical source.

IRHPA - Evolution of Indian Sub-continental Lithospheric Mantle: Insights from mineral chemistry of kimberlites, related rocks, and mafic dykes

State-of-the-art EPMA (April, 2016) and SEM (April, 2018) facilities have been established as a part of the project. These facilities have been extensively utilized by researchers from ~100 institutions across the country. More than 120 research papers in SCI journals have been published by the PIs and the other users so far.A number of PhDs were produced and important human resource on the running of these instruments and interpreting their date provided. One of the major outcome of the project is proposal for plate tectonic model for the evolution of the central Indian tectonic zone (Figure 3.72) with implications for north ward subduction of the southern Indian block during the Paleoproterozoic.The role of supercontinent amalgamation and breakup in the generation of Mesoproterozoic diamondiferous kimberlites and lamproites from the Eastern Dharwar craton, is brought out (Figure 3.73). Detailed mineralogical studies backed up by their chemistry, has brought out extensive magmatic plumbing system beneath the alkaline complexes associated with the end-Cretaceous Deccan Traps (Figure 3.74). The findings have important implications for the understanding of the Deccan Traps and the geophysical aspects related to the Indian lithosphere. This work was done at Institute of Science, Banaras Hindu University, Varanasi.

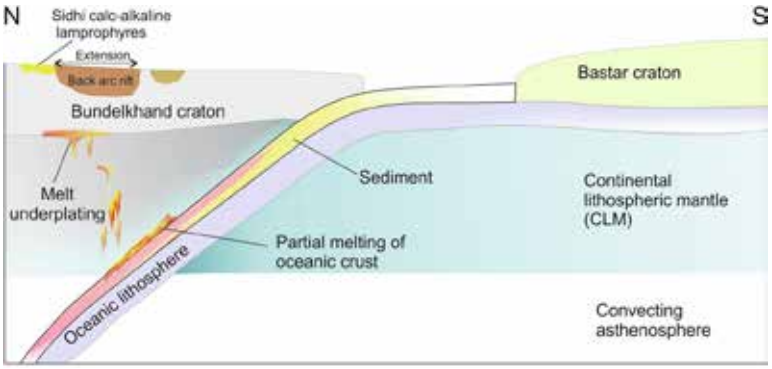


Fig. 3.72: Plate tectonic evolution of the Central Indian tectonic zone

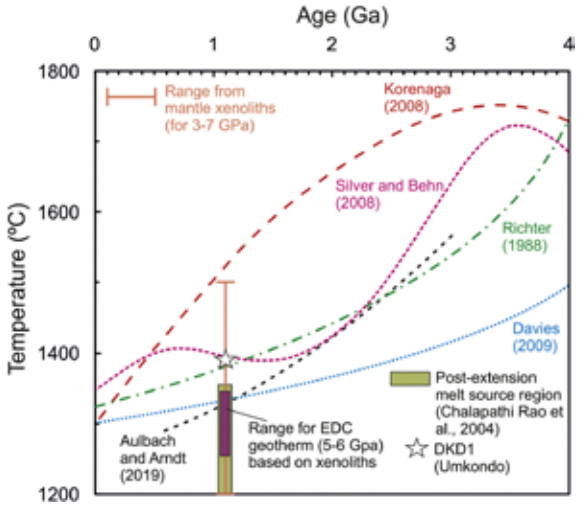


Fig. 3.73: Comparison between temperture range for the mantle xenoliths in kimberlites and genesis of kimberlites from eastern Dharwar craton

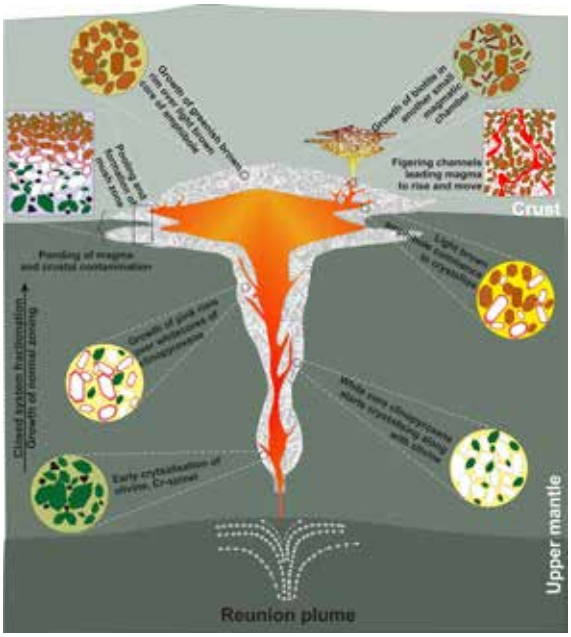


Fig. 3.74: Mineralogical evidence for plumbing system beneath the alkaline complexes of Deccan Traps (Mineralogy & Petrology)

IRHPA - Atmospheric Studies in the Geophysically sensitive Tropical to Sub-tropical transition region with ST Radar Facilities

The ST Radar project at University of Calcutta is at an advanced stage of implementation (Figure 3.75 (a-b)). This indigenously developed state-of-the-art 53 MHz VHF ST Radar is being established at Ionosphere Field Station, Haringhata, University of Calcutta. The ST Radar at Ionosphere Field Station will be the radar at this frequency (53MHz) in the entire Eastern and North-Eastern India as well as South-East Asian longitude sector. This radar is situated at the verge of the transition region between the tropics and subtropics, and near the northern crest of the Equatorial Ionization Anomaly (EIA) in the Indian longitude sector.Once completed, this facility is expected to bridge a vital gap that exists in ground-based monitoring of the atmosphere around the northern Bay of Bengal which is prone to intense thunderstorms, cyclones and lightning that affects a significant section of the society. This work was done at University of Calcutta, Kolkata.

(a)

(b)

Fig. 3.75: (a-b) establishment of ST Radar at Haringhata, University of Calcutta, West Bengal

IRHPA-National Interdisciplinary Center for Cyber Security and Cyber Defense of Critical Infrastructures

Major highlights of project for this year are, development of multiple advanced educational programs including certificate courses and degree courses in Cyber security, successful projects with multiple PSUs, augmentation of cyber security testbeds, and multiple technology development which are transferrable to industry.

The testbed creation in the various critical infrastructure sectors continued. This year, successfully installed and commissioned the power transmission testbed (Figures. 3.76 & 3.77), with 1.1 KV scaled down transmission system model fitted with substation automation, power protection relays, and phasor measurement units (PMUs).

Fig. 3.76: Control System for Power Testbed

Fig. 3.77: Smart load bank for power testbed

The C3i honeypots have been deployed in various locations via cloud based virtualization, as well as inside the C3i center network to collect malware. The honeypots deceiving attackers either as IT systems or OT systems have been helpful in collecting threat intelligence, and in developing SIEM (Security Incident and Event Management Tools) to make sense of the collected threat intelligence. One book has been published as mentioned in Figure 3.78.

Fig. 3.78: Cyber security book

The machine learning based malware analysis tools have been augmented to detect malware in JPEG files, Javascript files, and further improvements in performance of some of the previously developed models have also been done. Three papers on malware analysis work by C3i researchers got published in International Conference Proceedings – including one on adversarial malware generation and use of such samples to robustify the machine learning models. Multiple anomaly based intrusion detection methods have been developed and validated (Figure 3.79 & 3.80). These methods are robust to outliers, training data poisoning attacks, and boiling frog attacks.

Fig. 3.79: Host intrusion detection system – Dashboard

Fig. 3.80: Host intrusion detection system – User information

A start-up on deception technology developed at C3i center has been incubated under the C3iHub Prayas and Nidhi Prayas program. A lot of interaction with government agencies such as the National Cyber Security Coordinator, Central Electric Authority, National Thermal Power Corporation, National Highways Authority of India, Tehri Hydro Development Corporation India Limited (Tehri, Uttarakhand), National Power Training Institute(NPTI), are on-going. Several industries, such as Schneider Electric,Tech-Mahindra, LTTS, SMC, have been interacting quite often. Disclosures of vulnerabilities have been made to many ICS vendors – Aveva, Schneider Electric, Rockwell, WAGO and Synergy, in particular.

C3i center also promotes awareness and education in cybersecurity. Yearly cyber-security competition event CSAW, in cooperation with New York University, has been an on-going activity every year. In November 2021, the competition was held completely in online mode. C3i also hosted 20+ summer interns during the summer who worked for 2 months on various cybersecurity projects. C3i Center, IIT Kanpur, in association with TalentSprint, has designed a six-month Advanced Certification Programme in Cyber Security and Cyber Defense. Four cohorts have been completed and the fifth cohort is about to start. Talent Sprint launched a fresh graduate cyber security education programme online with C3i Center which will be open to participants who are within 2 years of their graduation and want to enter the cyber security field.

Also, started a Blockchain Technology Certification programme with Simplilearn, another online educational technology platform. The IITK Senate also approved M.Tech and MS in cyber security program, and also e-Masters (fully online) in Cyber Security. This work was done at Indian Institute of Technology, Kanpur.

IRHPA - Virtual reality-based solution for effective neuroanatomy teaching

A solution for supporting teaching of neuroanatomy based on virtual reality (VR) has been developed. The key contribution is that this enables a 3D visualisation of anatomy which should facilitate learning of structures and their spatial configuration within the brain. This visualisation is derived from T1 Magnetic resonance (MR) scans of the brain. The relevant structures are delineated (segmented) and coloured for clarity with the help of an authoring tool developed to support the teacher.

The hardware solution aims to convey the 3D spatial arrangement of the structure of the brain, by enabling a 3D visualisation. The software tool that was developed had a modular design as shown in Figure 3.81. The Neuro Anatomy (NA) viewer is responsible for splitting a 3D mesh into stereo (left and right) outputs for 3D projection.

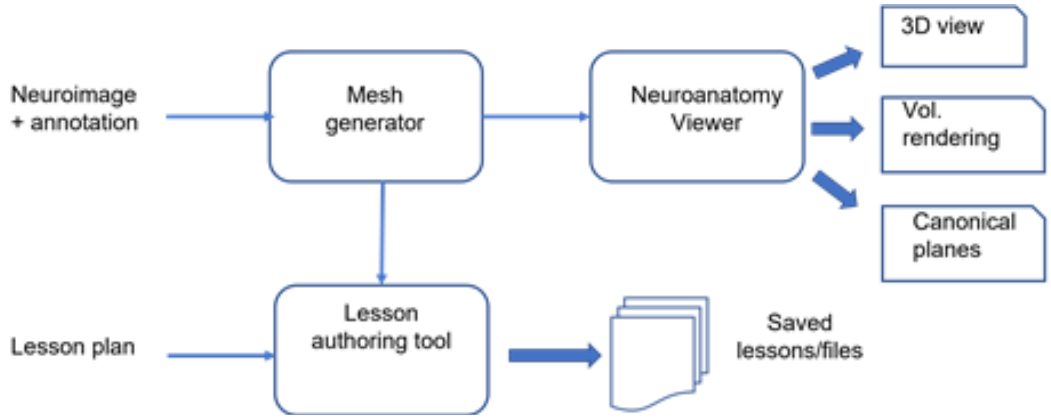


Fig. 3.81: Software tool for Virtual reality-based neuroanatomy lessons

The proposed VR-based system was designed and implemented at IIIT Hyderabad. Figure 3.82 (left) shows the auditorium and the VR based system. Specifically, one can see the wall-mounted 3D silver screen for projecting the neuroanatomy lessons, ceiling-mounted projectors in a cage. The server to house the software tool is behind the podium in a cabinet. Figure 3.82 (right) shows the calibration and tuning exercise by the team to get the optimal 3D projection on the screen.

Fig. 3.82: Installed VR system in an auditorium (left) and the display being fine-tuned by the project team (right).

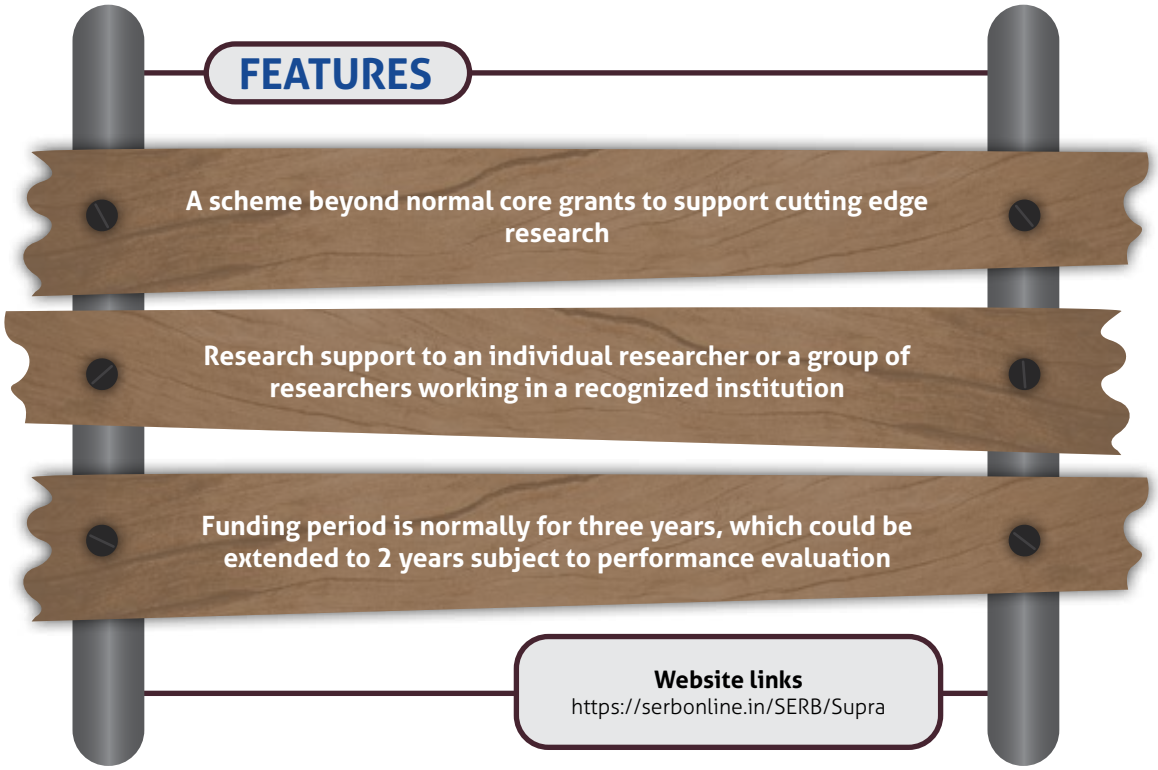
The project has committed to deploy the developed solution in 2 sites (medical colleges) with one in each of the city of the participating institutes, signed the MoU with Osmania medical college (OMC). Two site visits have been done to inspect the classroom in order to understand the site-specific requirements. Figure 3.83 shows the classroom at OMC along with the project team which visited the site for inspection.

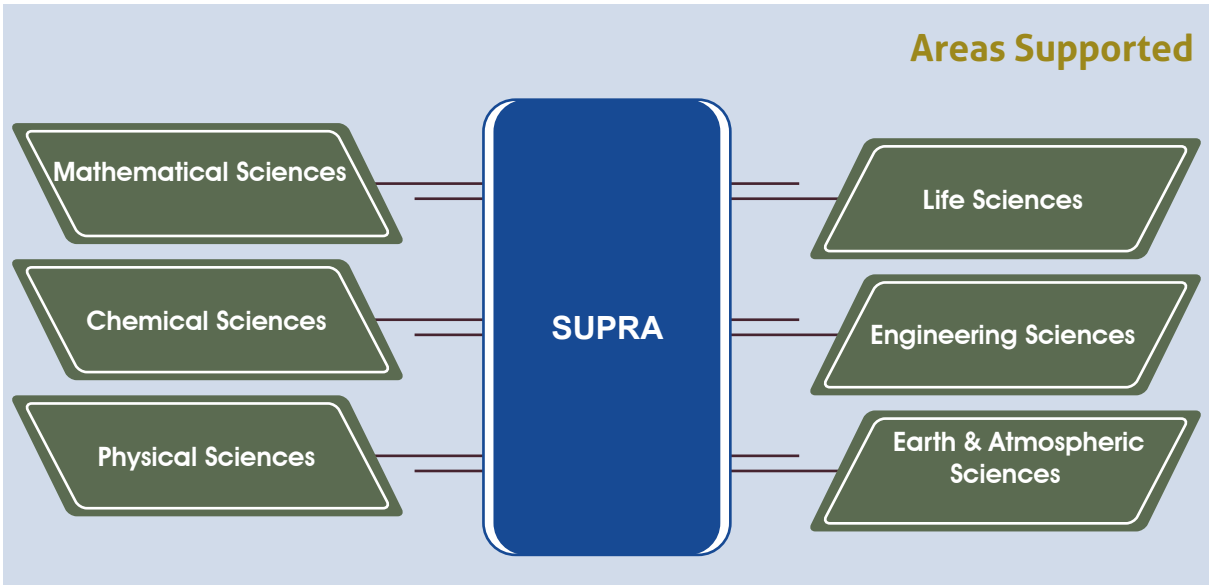
Fig. 3.83: Deployment site in Hyderabad. The classroom Osmania medical college where the VR solution will be set up. Project team is seen along with the Anatomy Professor.

The technical solutions that have been completed so far in the project can be summarized as follows: Design and installation for a VR set up that permits students in a class of 100-150 to view the brain as a 3D organ and understand the spatial oragnisation of structures within the brain. Design and implementation of an authoring tool software to give freedom to the teachers to create their own lessons. Development of an Android app that anatomy teachers can use to control the 3D visualisation while teaching in class. This work was done at Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum and IIIT Hyderabad.

3.2.2 Scientific and Useful Profound Research Advancement (SUPRA)

The scheme Scientific and Useful Profound Research Advancement (SUPRA) is a new initiation of SERB which aims to explore new scientific breakthroughs, with long-term impact on our fundamental scientific understanding, and offer disruptive technologies at the cutting-edge research. Transformative and disruptive research concepts based on innovative and unproven hypothesis, possessing a high degree of uncertainty, yet having conviction to produce a lasting impact across discipline boundaries qualify for support under this scheme. The proposals under this scheme are envisaged to obtain breakthrough solutions in identified areas. This will increase the knowledge base and at the same time will provide wealth of deliverable outcomes. It is expected that these innovative proposals will have considerable impact on global science and will also open up new opportunities in S&T.



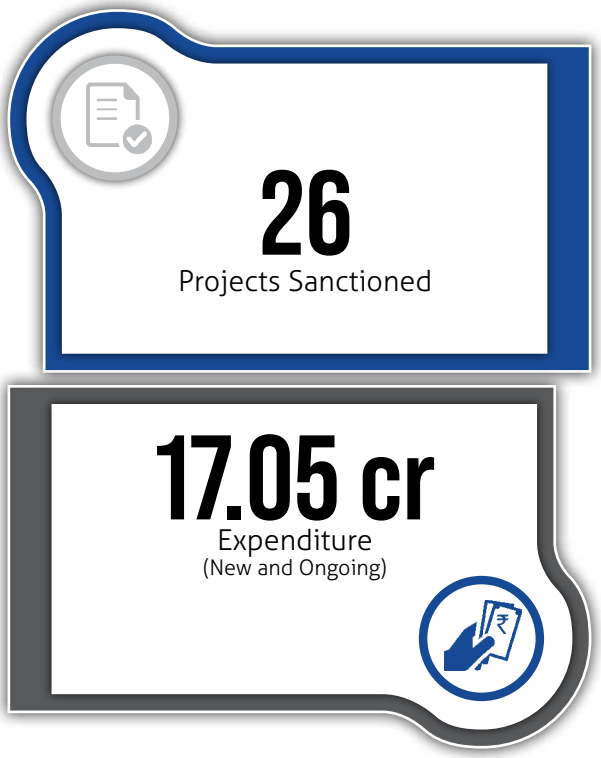


Research highlights

Exploring the role of mechanical force exerted by AAA+ ATPase in clearance of ubiquitinated pathogen

Sensing of pathogens by ubiquitination is a critical arm of cellular-immunity. However, universal ubiquitination targets on bacteria, especially of proteinaceous origin, remain unidentified. In this project, first identified protein-based ubiquitination substrates on bacteria by unveiling a novel strategy that utilizes recognition of degronlike motifs. It has been found that pneumococcal surface proteins such as BgaA, PspA are substrates for cellular ubiquitination. Additionally, introduction of the degron motif from the ubiquitinated substrate into HysA, an SPN surface protein lacking the tripartite motif, also increased its propensity to be recognized by host Ub-ligases, thus converting it to a ubiquitinable product. Such motifs can form a new class of intra-cytosolic pathogen associated molecular patterns (PAMPs) as their incorporation enabled identification of non-ubiquitin targets by host Ub-ligases. The canonical degron sequence present in BgaA and PspA is predicted to be identified by the SCFFBW7 E3 ligase. Using siRNA mediated knockdown and in-vitro reconstitution reaction, established the novel role of SCFFBXW7 in the ubiquitination of bacterial proteins followed by bacterial elimination from the intracellular milieu. This may explain the enhanced risk of infections in Chronic Lymphocytic Leukaemia patients bearing FBXW7 mutations. Exploitation of such generic pathogen sensing strategy allows conservation of host resources and boost anti-microbial immunity. The immediate application is to evaluate the applicability of this novel bacterial killing strategy against phylogenetically diverse and clinically relevant pathogens. Also, PROTAC (Proteolysis targeting chimeric) could be designed to facilitate ubiquitination or subsequent degradation to facilitate this newly identified pathway for bacterial killing.

The long term goal is to exploit the ubiquitination mediated pathway for effective antigen presentation via antigen presenting cells (APCs). This may lead to development of novel vaccines against *Streptococcus pneumoniae*. A serotype independent protein based vaccine formulation would affordable to large population and confer protection against all pneumococcal serotypes circulating in the world.



SCF complex is one of the principle ligases involved in cell cycle control and cell growth, its role in pathogen clearance is completely unexplored. Indeed it has observed co-localization of FBXW7 with intracellular SPN (Figure 3.84(A-B)). To verify the E3 ligase, siRNA directed knock down of FBXW7, Cullin1 and Skp1 genes were performed (Figure 3.84(C)). A co-localization study in FBXW7, Cullin1 and Skp1 knock down cells suggested a sharp drop of ~60% in K48-Ub with association with SPN (Figure 3.84(D-E)). Scrambled siRNA (siControl) transfected cells with n>100 bacteria / coverslip (Figure 3.84(F)). Further observed the increase of intracellular SPN persistence in these knockdown conditions (Figure 3.84(G-I)).

This work was carried out at Indian Institute of Technology, Bombay.

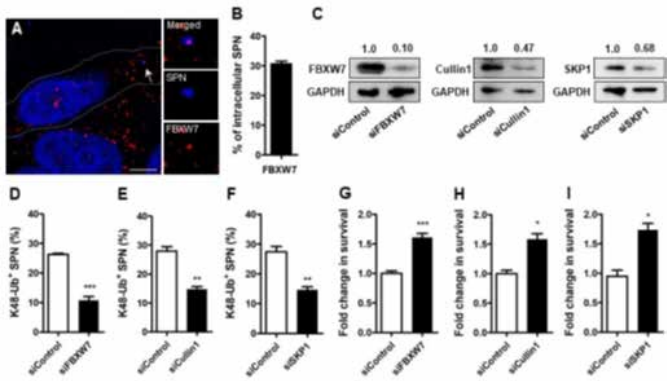


Fig. 3.84: A. Confocal micrograph of A549 cells at 9 h post infection showing association of SPN (blue) with FBXW7 (red), the substrate recognizing component of SCFFBW7 E3-ligase. B. Percentage of association of SPN with FBXW7 in A549 cells at 9 h post infection. n>100 bacteria/coverslip. C. Immunoblot demonstrating knock-down in expression of FBXW7, Cullin1, SKP1, the key components of SCFFBW7 E3-ligase in A549 cultures following transfection with siFBXW7, siCullin1, and siSKP1, respectively. D-F. Percentage of decoration of SPN with K48-Ub following knock down of FBXW7 (D), Cullin1 (E) and SKP1 (F) in comparison to scrambled siRNA (siControl) transfected cells. n>100 bacteria/coverslip. G-I. Fold change in intracellular survival of SPN in A549 cells transfected with siFBXW7 (G), siCullin1 (H) and siSKP1 (I) and normalized to siControl. Statistical significance was assessed by two-tailed unpaired student's t-test (D - I). *P < 0.05, **P <0.01, ***P < 0.005. Data are mean ± SD of 3 independent biological replicates.

Design and fabrication of microfluid based transparency switching Smart glasses suitable as windows

Progress has been made via theoretical modelling to gain insights into design and functioning of microchannels, wetting aspects related to the drainage leading to effective curtain effect. Referring Figure 3.85, two glass panes (1) and (4) of which at least one is roughened (1) will be taken and stuck together with spacer (2) made up of a polymer sheet with desired thickness, at the edges to create a cavity in between the glasses. The roughened surface of the glass is such that it will face the cavity. The composite device will be sealed from all the sides leaving an opening for inlet/outlet (3) of the liquid as well as opening for venting in and out gas inside the micro cavity. The liquid mix (M) will have same refractive index as roughened glass will be filled into the cavity either manually or through a pumping device via the inlet/outlet (3) between the glass.

The change in transparency will be observed by filling in a liquid, whose refractive index will exactly be matched in the visible region. Further, refractive index matching will be optimized through various strategies. A multi-scale algorithm and simulation tools will be developed to study the effect of physical heterogeneities on contact line dynamics and imbibition and also during receding of the working fluid in micro-channels of the devices which will be supportive tool in understanding the device mechanism and upscaling of the devices. Various scientific studies for transparent and translucent states, switching speed, interface of liquid and glass, etc. will be done using spectrophotometer, timers, contact angle meter, etc. Further, upscaling, optimization and testing of the glasses will be done for larger area (4 ft. X 1 ft.) and integration of IOT for operation will be tried out to make it more attractive product.

The research group has found an alternative liquid for the device which is much lower in cost and environmentally benign. Optimized and modified glass fabrication process and move to "tampered" glasses from "plain frosted glass". This process modification has given the advantage to bring device fabrication process much closer to industrially acceptable and favourable process. Various glass slide samples were prepared by the customized design of "micro abrasive blasting system" using a different set of parameters (air pressure, nozzle distance, and abrasive size), and their morphological studies were performed to optimize the parameter of the system. This work was done at Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru.

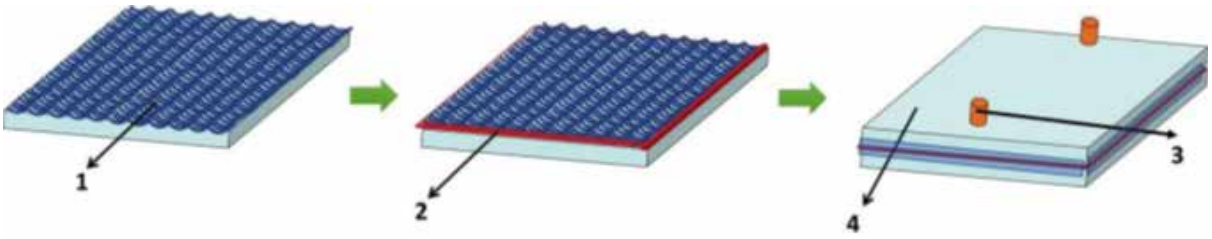
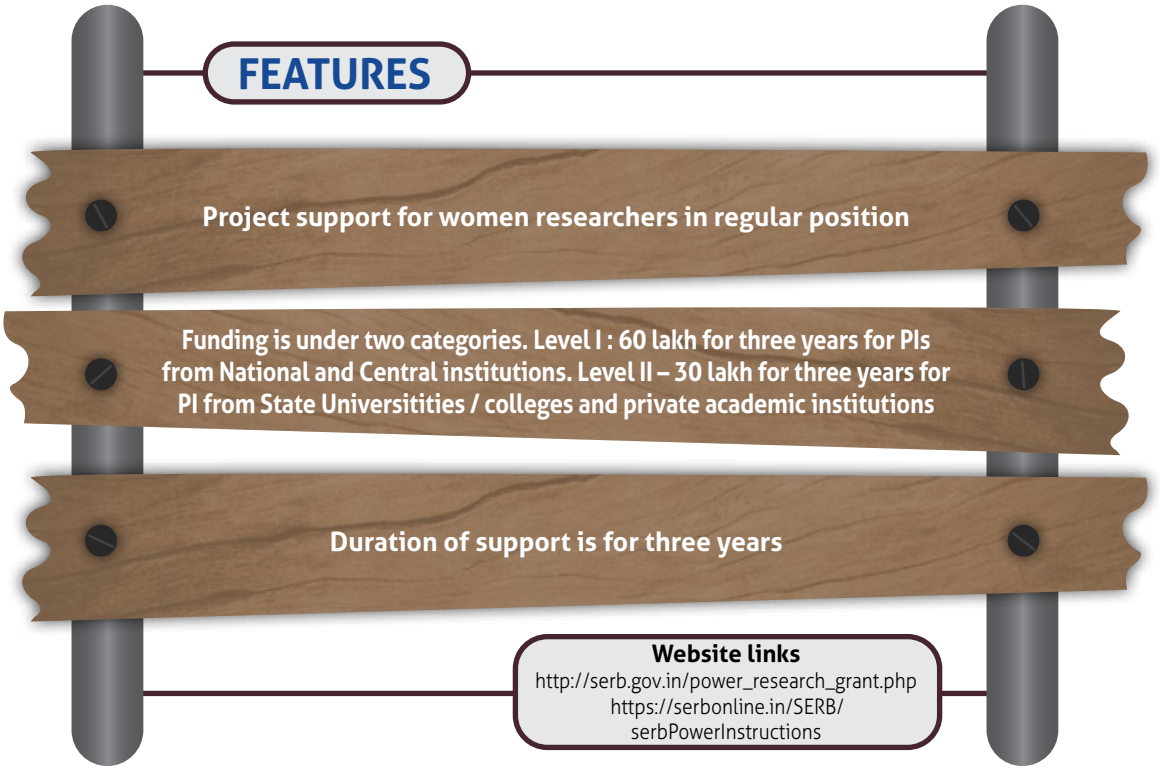


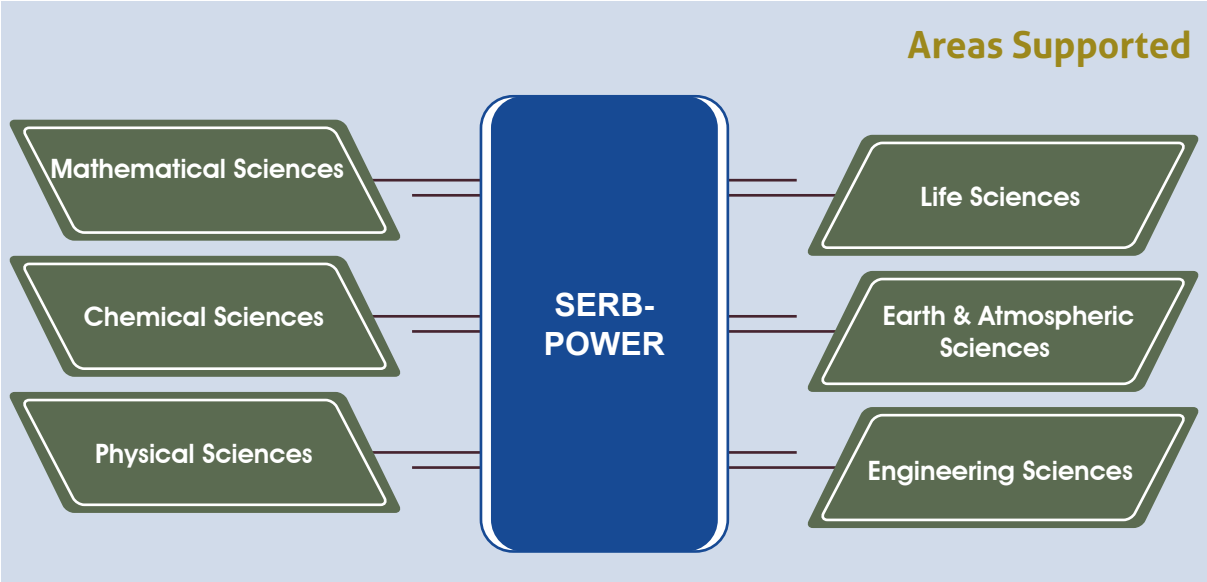
Fig. 3.85: Depicts the fabrication steps of the device

3.3 GENDER AND SOCIAL INCLUSIVENESS

3.3.1 Promoting Opportunities for Women in Exploratory Research (POWER) Grant

To promote women working in the frontier arears of science and engineering, a new scheme SERB-POWER (Promoting Opportunities For Women in Exploratory Research) was launched. This scheme is open to emerging and eminent women researchers to carry out R&D activities by providing them individual-centric and competitive mode of research funding. This grant aims to bridge the gender gap in science and engineering research funding in various S&T programs to ensure equal access and weighted opportunities for Indian women scientists engaged in R&D activities.





A total of 2695 proposals were received out of which 76 proposals were sanctioned for funding across all disciplines of science and engineering.

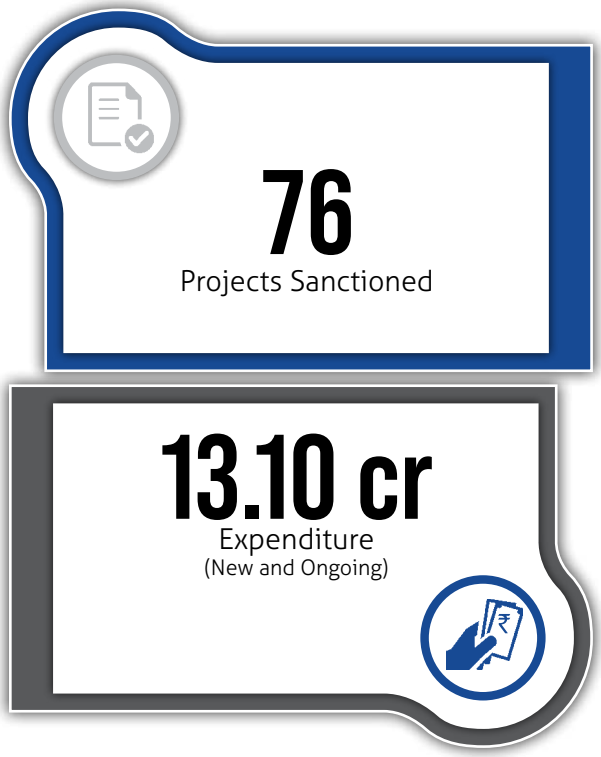
Highlights of some of the proposals supported are given below:

Molecular mapping and transfer of parthenocarpy trait in desi cucumber

The parental genotypes of parthenocarpic and non-parthenocarpic cucumber plants (Gynoecious-14, Punjab Kheera-1, Punjab Naveen, PBRK-5 and AVCU1303) were sown (Figure 3.86). The genomic DNA was isolated from the parental genotypes. The SSR markers were developed for parthenocarpy-related genes and parental polymorphism was determined in the genotypes. The genotypes showed polymorphism in relation to SSR markers. Expression analysis of parthenocarpy genes was also performed to identify candidate genes responsible for parthenocarpy.

The F_1 population of crosses were grown to phenotypically analyse the parthenocarpic behaviour. The F_1 populations were selfed in order to check the fruit set formation. The different crosses showed varied signs of early and late parthenocarpy. The phenotypic data was recorded for all the crosses (Figure 3.87). The crosses showing strong parthenocarpic behaviour were selected for mapping and transfer of parthenocarpy trait.

The F_1 crosses for mapping: Punjab Kheera-1 x Gynoecious-14 and Punjab Kherra-1 x Punjab Naveen. These crosses are being selfed to generate F_2 populations for BSA-seq analysis.



The cross for transfer, PBRK-11 x Punjab Naveen is being back crossed with Punjab Naveen for transfer of parthenocarpy trait.

This work was done at Punjab Agricultural University, Ludhiana.

Fig. 3.86: Cucumber at various stages of growth (A) Sowing in trays (B) Two leaf stage (C) Transplanting in net house (D) Fully grown cucumber plants

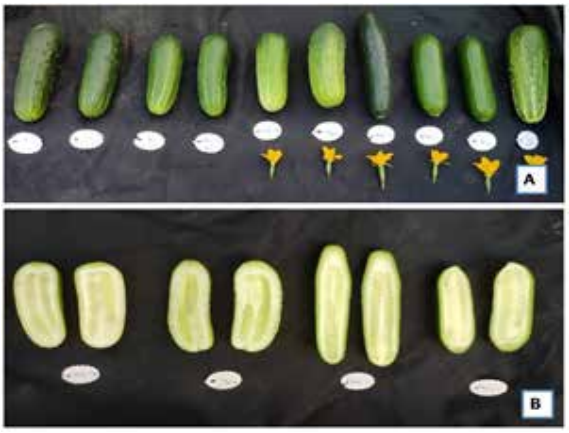


Fig. 3.87: Phenotypic variation among fruits of different parental genotypes and F1 crosses (A) Variation in fruit color, shape, size and warts (B) Variation in fruit cavity

Synthesis of Mono- and Bimetallic Pseudo-Stannatrane cages with rigid and Asymmetric Skeletons for their potential applications

The first phase of the research i.e. synthesis of tripodal ligands has been successfully accomplished. Some multidentate tripodal ligating skeletons (1a-1d) possessing heteroatoms for metal coordination have been synthesized by Schiff base condensation followed by reduction (see Figure 3.88 for structure). The confirmation of 1a-1d was done by FTIR, NMR, and, Mass Spectrometry. Compound 1a was obtained in crystalline forms by slow evaporation method using mixture of solvent i.e. acetone and hexane and the structure of compound 1a was elucidated by single-crystal X-ray diffraction.

This work was done at Panjab University, Chandigarh.

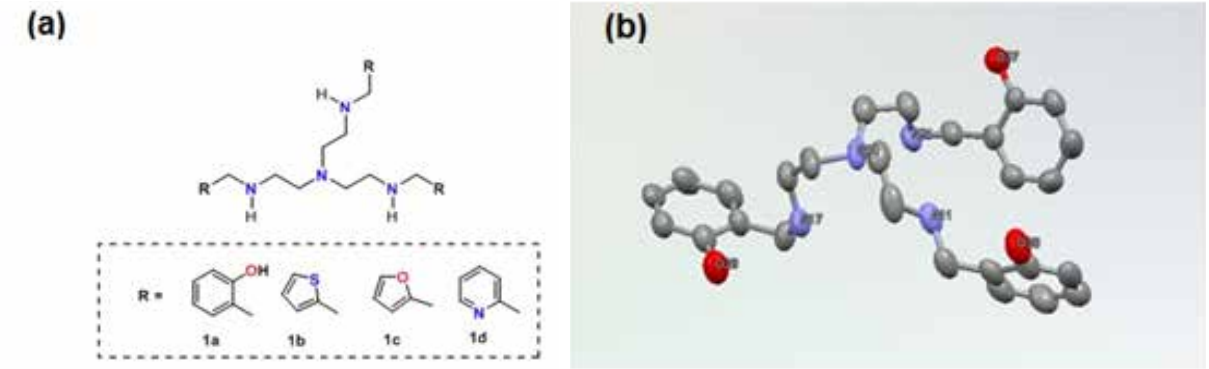
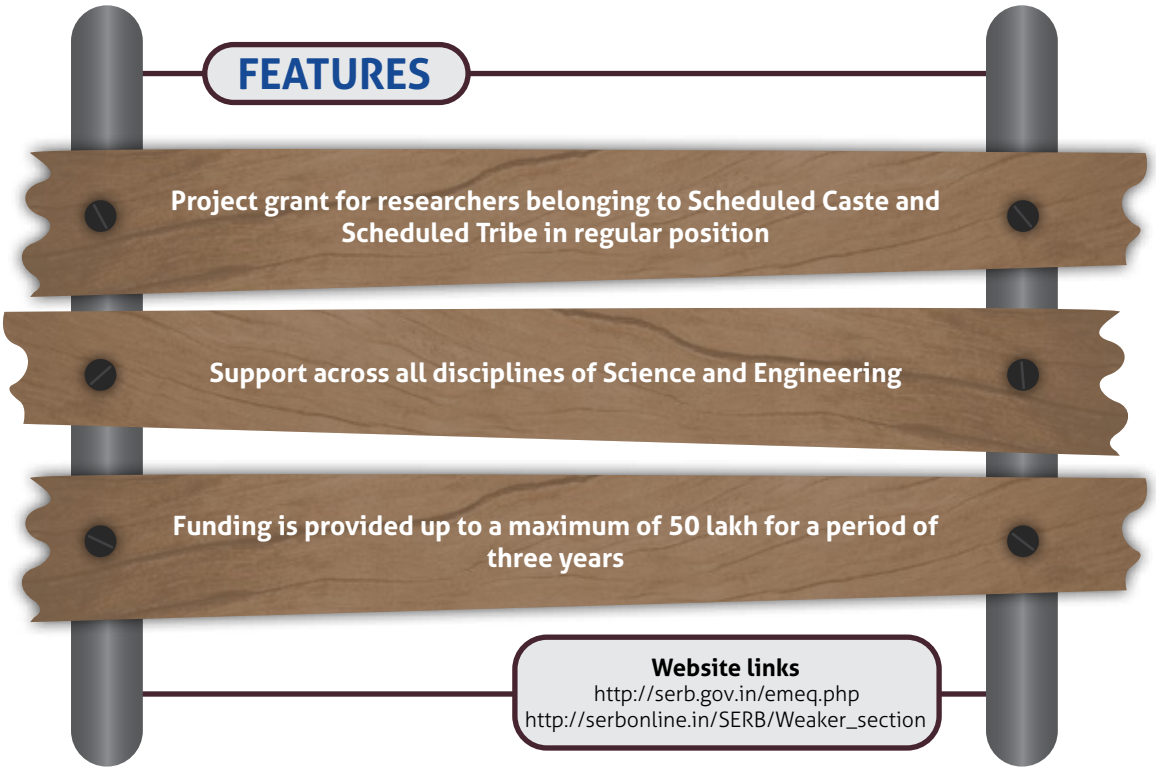


Fig. 3.88: (a) General structure of tripodal ligands 1a-1d (b) Single crystal X-ray structure of 1a

3.3.2 Empowerment and Equity Opportunities for Excellence in Science (EMEQ)

The EMEQ scheme was launched with an aim to provide research support to the scientists belonging to the Scheduled Caste and Scheduled Tribe. The basic idea was to encourage them for undertaking research in newly emerging and frontier areas of Science and Engineering and to involve them in the National Science and Technology development process. This scheme has been successfully implemented since its launch in 2013 and so far more than 1550 researchers have been benifited by this scheme.

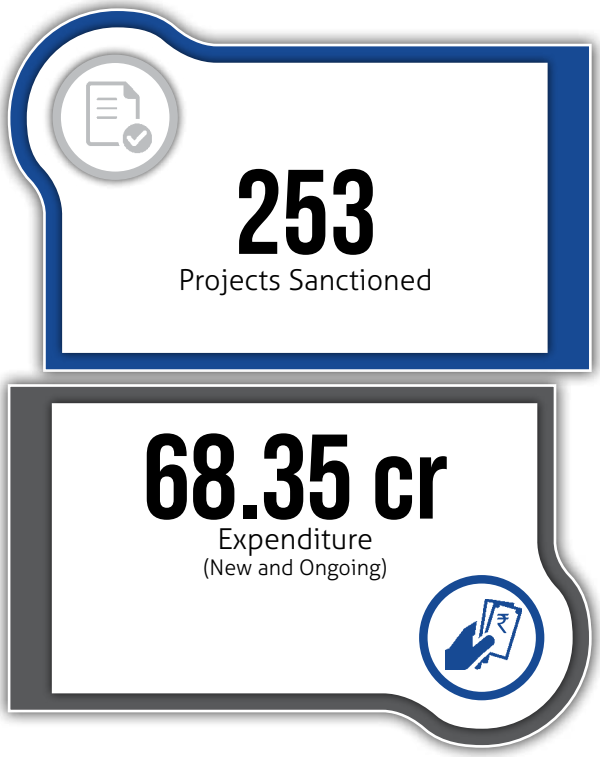


Research Highlights

A highly flexible Piezo-tribo nanogenerator based on electrospun PVDF nanofibers containing the modified and decorated carbonaceous nanoparticles for capturing human kinematics

The PVDF nanocomposites were prepared using the low-temperature phase-inversion method. The phase-inversion at a lower temperature (5 °C) will induce a strong thermal gradient, which primes to self-alignment of the polar crystal. This fabrication method assembles high electroactive and self-polarized PVDF nanocomposites. Further addition of MWCNTs acted as a nucleating agent, which increases the beta-phase of prepared films. To increase the interaction with the PVDF matrix, the MWCNTs were functionalized using APTES. The result shows that by addition of MWCNTs and MWCNTs-APTES has enhanced the β-phase of PVDF film by 13.4 % and 44.2 %. Further, the β-phase content on the piezoelectricity was investigated using an oscilloscope under hand-tapping. MWCNTs-APTS/PVDF nanocomposite gave maximum voltage of ca. ~10.4 V, followed by 8.6 V for MWCNT/PVDF and 2.43 V for Neat PVDF.

Also, inherent piezoelectric materials like Zinc Oxide (ZnO) nanoparticles (NPs) were incorporated to enhance the PVDF polymer's polar phase. The optimum ZnO NPs loading in the PVDF matrix was identified. For increasing the ZnO NPs interaction with the PVDF matrix, the NPs were surface-functionalized using APTES chemical (Figure 3.89). Further, incorporating the same weight percentage (5 wt. %) of APTES functionalized ZnO nanoparticles in the PVDF matrix has enhanced the β-phase fraction from 20.6 % to 63.8 %, which corresponds to an overall ~213 % enhancement in the polar β-phase fraction. Further, MWCNTs were incorporated into PVDF nanofibers and studied their effect on polar β-phase and piezoelectric properties. The addition of MWCNTs has improved the polar β-phase and performance of the neat PVDF nanofibers. The output voltage has increased from 6.1 to 20 V for 0.25 wt. % of MWCNT loading in PVDF nanofibers. This work was done at National Institute of Technology, Calicut.



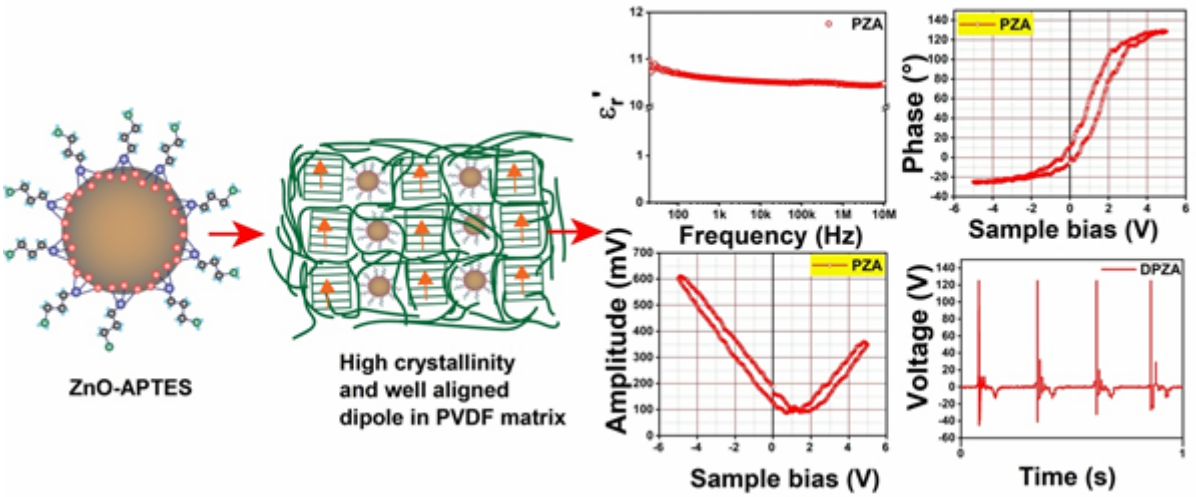


Fig. 3.89: ZnO NPs interaction with the PVDF matrix

Hypergravity as a novel tool for enhancing germination and seedling vigour in selected crops

Screening experiments to determine the best hypergravity intensity and duration to induce desirable phenotypes were tested in proposed five crops with specific genotypes – Cotton (Sahana), Rice (BPT-5204), Sorghum (SPV-2217, DSV-4, M35-1, SVD1418R, and IS-18551), Pigeon pea (Maruti), and groundnut (DH-256), and additionally wheat (UAS 375). Optimum intensity and duration of hypergravity that influenced the seedling growth and morphogenesis in three crops such as wheat at 10g for 12hrs, sorghum at 1000g for 1hr, and groundnut at 10g for 6 hrs were followed up with further studies/ objectives. No change in germination rate was observed in any of the tested crops. Molecular basis of root phenotype through a 45-days old wheat root transcriptome using the Illumina sequencing platform was attempted. The data

also revealed a robust transcriptional response to hypergravity with 3765 up-regulated and 2102 down-regulated transcripts when compared to the control (Figures 3.90 (1-5)). Significant downregulation of salicylic acid, jasmonic acid, and abscisic acid synthesis associated transcripts confirms a reported inverse relationship between these endogenous hormone levels and root growth. Positive regulators such as Abscisic acid 8'-hydroxylase 1, Indole-3-glycerol phosphate synthase, replication protein A, cell division control protein 25 and cellulose synthase that directly promote root growth were significantly upregulated. However, study did not find the same root phenotype/s in the next generation indicating the possible physiological adaptation rather than the genetic inheritance of traits. This work was done at University of Agricultural Sciences, Dharwad, Karnataka.

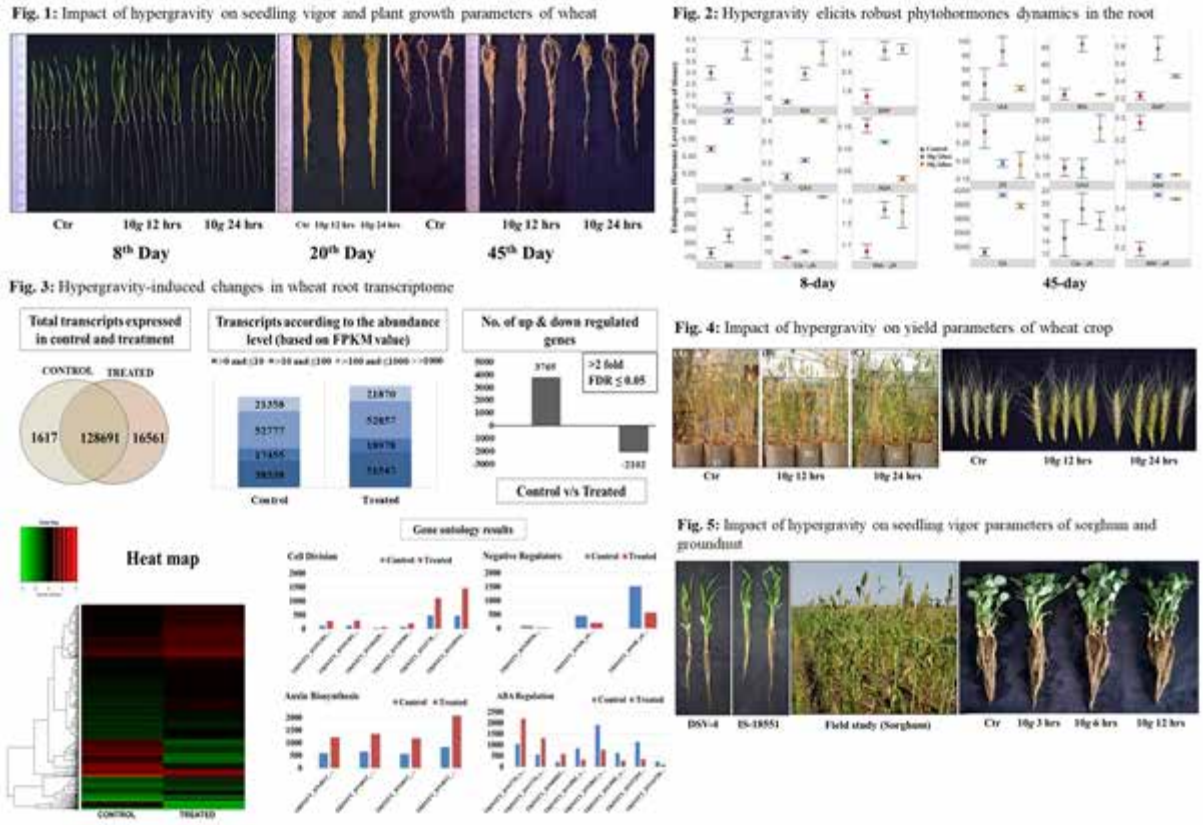


Fig. 3.90 (1-5): Impact of hypergravity on various growth parameters of tested crops

4

AWARDS AND FELLOWSHIPS

SERB offers several awards and fellowships to recognise and reward outstanding researchers who have performed exceedingly well in Science and Engineering and having proven track record. SERB recognises brilliant young researchers, active superannuated scientists, and exemplary women scientists by providing them awards and fellowships. The aspiration is to motivate the scientists for excellence in scientific R&D.

The aim of these awards and fellowships is to generate a R & D ecosystem where quality research is recognized, supported, and empowered. These awards and fellowships cover a broad spectrum of basic, translational, and applied research initiatives across all the areas of Science and Engineering. Keeping this in consideration SERB has the National Science Chair scheme for active eminent superannuated scientist to continue their research after their retirement.

To inspire the young dynamic researchers and to uplift their impactful research to the forefront the prestigious awards such as SERB-STAR (Science and Technology Award for research) and Swarnajayanti fellowship were formulated.

The prestigious fellowships like J C Bose fellowship and Abdul Kalam Technology Innovations National (AKTIN) fellowship are to award Scientists and Engineers for their proven track record. In addition, SERB Technology Translation award (TETRA) is to support researchers who have generated Intellectual property (IP) in terms of patents/copyright etc. from SERB supported projects and wish to translate their IP.

SERB offers National post-doctoral fellowship (NPDF) to the young researcher with the aim to retain scientific talent in the country and provide funding support to them for pursuing research. Similarly, SERB also facilitates reverse brain drain by attracting trained minds from abroad through Ramanujan fellowship and help them in starting career in national labs and Indian institutions.

The need to bridge the gap between the premier institutes and private or state universities, is recognized in schemes such as Teachers Association for Research Excellence (TARE). Also recognized is the importance of steering youth to take on the challenges of industrial research in the design of Prime Minister's fellowship programme for doctoral research.

SERB is at the forefront in recognizing women scientists of extraordinary potential who have contributed immensely in transforming the scientific landscape. The SERB POWER fellowships and grants along with Women Excellence awards honor eminent women scientists for their incredible contributions across disciplines in Science and Engineering.

In line with SERB's approach of being synergetic and inclusive, relevant organizations are partnered for specific awards, to ensure sharing of domain expertise and coordinate efforts. Notable partner agencies include, Indian National Academy of Engineering (INAE), Federation of Indian chambers of commerce and industry (FICCI) and Confederation of Indian Industry (CII).

4.1 Recognition for Senior Scientists

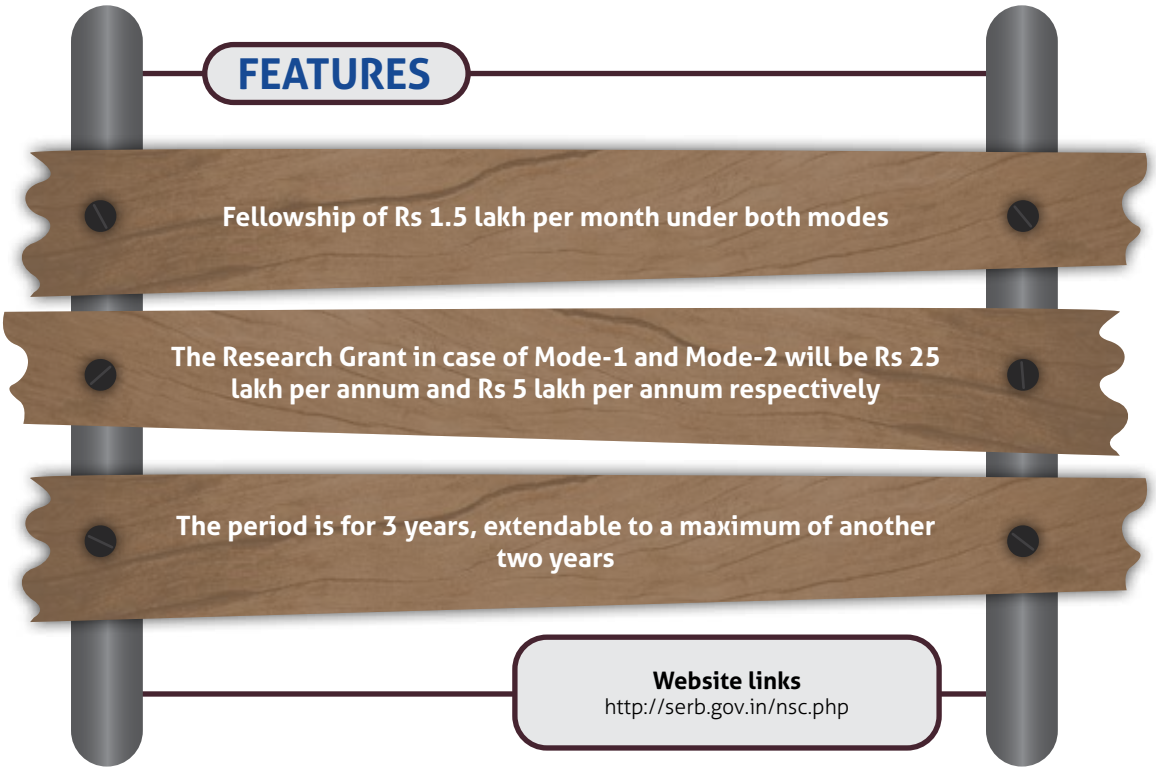
4.1.1 National Science Chair (NSC)

To recognize the active eminent senior Indian superannuated scientists for their outstanding contributions both nationally and internationally, in the area of Science, Technology, Engineering, Mathematics (STEM) and Medicine and to utilize their scientific knowledge in promotion of excellence and growth in R&D, the National Science Chair was instituted. Five National Chairs were sanctioned during the reporting time. NSC is implemented in two modes. Under Mode 1: Scientific Excellence, the support is extended to senior eminent scientists who after superannuation continue to be active in research but do not possess a formal supporting arrangement. Mode 2 recognizes outstanding superannuated scientists to establish a benchmark for stature, value, and eminence in national and international Science and Technology communities as a R&D leader.

Awardees of National Science Chair in the reporting period under Mode 1 are:

Mode 1:

1. **Prof. Rahul Mukherjee**
   Indian Institute of Management Calcutta
   Kolkata – 700104
2. **Prof. Bhim Singh**
   Indian Institute of Technology Delhi,
   New Delhi – 110016
4. **Prof. M. Lakshmanan**
   Bharathidasan University
   Tiruchirappalli – 620024
4. **Prof. Seyed Ehtesham Hasnain**
   Indian Institute of Technology Delhi,
   New Delhi – 110016
5. **Prof. B. K. Thelma**
   University of Delhi
   South Campus, New Delhi – 110021



Research Highlights:

Mechanism and rate of insulin dimer dissociation: Insulin dimer dissociation is an important biochemical process for sustaining human life. Moreover, this system acts as a prototype of several other dissociation reactions. Using large-scale molecular dynamics simulations coupled with the metadynamics sampling technique, a group led by National Science Chair fellow at Indian Institute of Science, Bengaluru have developed a free energy landscape for this process with respect to two order parameters, namely the number of C_2 contacts and centre-of-mass distance between the two monomers. It was found that the water molecules between the two monomers play a dynamical role in this process. The friction experienced by the hydrogen bonds at the monomeric junction from the cross-correlation of forces exerted by protein and water is negative and acts as a lubricant, which in effect, increases the rate of the dissociation process. They developed a step-wise mechanism of insulin dissociation that involves not only the large-scale internal motions of the protein but also the dynamics of water (Figure 4.1). They also calculated the rate of this process using multiple chemical reaction dynamics theories.

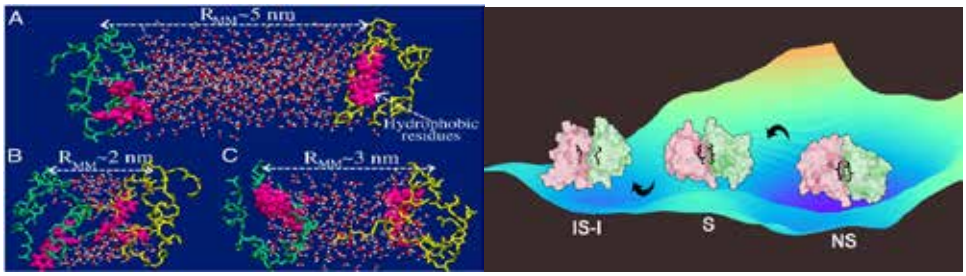


Fig. 4.1: Pictorial representation of insulin dimer dissociation.

Exploring *Providencia rettgeri* for application to eco-friendly paper based microbial fuel cell: Research undertaken by National Science Chair's group at Delhi Technological University, in collaboration with Kyushu Institute of Technology, Japan reported the studies relating to improved stability (40 days) of small sized microbial fuel cell (MFC) fabricated using agarose embedded paper-based proton exchange membrane. A fermentative bacterium *Providencia rettgeri* was isolated from rotten potato slurry and identified by 16S rRNA sequencing. The electroactivity of the bacteria was monitored *via* chronoamperometric and cyclic voltametric studies using a three-electrode system which indicated the presence of bacterial redox mediator (Figure 4.2). The Matrix-Assisted Laser Desorption/Ionization-Time of Flight (MALDI-TOF) and UV–Vis absorption spectroscopy provided the evidence that *Providencia rettgeri* synthesized folate (vitamin B9) during fermentation that was found to act for the first time as a redox mediator in an MFC. The paper based designed MFC fed with *Providencia rettgeri* yielded open circuit voltage of 787.9 mV with power and current density of 5.02 W/m^3 and 11.26 A/m^3, respectively when measured across 10 kΩ. The microbial re-chargeable battery comprising of an assembly of parallelly aligned four units of MFCs when connected in series (total 16 MFCs), generated 1.5 V that was used for powering a red-light emitting device (LED).

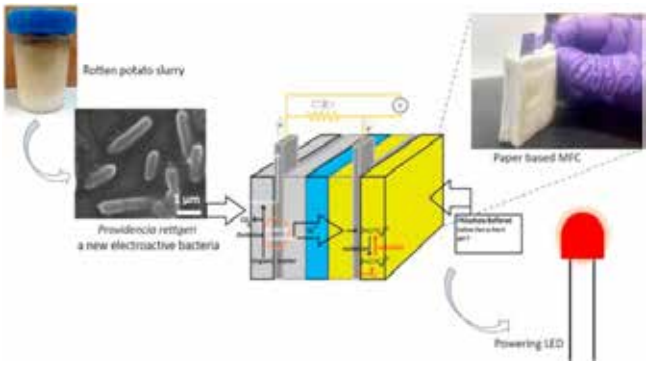
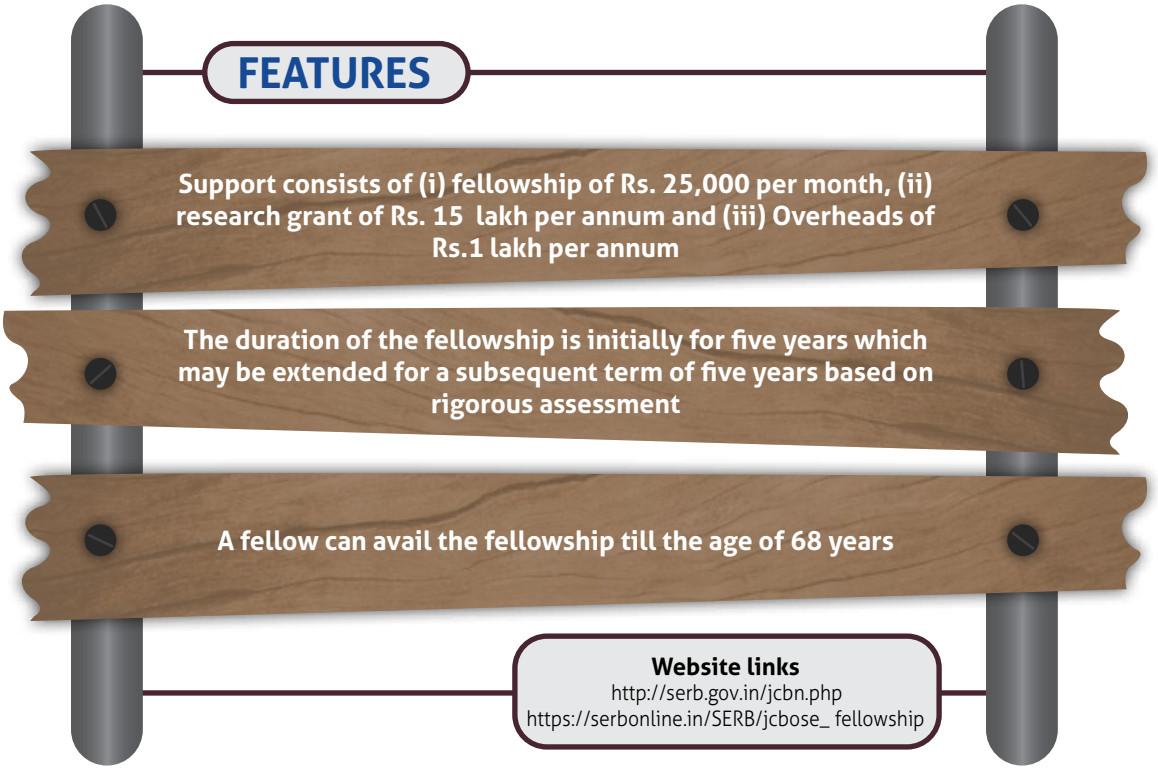


Fig. 4.2: Isolation and characterization of *Providencia rettgeri* as a new electroactive bacterium for application to paper based Microbial Fuel Cell.

4.1.2 J C Bose Fellowship

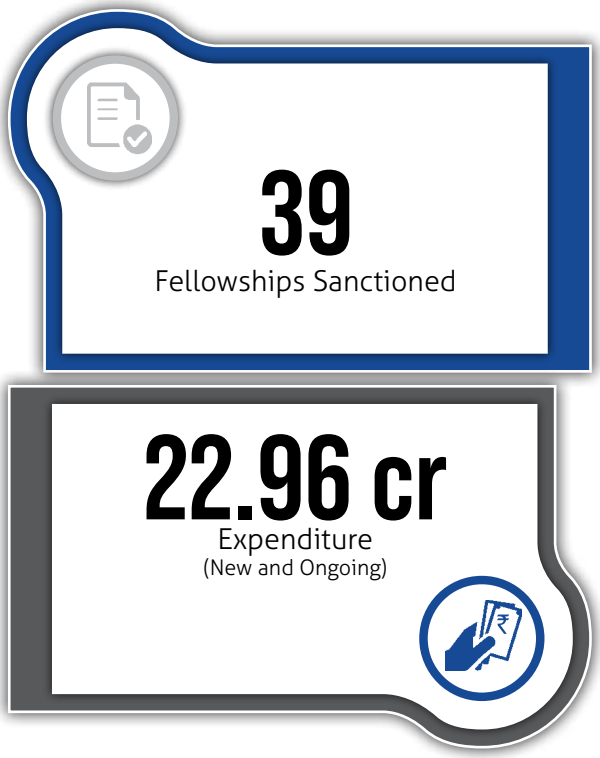
This fellowship is awarded to active Indian scientists and engineers to recognize their outstanding performance and significant contribution towards scientific research. This scheme was started in the year 2006 to recognize eminent scientists and engineers in all areas of science and engineering. The fellowship is scientist-specific and very selective.



Research Highlights

Increased oxidative stress and alterations in the nitric oxide (NO) pathway have been implied in the Neurological and Metabolic disorders: A research group led by a J C Bose fellow at Central Drug Research Institute, Lucknow has undertaken two major studies in the patients of major depressive disorder (MDD) and in iNOS KO mice. The study was aimed to assess the levels of oxidative and nitrosative stress in the neutrophils of drug-naive MDD patients and their first-degree relatives. The results obtained demonstrate time that neutrophil ROS/RNS, plasma nitrite, and serum cortisol levels correlated positively between MDD patients and their first-degree

relatives, indicating to extend these studies to assess their potential as biomarkers to identify persons at high risk for psychopathology (Brain Sciences, 11: 144 (1-14), 2022). They also examined the role of gut microbiome in insulin-resistant (IR) and dyslipidemic iNOS-/- mice, which displayed reduced microbial diversity, with a higher relative abundance of gram-positive bacteria, *Allobaculum and Bifidobacterium*, and altered serum metabolites (Figure 4.3). Vancomycin, which largely depletes gram-positive bacteria, reversed IR, dyslipidemia, and changes in select serum metabolites such as 10-hydroxydecanoate, indole-3-ethanol, allantoin, hippurate, sebacic acid, aminoadipate, and ophthalmate, along with improvement in phosphatidyl ethanolamine to phosphatidylcholine (PE/PC) ratio (Figure 4.4). They demonstrate that the depletion of gram-positive bacteria in iNOS-/- mice reversed the metabolic perturbations, dyslipidemia, and IR.



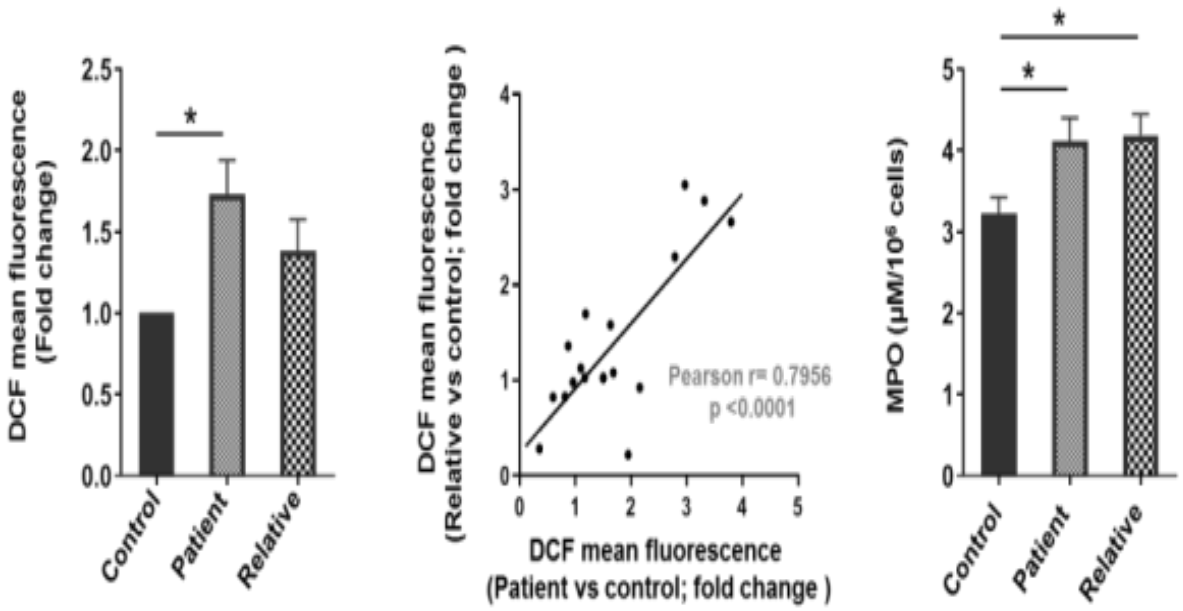


Fig. 4.3: Oxidative and nitrosative stress in major depressive disorder and first-degree relatives in comparison to healthy control subjects.

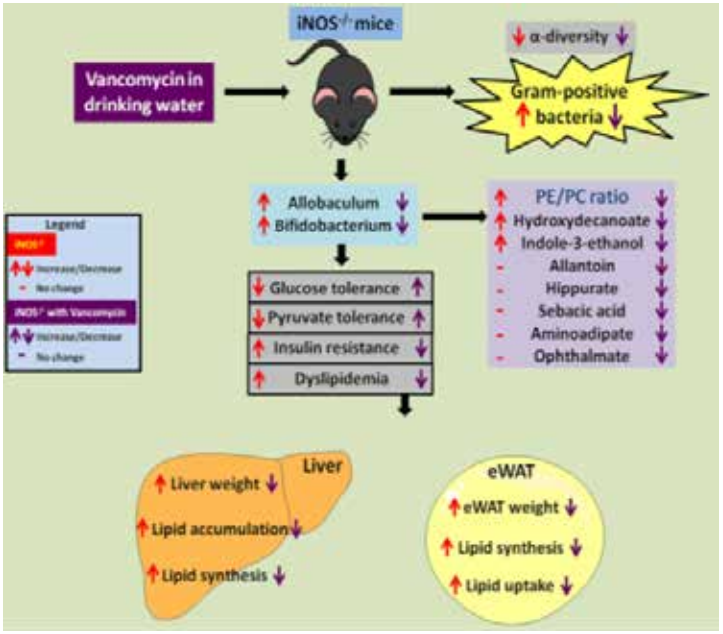


Fig. 4.4: Vancomycin-induced depletion of gram-positive gut bacteria in iNOS−/− mice, led to the modulation of serum metabolites, rescued IR and dyslipidemia

Superoxide Dismutase Mimetic Cerium Vanadate Nanozyme Regulates Mitochondrial Polarization and ATP Synthesis in Neuronal Cells: The superoxide dismutase enzyme (SOD) forms the first line of defence against oxidative stress in mammalian cells by tightly regulating the levels of superoxide radical (O_2^-). The SOD inefficiency or deficiency is associated with the genesis and progression of various neuronal and vascular abnormalities, prompting scientists worldwide to develop artificial SOD enzymes that can circumvent the detrimental effects of oxidative injury without perturbing the redox stature of the cell. A Fellow at Indian Institute of Science, Bengaluru have designed a novel SOD mimetic nanoparticle (nanozyme) capable of substituting the function of the natural SOD enzyme. The authors report that cerium vanadate nanorods ($CeVO_4$) effectively performs the key functions of SOD_1 and SOD_2 enzymes in SOD-silenced neuronal cells (Figure 4.5). The nanozymes restore the physiological levels of the anti-apoptotic Bcl-2 family proteins under oxidative stress conditions and thus prevents mitochondrial membrane depolarization. To a greater significance, these nanozymes efficaciously regulate and maintain the basal levels of ATP in SOD downregulated neuronal cells. The $CeVO_4$ nanoparticles represent the first example of a nanozyme capable of regulating cellular energy levels by restoring the mitochondrial integrity under oxidative stress.

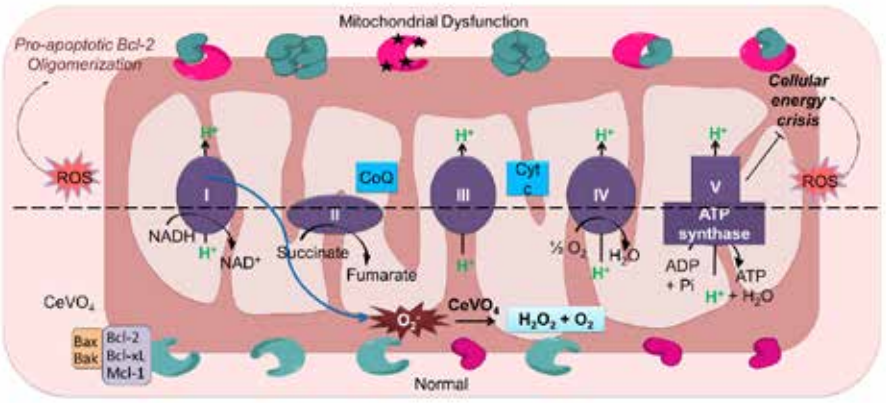
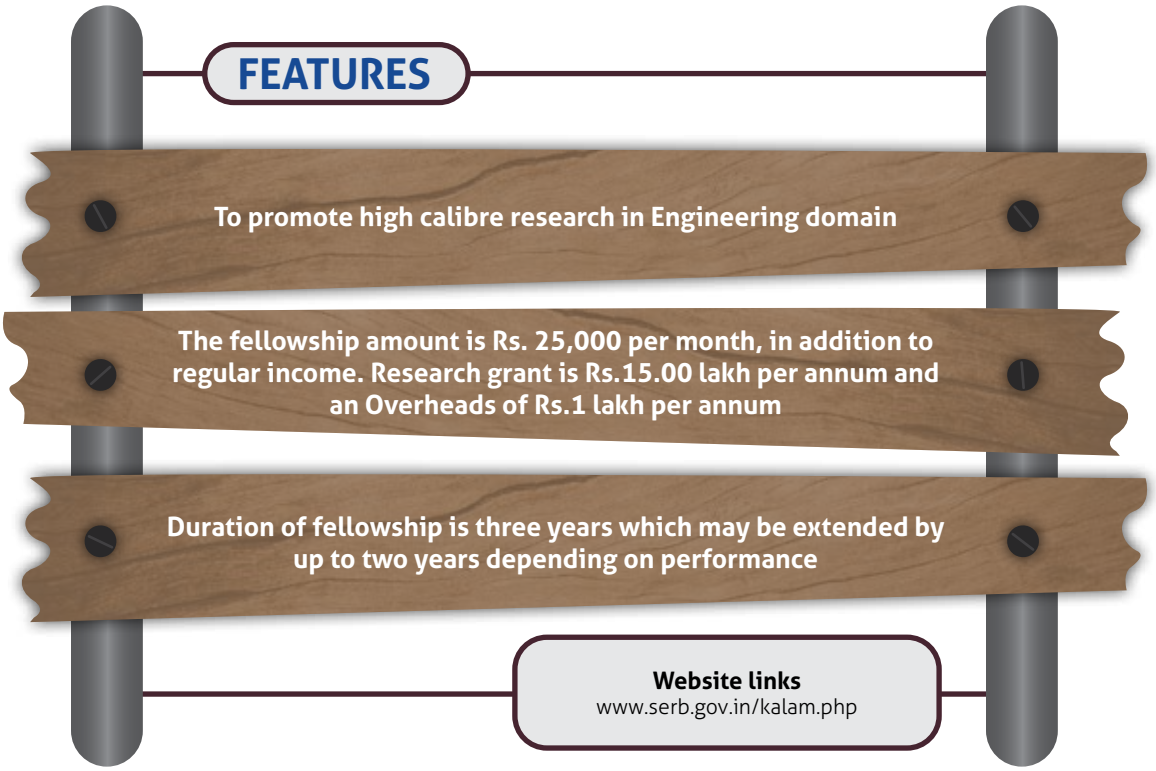


Fig. 4.5: Cerium vanadate nanozyme regulates the ATP Synthesis in Neuronal Cells.

4.1.3 Abdul Kalam Technology Innovation National (AKTIN) Fellowship

Abdul Kalam Technology Innovation National Fellowship was launched by SERB in 2017 to recognize, encourage and support translational research by Indian Engineers. Indian National Academy of Engineering (INAE), in association with SERB, coordinates and awards Abdul Kalam technology Innovation National Fellowships to outstanding engineers to recognize, encourage and support translational research of excellence in the fields of engineering, innovation and technology development across all fields of studies.



Research Highlights

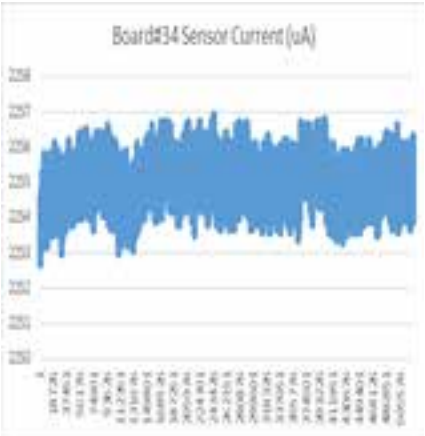
Nanostructured Semiconductor Gas Sensors: In one of the projects, a Fellow has been pursuing research on Nanostructured Semiconductor Gas Sensors with prototype building and Field Trials. An Abdul Kalam fellow at Indian Institute of Science, Bengaluru, working on new materials and device structures for highly sensitive and selective gas sensors; Optimization of single chip gas sensor array for multiple gas sensing and processing gas sensors in a cleanroom and calibration of gas sensors. The process flow was successfully optimized for the wafer scale production of gas sensors, as a baseline platform technology with reasonable yield of about 50%. A generalized signal conditioning interface electronics circuit with analog section and controller section was developed and prototyped. A core-shell metal-metal oxide structure has been developed for highly sensitive gas sensing. During the design of sensor system, first set of sensor systems

were subjected to exhaustive burn-in process to weed out any unreliable parts. Four different gas sensors (Figure 4.6), i.e. O_2, H_2, NO_2 and N_2H_4, with 50 prototype boards were used for burn-in tests. Only those sensor boards which had parameter drift less than 5%, were considered to pass the burn-in test for further deployment. Figure 4.7

shows typical response of good sensor which passes the burn-in test criteria.

A custom made set-up was created at SHAR, to assess effect of humidity, by introducing programmed humidity and gas concentration (Figure 4.8). The objective was to develop an algorithm, from experimental data collection, to compensate for environmental temperature and humidity effects during the real life deployment of sensor systems. Figure 4.9 shows typical response of Oxygen gas sensor for varying humidity condition. This data will subsequently used to develop intelligent algorithms to compensate external humidity effects.

Fig. 4.6: Fully fabricated sensor systems.



Min uA	Max uA	Delta %	Initial Value uA	Final Value uA	Delta %
2252	2256	0.19	2253	2255	0.115

Fig. 4.7: Board #34 Sensor Current Plot under Active Burn-in (Sensor passes)

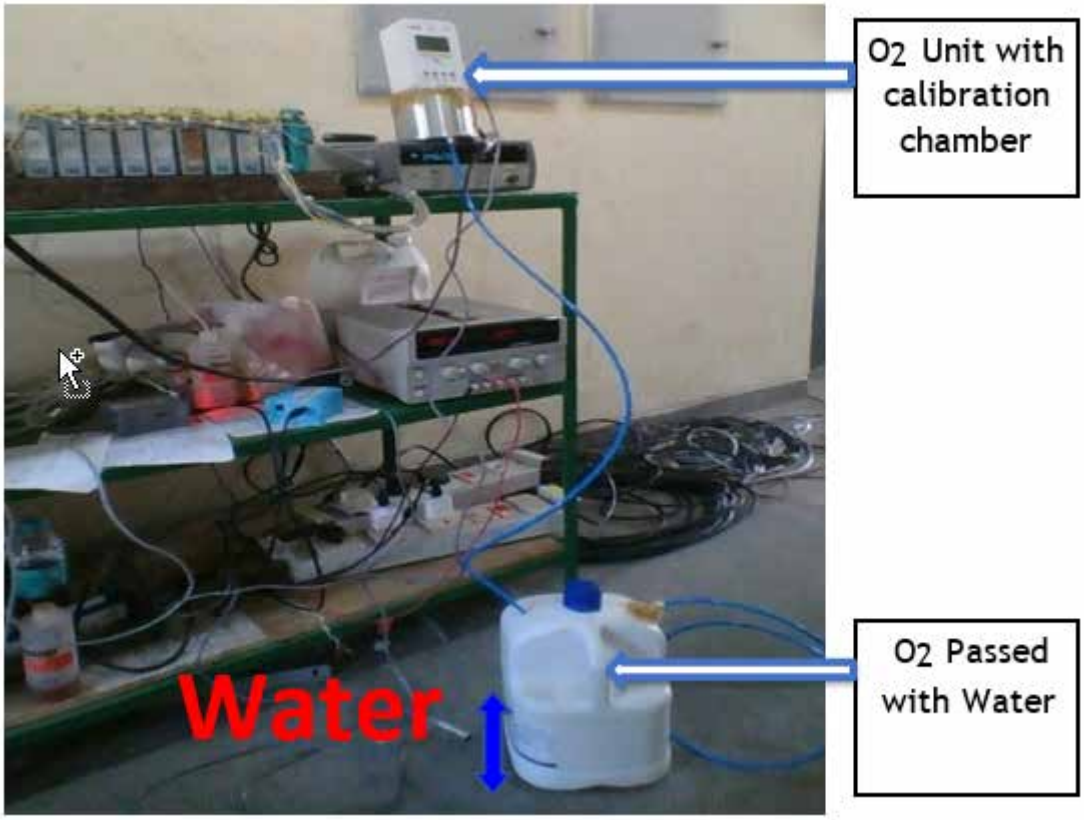


Fig. 4.8: O_2 Transmitter Humidifier Test Set Up.

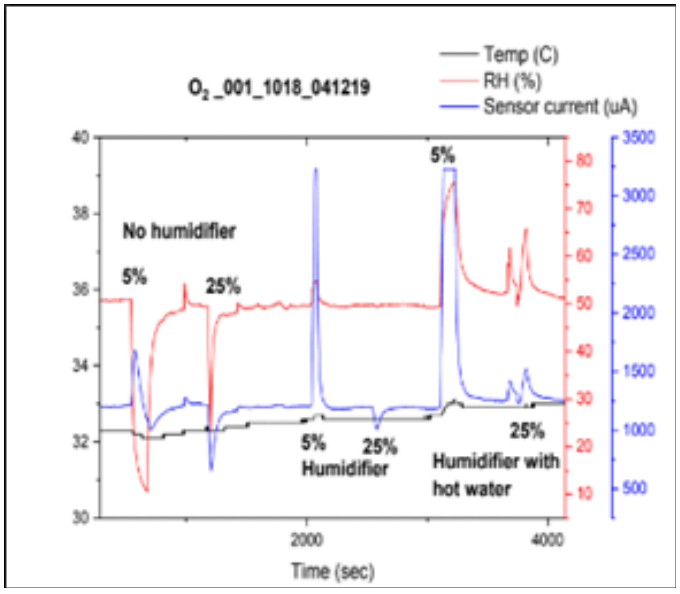


Fig. 4.9: Typical response of O_2 sensor at different humidity.

Prototype building and field trials and commercialization of the following: i) Rotary Wing UAV of 5 kg and 10 kg payload capacity, ii) High efficiency Vertical Axis Wind Turbine (VAWT) and (iii) Hybrid multirotor UAV: The work was aimed at Rotary-wing Unmanned Aerial Vehicle (RUAV) Ruggedization and field trials for commercialization. Research work at Indian Institute of Technology Kanpur, towards commercialization of an already developed

product with Technology Readiness Level (TRL) 6, to a level 8 to 9 product has been carried out. Industrial grade prototype has already been developed and flight tested for over 50 hours (Figure 4.10 a & b). One IC engine RUAV has been delivered to Aeronautical Development Establishment (ADE, DRDO) and two electric and one additional engine RUAV has been fabricated for delivery to ADE. ADE intends to use these as aerial platforms for their own research. A military grade prototype has also been developed using MIL grade Electric Fuel Injection (EFI) type engine and a MIL grade autopilot. The fabrication of this prototype has been completed, the flight testing with MIL autopilot is underway. A 30x zoom day with IR camera was also integrated with the current industrial grade prototype to create a high endurance surveillance solution that underwent Beyond Visual Line of Sight (BVLoS) trials with Indian Army at Mhow where the UAV successfully completed multiple missions that required it to fly at 1 km altitude above ground level to demonstrate at least 1 hr hover and surveillance capability and also flew for 15 km from launch location to target point and hovered there for over 20 minutes and then returned to launch point for precision landing (Figure 4.11).

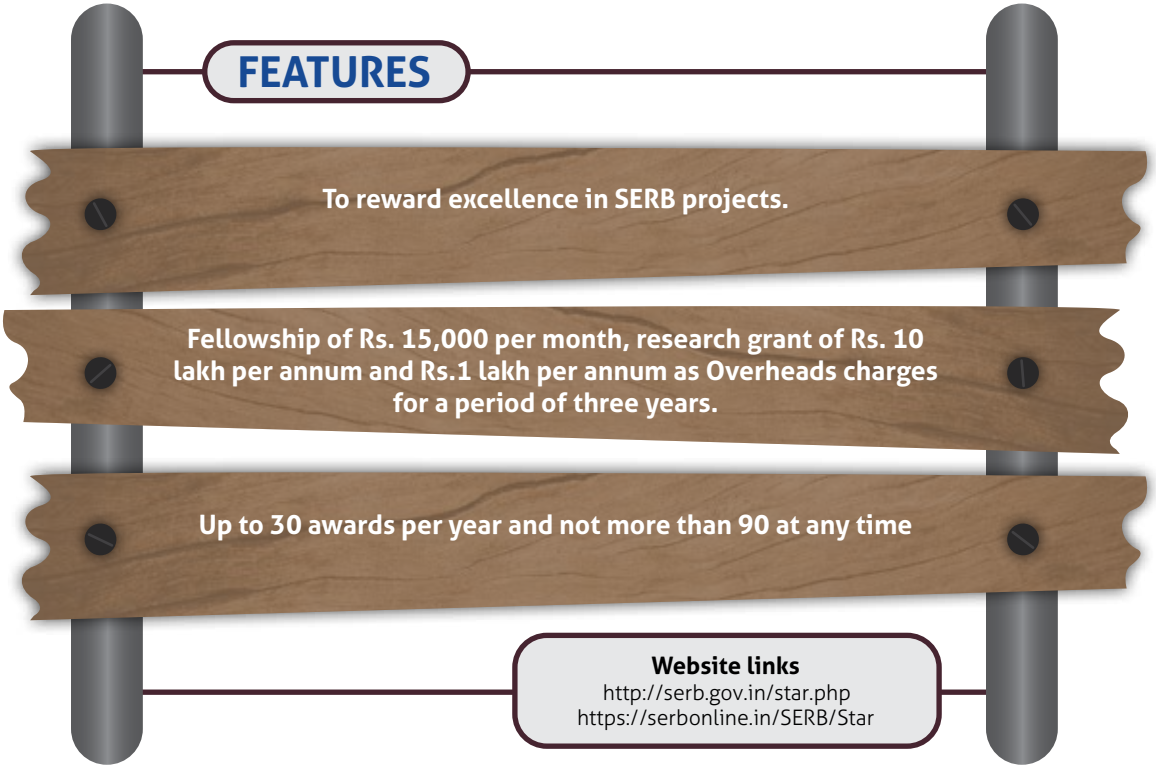
Fig.4.10: (a) Research prototype (b) Industrial grade prototype

Fig.4.11: Ground station screenshot from 15 km flight trial.

4.2 Fostering Young Scientists

4.2.1 SERB Science and Technology Award for Research (SERB-STAR)

SERB Science and Technology Award is instituted by SERB to recognize and reward outstanding performance of Principal Investigators (PIs) of SERB Projects. SERB-STAR is an initiative to acknowledge exemplary contributions in research and to motivate the PIs of ongoing projects for outstanding performance.



Research Highlights

Transition Metal Mimicking Catalysis Through Small Molecular Activation: Today's major concerns on the industrially used catalytic systems are i) high expense of catalysts; ii) toxicity of transition metals; iii) difficulties in the removal of trace amounts of toxic-metal residues from the desired product; and finally, iv) the large consumption of heavier and rare transition metals which do not meet the requirement of sustainable development. In this regard, the development of environmentally benign cost-effective catalysts is an ideal alternative. Naturally, the most recent trend in catalyst development heralded a new era using either earth-abundant, nontoxic, inexpensive metals or metal-free catalysis (Figure 4.12a, b).

The phenomenal ability of phenalenyl molecule, an odd alternant hydrocarbon, to switch between three redox states, namely closed shell cation, open shell radical and closed shell anion, have been utilized in this work. The research work carried out at Indian Institute of Science Education and Research, Kolkata focused to utilize the

various redox states of phenalenyl molecule in activating small molecules for different catalytic transformations. PI successfully achieved the anionic state of the molecule by employing a strong reductant, such as metallic potassium. Such double reduced anionic state successfully activated the carbon-halogen bonds for further C-H arylation of arene and heteroarene at room temperature without any external stimulation, such as heat, light, or constant electrical source. The strategy was further utilized for hydrodehalogenation and dehalogenative deuteriation.

With these exceptional properties of phenalenyl molecules, PI developed another important reaction, Heck-type C-C cross coupling reactions, exploiting both radical and anionic states of a phenalenyl molecule. It may be noted that Heck-type coupling traditionally uses expensive Pd-metal based catalysts and is a Nobel prize winning reaction for its tremendous industrial applications. For the first time, PI has developed a metal-free Heck type coupling protocol using the pehenalneyl catalyst. Different aryl halides were coupled with a styrene substrate to achieve a stilbene derivates *via* Mizoroki-Heck-type coupling at room temperature without any external stimulation.

22
Awards Sanctioned

4.04 cr
Expenditure
(New and Ongoing)

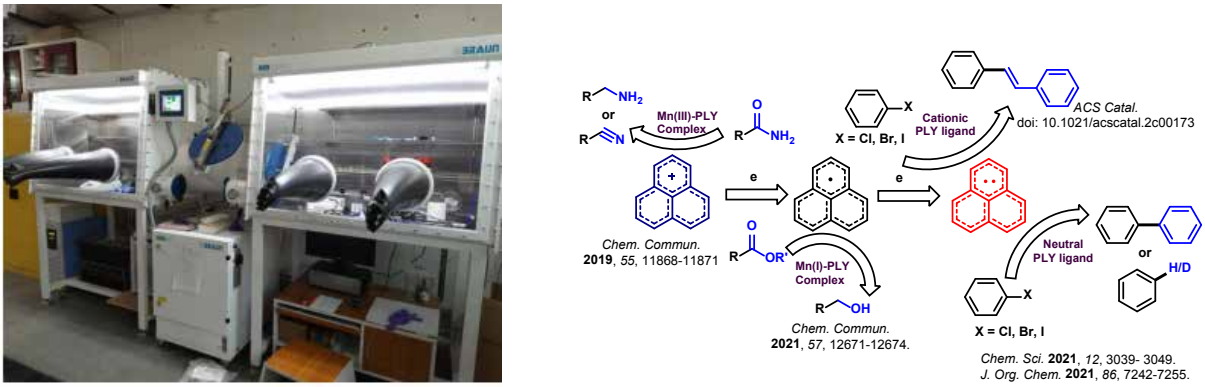


Fig. 4.12: a) Schematic diagram regarding the developments made under this project. b) Image of equipment procured under this project (Glovebox integrated with spectro-electrochemistry setup).

Elucidating Vitamin B12-driven diet-gene interactions that regulate food choice and longevity: There is an extensive range of dietary choices that an organism encounters in its natural habitat. The macronutrient and micronutrient quotients of these diets instruct downstream molecular events, eventually orchestrating complex physiological responses in the organism that determine their life history traits, including life span. In response to diverse nutritional inputs, organisms deploy multiple adaptive mechanisms to maintain optimal lifespan and health.

The PI at National Institute of Immunology, New Delhi worked on complex interaction between diet and genes that regulate life span of an organism in response to diverse nutritional inputs. These interactions are hard to identify in the laboratory as an organism maintains normal life span on a wide range of diet. However, in rare cases, a mutant laboratory animal, with the

mutation attributed to a single gene, may exhibit altered physiological traits only on a particular diet but not in others. These "gene-diet pairs" are instrumental in understanding how the quality of diet influences physiological traits like longevity and health.

In 2018, investigator's lab identified one such diet-gene pair in the bacterivore nematode *C. elegans* when the *flr-4* gene mutant was found to exhibit a diet-responsive increase in life and health span. The mutant lives longer on one bacterial diet but not on the other. Vitamin B12 as the micronutrient whose quantity is different between the two bacterial strains was identified. Importantly, the bacteria with higher Vitamin B12 content can drive life span extension in the mutant worm. He showed that the increased Vitamin B12 content in the bacteria, coupled to the increased sensitivity of the mutant to this micronutrient, engages downstream metabolic processes and signaling pathways to activate cyto-protective programs required for extending life span. It may be noted that humans cannot synthesize Vitamin B12 and are completely dependent on food as well as their gut-resident bacteria (microbiota) for its supply. For the nematodes, the bacteria act both as their food as well as the microbiota that supplies micronutrients like Vitamin B12 (Figure 4.13). So, molecular genetic characterization of such micronutrient-responsive gene-diet pairs provide insightful understanding of how the varied nutritional/dietary inputs, having different micronutrient content, modulate organismal health through the commensal gut microbiota.

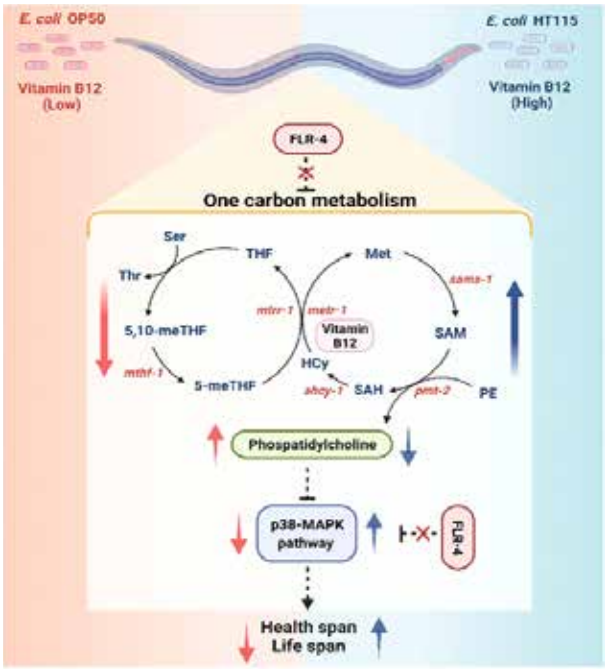


Fig. 4.13: A model depicting the possible mechanism by which *C. elegans* FLR-4 maintains adaptive capacity to bacterial diet differing in B12 content. On high B12 diet, flux through the one-carbon metabolism increases to potentially lower PC levels; this leads to activation of the p38-MAPK pathway. However, FLR-4 prevents aberrant activation of the p38-MAPK pathway leading to normal life span in wild-type worms. In the *flr-4(-)*, the lower PC levels activate the p38-MAPK, increase CyTP gene expression, enhance osmotic tolerance and increase life span.

4.2.2 Swarnajayanti Fellowship

Swarnajayanti Fellowship was initiated in the year 1997-98 to commemorate the 50th year of India's independence. The scheme entails fellowships and research grants to young scientists in contemporary areas of science and technology.

Presently, DST is executing the scheme, and SERB will be providing additional funding to meet the required expenditure pertaining to the research objectives enumerated in the proposal submitted by the selected applicants.

AWARDS AND FELLOWSHIPS

FEATURES

Prestigious fellowship awarded annually by DST for notable and outstanding research by young scientists

The award consists of a Fellowship of Rs 25000 per month in addition to the salary drawn from the parent Institute for a period of five years

The fellows selected along with projects will be considered for funding by SERB

Website links
https://dst.gov.in/scientific-programmes/scientific-engineering-research/human-resource-development-and-nurturing - young-talent-swarnajayanti-fellowships-scheme

Research Highlights

Ocean alkalinity enhancement and its impacts on biogeochemical cycling: Atmospheric CO_2 pose a serious threat to climate and ecosystems and developing reservoirs that can store up to trillions of tons of CO_2 emitted from industrial and other man-made emissions, is therefore imperative. Based on the understanding of the intense chemical weathering resulting in global cooling in the Cenozoic era, it is proposed that the enhanced ocean alkalinity through large-scale mineral dissolution has the potential to provide a solution to store large amount of CO_2 in the ocean. Mineral dissolution will lead to a change in the ocean carbonate chemistry equilibrium towards HCO_3^- and CO_3^{2-} (i.e., increase in alkalinity), so that additional CO_2 from the atmosphere could be dissolved and stored for a long time (>1000 years) in the ocean. It may be possible to sequester up to trillion tons of carbon without surpassing present-day carbonate saturation states in the ocean. In turn, the impacts of elevated alkalinity will be potentially small and may even help to reduce the effects of ocean acidification on the microbial ecosystem, but these aspects have not been tested experimentally. In the project supported under Swarnajayanti Fellowship, the fellow group at Physical Research Laboratory (PRL) Ahmedabad, have proposed to test the potential of enhanced ocean alkalinity for atmospheric CO_2 removal and identify minerals that can be used to enhance

16
Fellowships Sanctioned

26.78 cr
Expenditure
(New and Ongoing)

ocean alkalinity in a sustained way (Figure 4.14). The project also aims to examine the impact of increased ocean alkalinity on carbon, nitrogen and phosphorous cycles, and understand the effect of increased alkalinity on phytoplankton and bacterial community structure.

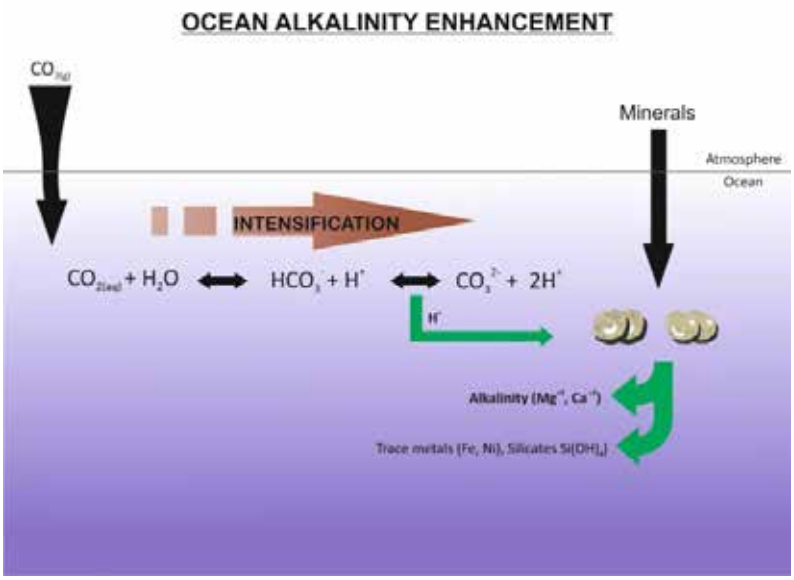


Fig. 4.14: Schematic showing the atmospheric CO_2 removal through enhanced weathering in the ocean.

4.2.3 Ramanujan Fellowship

Ramanujan Fellowship is meant for brilliant Indian scientists and engineers working abroad who aspire to take up scientific research positions in India.

FEATURES

- The Fellowship amount is Rs. 1,35,000 per month (consolidated including HRA)
- Each Fellow will receive a research grant of Rs. 7 lakh per annum and Rs. 60,000 per annum as Overheads charges
- The duration of the fellowship is for five years, and not extendable

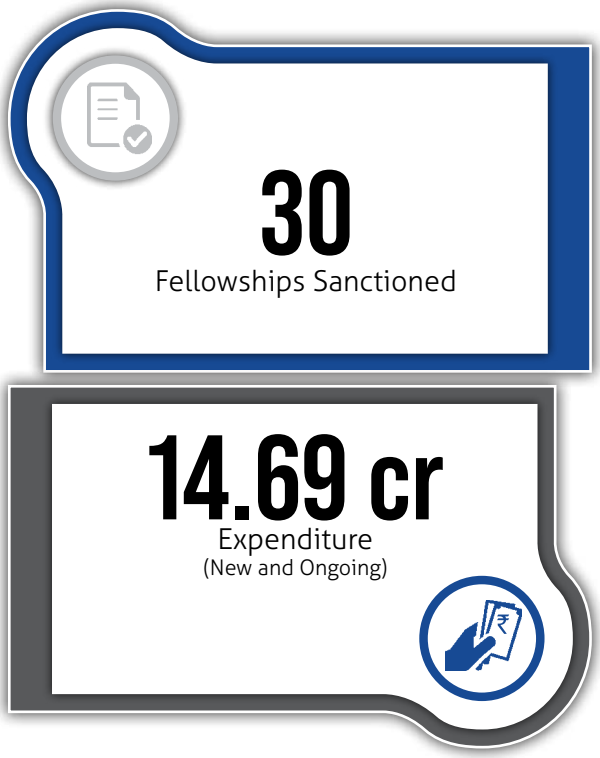
Website links
http://serb.gov.in/rnf.php
https://serbonline.in/SERB/Ramanujan_fellowship

Research Highlights

Disinfection-Solidification System for Pathogenic Biomedical Waste Disposal: With the advent of Covid-19 and the emergence of harmful microbes, effective disposal of biomedical waste has seen an unprecedented significance. One way to manage liquid biomedical waste is to add a solidifying agent to reduce the risk of spills and aerosolization. If the solidifying agent contains a disinfectant, it may be possible to dispose the waste as non-regulated medical waste, which is less expensive than red-bagging. However, simple acrylates or hypochlorites are not always capable of treating biomedical waste effectively (Figure 4.15).

In an attempt to prioritize the R&D activities towards the national demand in mitigating the spread of the pandemic, developed potential candidates for spontaneous disinfection and immobilization of pathogenic biomedical waste using a dual disinfection-solidification system. This system, with inherent antimicrobial activity, is capable of disinfecting both liquid as well as solid samples, and results in complete solidification instantaneously upon mixing. Complete microbial disinfection was observed within 1 minute of contact. Segregation, transportation and disposal of such disinfected medical waste are easier and safer with significant reduction in cost for a healthcare facility. The team has tested and validated several fluid and solid biomedical waste models and mixtures in the laboratory. Accordingly, three families of patents have been filed to ensure IP protection.

The know-how has been transferred to a start-up in Kerala, Bio Vastum Solutions (BVS) Pvt. Ltd. (Angamaly) and was recently demonstrated in full-scale at the industrial facility. PI and his team are currently working towards a completely biodegradable solidification system that would provide an innovative and sustainable solution to the pathogenic biowaste disposal issues in the country. This technology is fully aligned to the government missions on Atma Nirbhar Bharat, Swachh and Swasthya Bharat and Start-up initiatives. This work is being carried out at CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram.



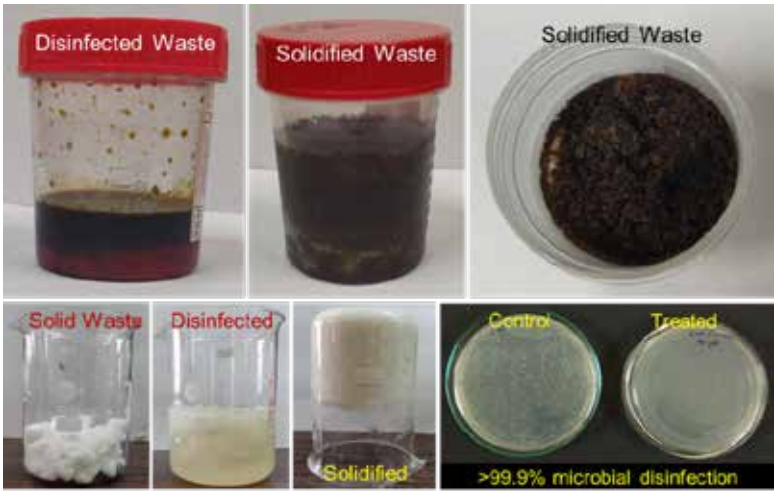


Fig. 4.15: Photographs showing the disinfection-solidification process involving fluid biomedical waste model (top), and solid biomedical waste model and microbial disinfection after 1 minute of contact (bottom)

A 2 - Tyr - 1 - carboxylate Mononuclear Iron Centre Forms the Active Site of a Paracoccus Dimethylformamidase: *N,N*-Dimethyl Formamide (DMF), due to its miscibility in water and many organic solvents and high boiling point is one of the most used solvents in industry. These properties of DMF also make it hazardous. Not surprisingly, several bacterial species have evolved pathways to breakdown DMF and use them as energy source for growth. Dimethylformamidase (DMFase) is the first enzyme in this pathway, which breaks down DMF into dimethyl amine and formate. It was biochemically characterized the enzyme from the bacteria *Paracoccus* sp. strain DMF and determined the structure by electron cryomicroscopy and X-ray crystallography (Figure 4.16). The structure reveals a ternary complex whose equilibrium depends on salt concentration. The active site is made of a mono-nuclear iron coordinated by two tyrosine residues and a glutamic acid. The large size of the enzyme plays the dual role of providing halo-stability as well as the stabilization of the unusual coordination state of the iron that is critical for breaking down the stable DMF at ambient temperatures. Our results reveal the molecular architecture and properties of an interesting amidase that evolved recently and breaks down a highly used, toxic industrial solvent. This work is being carried out at National Centre for Biological Sciences, Bengaluru.

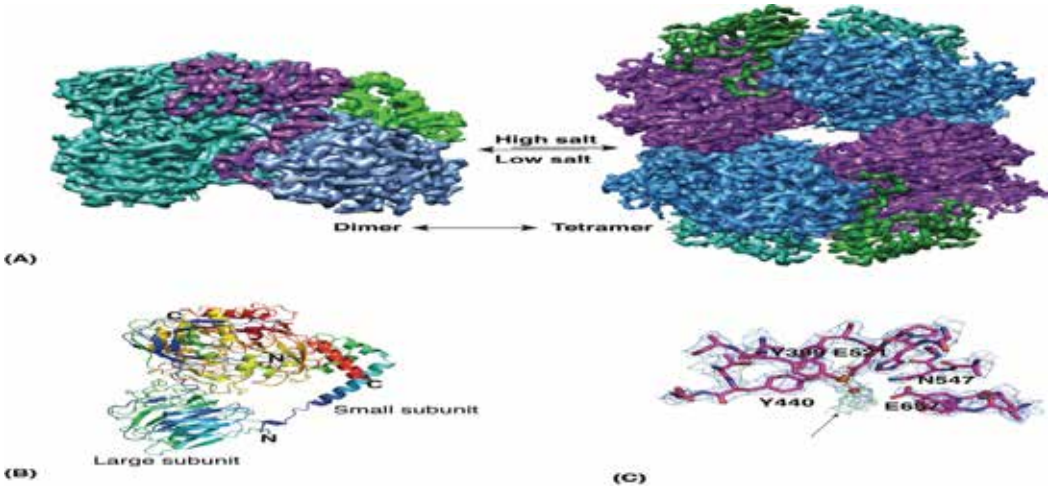
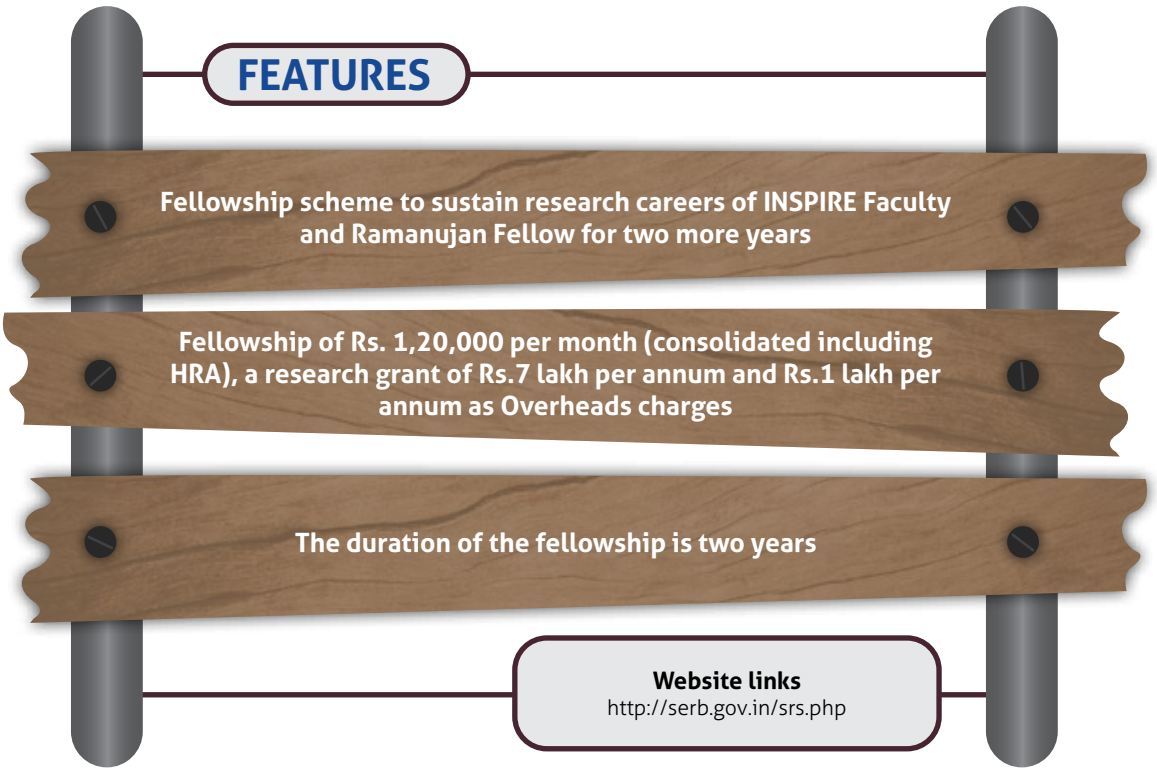


Fig.4.16: Structure of Dimethylformamidase (DMFase): (A) CryoEM maps of the dimeric and tetrameric forms. DMFase has two polypeptides (85 kDa and 15 kDa, which are the large and small subunits). The polypeptides of the large subunit are colored in blue and teal, while that of small subunit is colored in magenta and green. The equilibrium between dimer ($\alpha_2\beta_2$) and tetramer 2x($\alpha_2\beta_2$) is dependent on salt concentration. (B) The fold of the monomer of the enzyme. Both subunits are colored in rainbow with the N-terminus in blue and the C-terminus in red. The active site is present in the large subunit. (C) The active site of DMFase showing the FE atom coordinated with hydroxyls of tyrosine and glutamate. Other key residues are labelled. The cryoEM map is in blue mesh and the extra unmodelled density in the active site is marked with an arrow.

4.2.4 SERB Research Scientist (SRS) Scheme

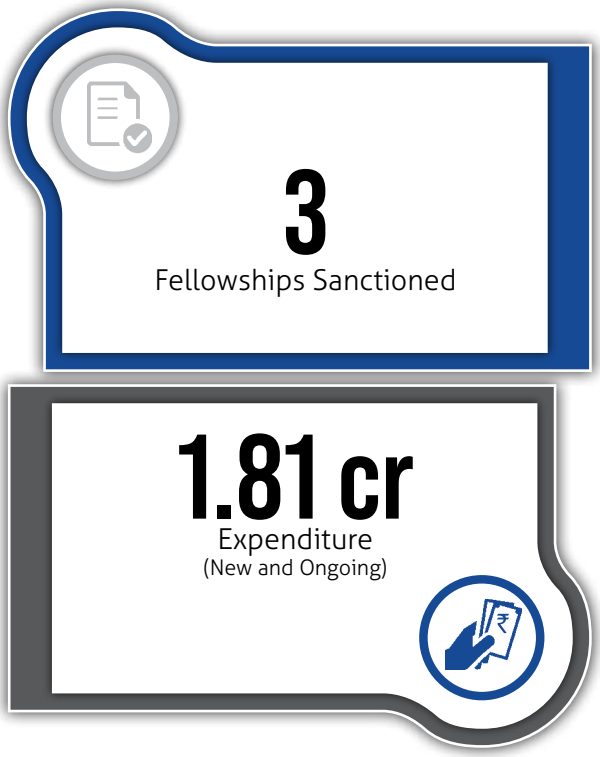
The INSPIRE Faculty Scheme of DST and Ramanujan Fellowship Scheme of SERB offer opportunities for young scientists in various field of Science and Engineering. These schemes do not offer extension of the fellowship after completion of five years. The support link is broken after the end of the tenure of the respective fellowships. To provide a platform for sustainment of their research for some more time, SERB initiated a scheme called SERB Research Scientists (SRS) Scheme in 2018-19 for the awardees of INSPIRE Faculty scheme and Ramanujan Fellowship, who fail to secure regular positions after completion of the regular tenure of five years in the respective schemes. The scheme provides an opportunity for them to continue their research activities and to explore for regular positions during the intervening period.

AWARDS AND FELLOWSHIPS



Research Highlights

Decrypting the molecular circuitry of human brain development: Expanding horizons of 3D human brain organoids for studying neurological disorders: Till now, animal models have been used tremendously to study the brain related disorders and the drugs which function in animal models have been failed in clinical trials. This project work was done at Translational Health Science and Technology Institute, Faridabad, supported to generate human based 2D and 3D brain *in vitro* models to understand the brain dysfunction. The group has optimized a method from India for the first time by generating and producing induced pluripotent stem cells (iPSCs) from human umbilical cord blood and differentiated iPSCs into the 2D brain specific stem cells i.e., neural stem cells (NSCs). The earlier work has revealed how the small non-coding RNA converts neural stem cells into neurons (Figure 4.17). Now they have seen how the energy demands of newly generated neurons are satisfied by non- coding RNA. This work suggests that generation of new neurons by a small non-coding RNA may facilitate the new treatment paradigms for neurodevelopmental disorders and aging-associated neurodegenerative diseases.



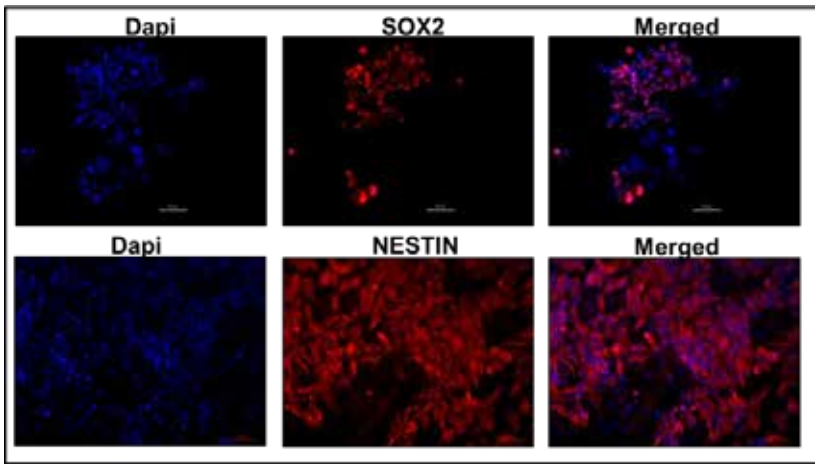
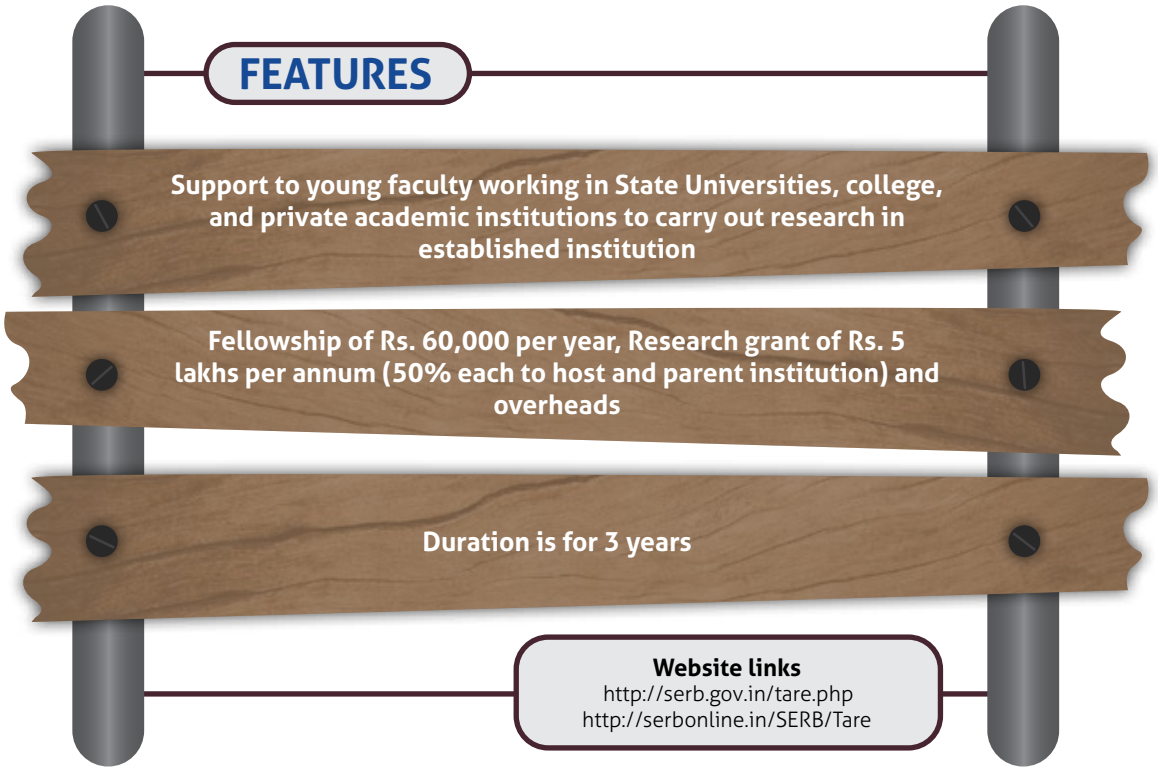


Fig. 4.17: Differentiation of IPSCs into neural stem cells (NSCc): NSCs generated from IPSCs were immunostained with neural stem cell markers SOX2(upper panel),NESTIN (lower panel) and DAPI for nucleus (blue). These images were obtained using a 20X objective.

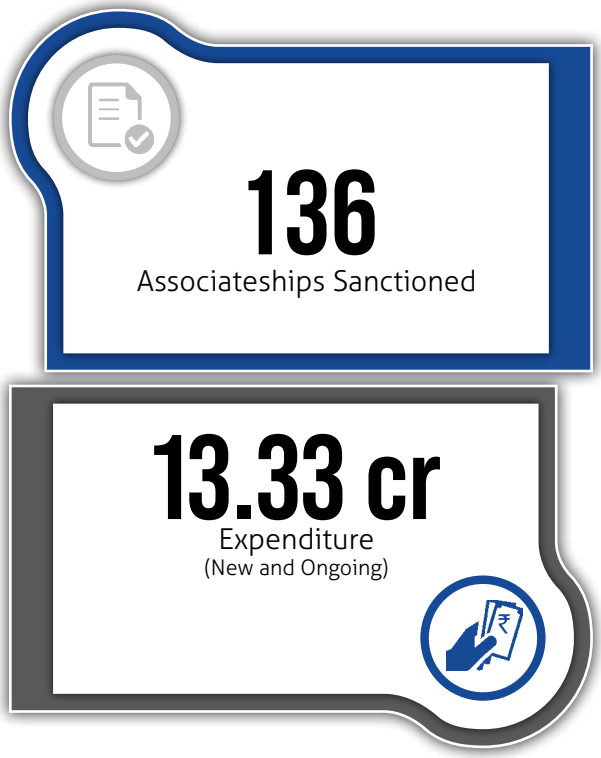
4.2.5 Teachers Associateship for Research Excellence (TARE)

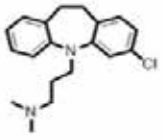
This scheme facilitate mobility of faculty members working in a regular capacity in State Universities / Colleges and in private Academic Institutions to get experience and carry out research work in an established public funded institution such as IITs, IISc, IISERs, National Institutions (NITs, CSIR, ICAR, ICMR labs and other central institutions) and Central Universities, located preferably nearer to the institution where the faculty member is working. Research work is planned in a manner such that PI continues to work in the host institute as well as in the parent institute on mutually agreed terms between the PI and the mentor.



Research Highlights

Synthesis and Characterization of Functional Carbon Quantum Dots as Chemosensors for Drug Molecules: Carbon quantum dots (CQD) have attracted a lot of attention these days due to their distinguishable characteristics such as size-tunable light emission, better signal brightness, resistance against photobleaching and simultaneous excitation of multiple fluorescence colors 1,2 etc. from that of the conventional organic dyes and fluorescent proteins. In addition to having the similar fluorescent properties as compared to heavy metal semiconductor quantum dots, these CQDs are in vogue these days in the field of research due to their added advantages of low toxicity, low cost, aqueous solubility and simple synthetic routes. CQD-Tb were used in the present study, owing to the unique spectroscopic characteristics of lanthanides such as large Stroke shifts, long fluorescence lifetimes and sharp line like emission bands arising from f-f transitions. CQD-Tb were synthesised by a single step one pot hydrothermal method in an aqueous medium and characterized. Competitive binding studies were performed in the presence of other drugs so as to check the interference of other drugs with Clomipramine – CQD-Tb binding (Figure 4.18). The selective response was found for Clomipramine, which was further confirmed by performing competitive binding studies. No interference in the presence of other drugs is found which make CQD-Tb as a selective and sensitive sensor for the detection of Clomipramine. fCQDS synthesized was found to be selectively responded by CN-. Competitive binding studies confirmed that no interference in the presence of other anions, thus, making fCQDs as a selective and sensitive sensor for the detection of CN-. Hence, it is reported CQD-Tb as a selective and sensitive sensor for the detection of antidepressant drug Clomipramine and the fCQDs as an effective sensor to detect the cyanide ion. This work is being carried out at Post Graduate Government College for Girls, Chandigarh.





Structure of Clomipramine

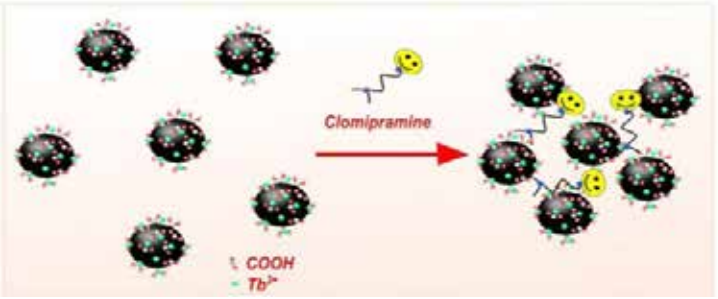


Fig. 4.18: Schematic representation depicting the sensing mechanisms of Chlompramine detection.

Establishment of an experimental setup for validation of analytical modal and simulation of thermal analysis of a travelling wave tube for space applications: The heat-dissipation capability of the slow-wave structure (SWS) of the Travelling Wave Tube (TWT) is one of the influencing factors that can contribute to obtain high average output power. The thermal performance of the SWS can also affect the stability and reliability of the TWT. Hence, the main goal of this proposed work was to develop a thermal model for SWS, that is the most important and critical part of the tube, as it plays a significant role in performance and efficiency of satellite transponder. An experimental setup was introduced for the estimation of helix temperature in its operating conditions to investigate the performance of the tube (Figure 4.19). For this measurement setup, practical operating conditions including high vacuum is established to predict the temperature distribution using thermocouple wire at several points on helix. When achieving the required vacuum level, voltage in regular steps is increased applied to the helix assembly thereby increasing the helix power. It was observed that at low input power levels (4 watts), helix temperature is not measurable due to the resolution limitation of optical pyrometer. On increasing the input power beyond 4 watts, temperature of the helix increases and reaches to a maximum possible value. Simulations are carried out in ANSYS software for predicting the temperature distribution of SWS. In simulations (Figure 4.19), saturation of temperature is not achieved; instead, a linear relation between the applied input power and obtained helix temperature is seen whereas in experiment, saturation of helix temperature is observed, because of neglecting the TCRs and temperature independent thermal conductivities of materials tested. This work was carried out at Banasthali Vidyapith, Banasthali.

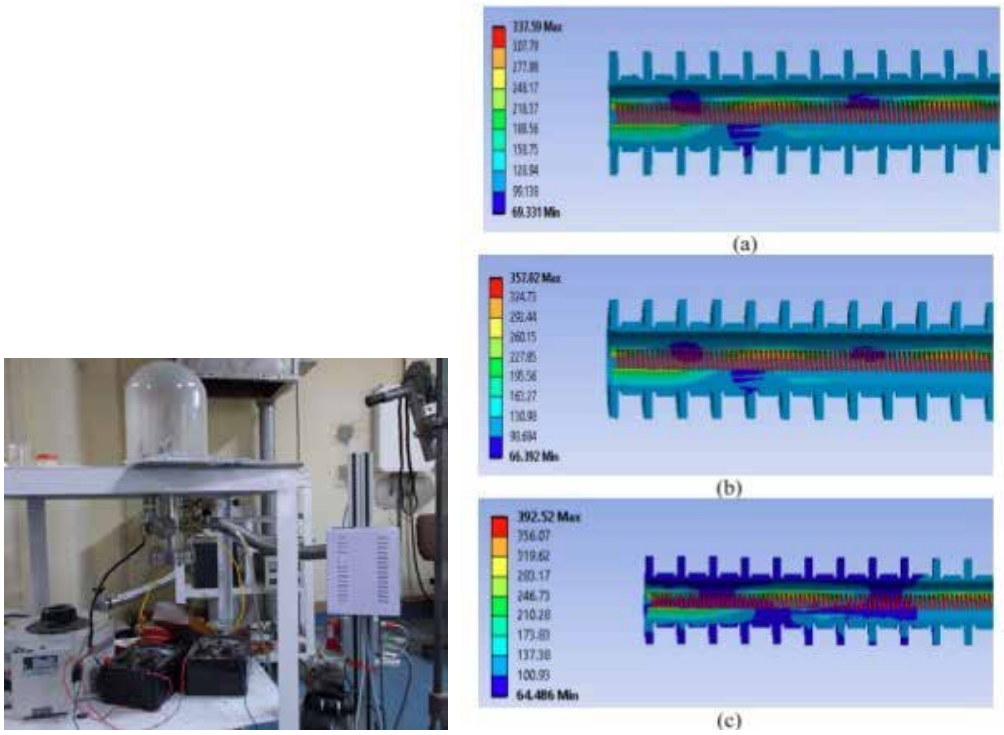
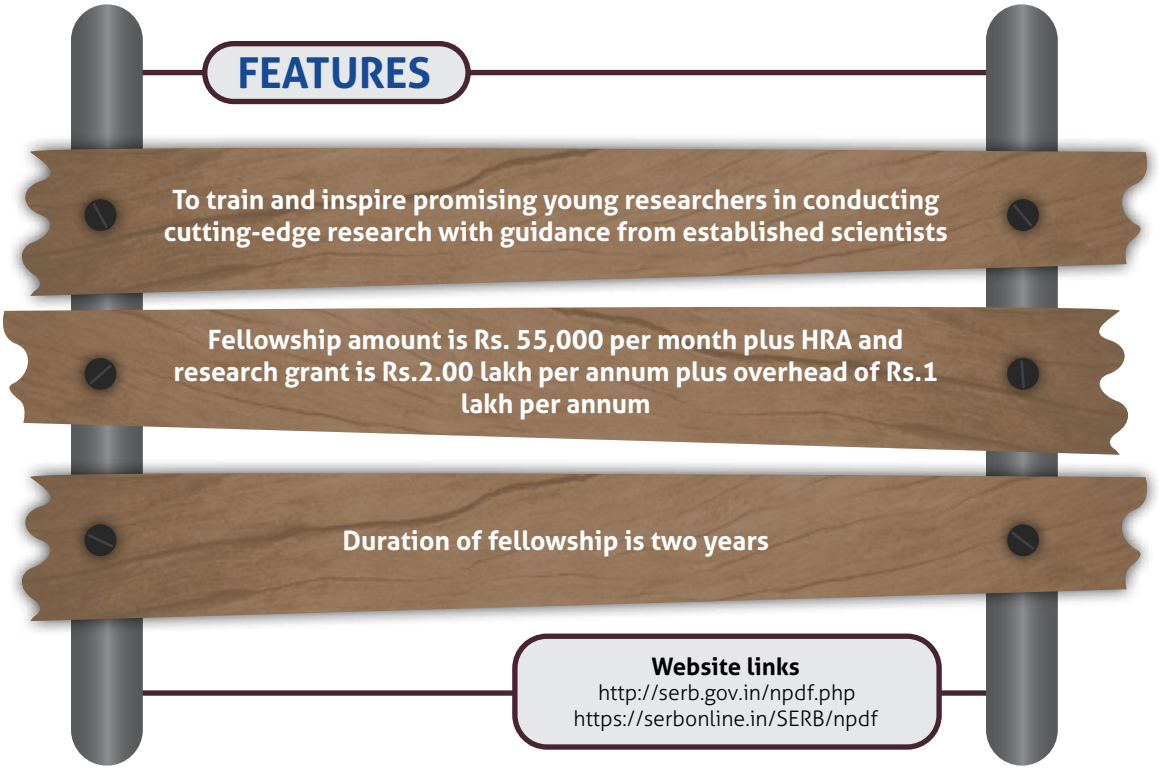


Fig. 4.19: Experimental setup for the estimation of helix temperature and simulations.

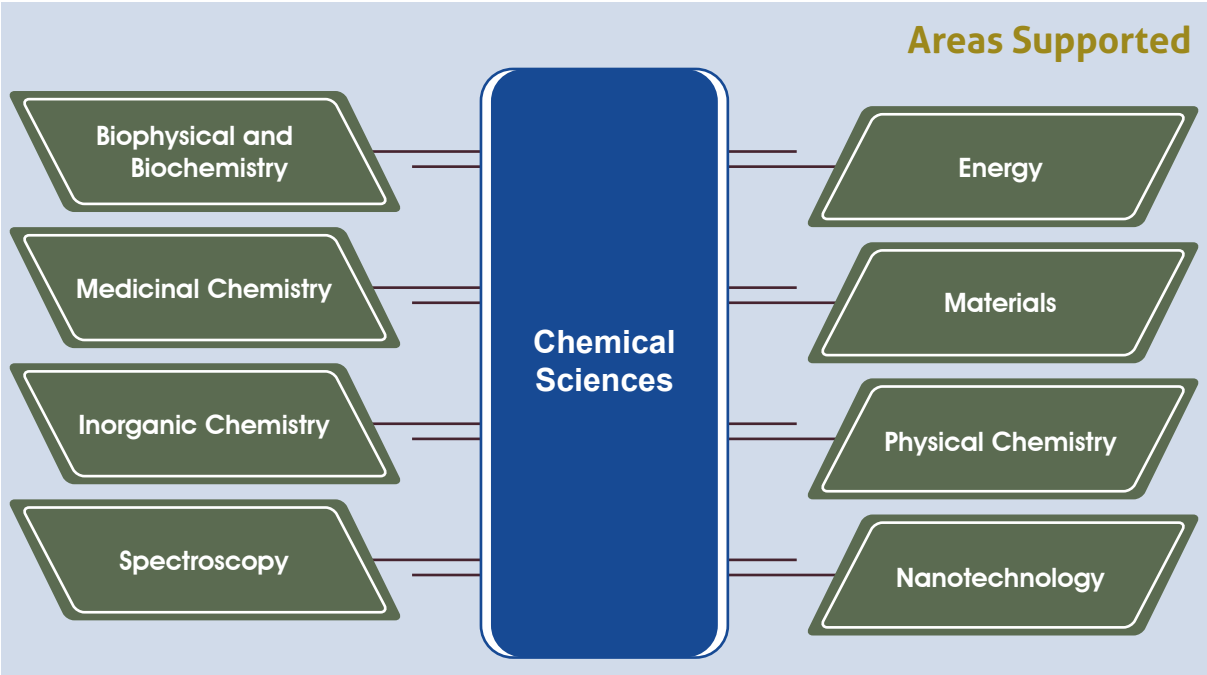
4.2.6 National Post-Doctoral Fellowship (NPDF)

The SERB-National Post-Doctoral Fellowship (N-PDF) aims to provide support to young researchers to undertake the research in frontier areas of Science and Engineering. The fellows will work under a mentor, and it is hoped that this training will provide them a platform to develop as an independent researcher. There are five discipline-wise verticals that are guided by individual Expert Committee.



4.2.6.1 Chemical Sciences

In the reporting period, 45 new fellowships were sanctioned. The areas supported under NPDF – Chemical Sciences are shown in the following figure.

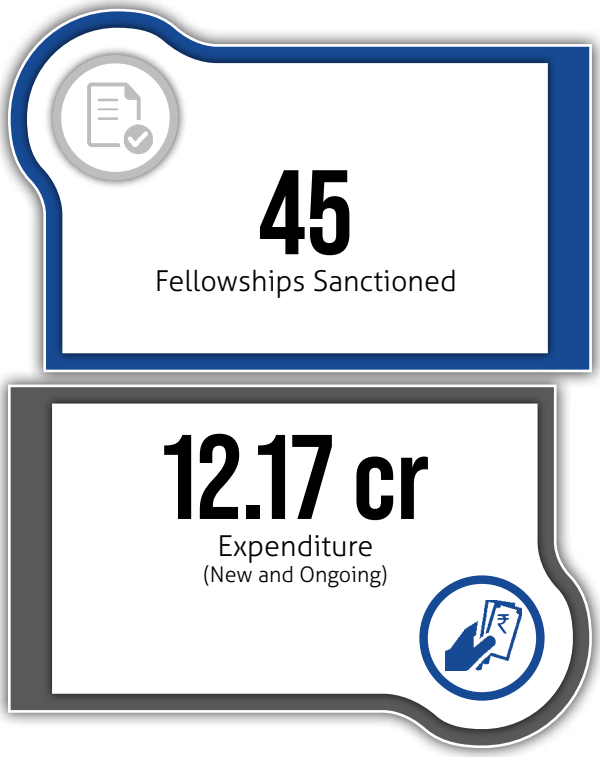


Research Highlights

Interface Engineering of Inorganic Nanomaterials utilizing 0D Carbonaceous Materials for robust and overall Water Splitting: Electrochemical and solar-driven photo-electrochemical water splitting for hydrogen and oxygen production are appealing approaches to provide affordable clean energy. In this regard, zero-dimensional (0D) carbon based material, especially, carbon dots (CDs) or graphene quantum dots (GQDs) associated with quantum-confinement and edge effects will be suitable to integrate the HER and OER catalysts in a single electrolyte.

The group at Indian Institute of Technology, Kharagpur have developed a facile carbothermal approach for the design of CoNi@N-doped bamboo-like carbon nanotubes (NCNTs) from NiCo-MOF (Figure 4.20) The hollow MOF here is found to play a sacrificial role for the controlled growth of CoNi alloy and NCNT, resulting different degree of graphitization. The synthesized material acted as robust oxygen electrocatalyst with a low potential gap (ΔE) of only 0.8 V. The electrocatalyst showed excellent durability while retaining the phase purity as well as morphology even after an extensive durability test. This is attributed to the encapsulation of alloy into graphitic carbon.

An aqueous rechargeable Zn-air battery (ZAB) was fabricated, which demonstrated high open-circuit voltage of 1.53 V and a maximum peak power density of 167 mW cm^{-2}, with negligible loss in voltaic efficiency after 36 h of charge–discharge cycles. ZAB driven water splitting was also demonstrated and the assembled ZAB successfully powers the water electrolyzer for 15 h without additional power, further highlighting the performance of the ZAB. These developed methods could potentially be utilized for the large-scale synthesis of bamboo-like nanostructured materials with different degrees of graphitization and can be effectively used for various other electrocatalytic applications.



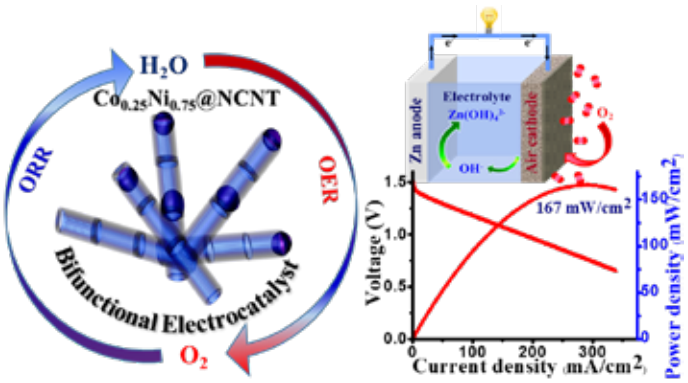


Fig. 4.20: Graphitic Carbon Encapsulated CoNi@N-doped Bamboo-like Carbon Nanotube as Oxygen Electrocatalyst for Zn-Air Battery Application.

Utilization of Oleophilic Atomically Precise Metal Nanocluster in Aqueous Medium through Host-Guest Self-Assembly Approach: Structure-property correlation, with great control over the atomic homogeneity in size, shape, composition and electronic wave-functions is a desired attribute of metal nanoclusters. However, issues related to their stability and solubility make

it difficult for application. Encouraged by the concept of atom-precision, the group at Indian Institute of Science Education and Research, Thiruvananthapuram has developed strategies, to counteract this inherent disadvantage of nanoclusters. At a first step, atom precise silver and copper nanoclusters were synthesized by varying the surface protecting ligands. The choice of the ligands played an important role in determining their solubility. To boost the stability of water-solubilize ligand containing silver nanocluster, the fortifying impact of assembling individual nanoclusters by organic ligands was then utilized (Figure 4.21). The designed one-dimensionally linked phenyl phosphonate protected $[Ag_2(PhPO_3H)_2(4,4'\ azopyridine)_2]$ is a water-soluble silver cluster assembled material, that was successfully applied as an imaging probe to mimic the blood vessel inside the chicken breast tissue through photoacoustic imaging. The stability of oleophilic adamantanethiol-protected Cu(0) containing $[Cu_{18}H_3(S\text{-}Adm)_{12}(PPh_3)_4Cl_2]$ nanocluster was improved by recognition site-specific host-guest adduct formation with water-soluble β-cyclodextrin. The attachment of a bulky supramolecular architecture on the ligand restricted the surface molecular motion of the nanocluster in solution by imposing rigidity that protected the fragile core by blocking the direct interactions with the destabilizing agents. The surface rigidity directly influenced the photophysical properties which were employed in photocurrent generation.

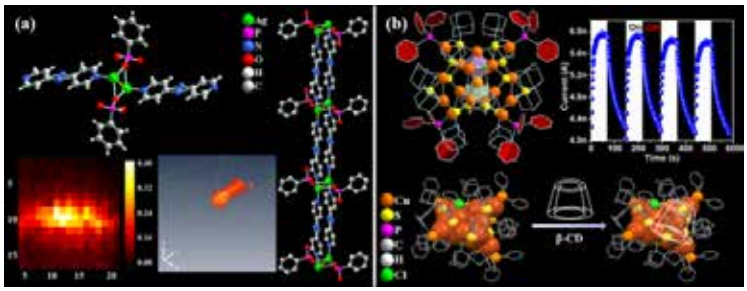
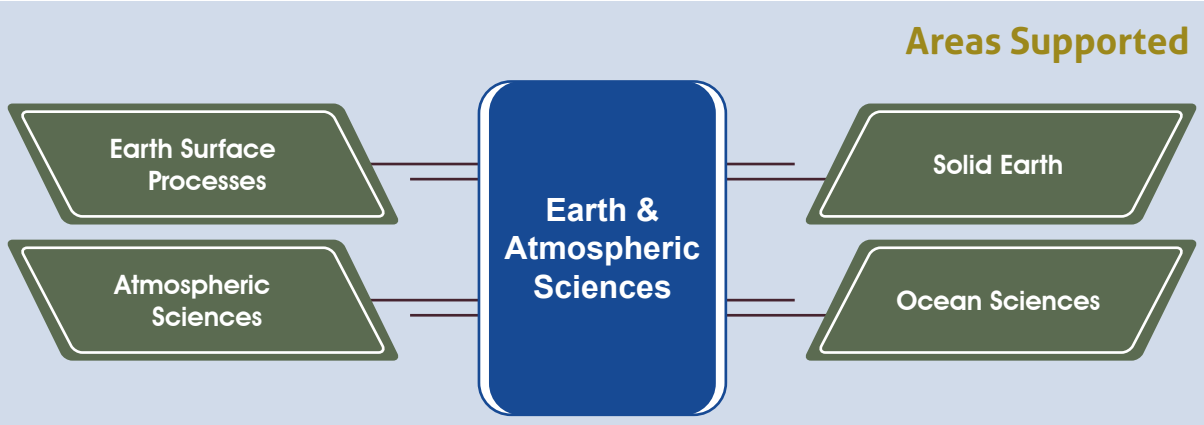


Fig. 4.21: (a) The structure of smallest silver cluster node which is assembled one-dimensionally, due to its water solubility it was utilized as 2-D and 3-D imaging probe for photoacoustic imaging. (b) Adamantanethiol-protected Cu(0) containing nanocluster which was capped by β-cyclodextrin and utilized in photocurrent generation.

4.2.6.2 Earth and Atmospheric Sciences

In the reporting period, 14 new fellowships were sanctioned. The areas supported under NPDF – Earth and Atmospheric Sciences are shown in the following figure.



Research Highlights

Molluscs response to the Early Paleogene hyperthermal and trangressive events: A case study from western India: The research aims to delineate the early Eocene hyperthermals in the Kutch Basin based on the $\delta^{13}C$ analysis of organic carbon and intends to see if there is any relationship between the mollusc-bearing marine interval of the succession and hyperthermals.

High-resolution $\delta^{13}C$ data have been gathered from Umarsar lignite mine section of Kutch. The data, when plotted against the lithological succession, reveal five negative carbon isotope excursions (CIE) representing early Eocene hyperthermal events (Figure 4.22). They are identified based on their position in the succession and relative spacing. ETM2 and H2 represent mollusc bearing units that seems to corelate with marine transgression which shows the association between hyper thermal events and transgression. A higher sea level during this time than during the Palaeocene-Eocene Thermal Maximum (PETM) is also suggested which is supported by the global sea level curves.The present work was carried out at Presidency University, Kolkata also involves a detailed study of the Eocene bivalve fauna of Kutch Basin. The systematic study on the Eocene bivalves from Kutch has yielded 40 species belonging to 26 genera. This include 14 new species (Figure 4.23). The palaeobiogeographic distribution of the identified Eocene Kutch species show strong endemism. A total of 17 species are found to be restricted to the Kutch Basin and 28 are restricted to the Western Indian Province. The latter province includes other western Indian and Pakistan basins along with Kutch. Global palaeobiogeographic distribution of all the Paleogene bivalve genera was found to be longitudinally widespread. In contrast, the strong specific endemism of the Eocene bivalves, in spite of their largely planktotrophic larval development, indicates rapid allopatric speciation. Composition, morphology, diversity and abundance of benthic molluscs from the early Paleogene of Kutch, Gujarat indicates marginal marine environment with restricted and often fluctuating marine influence. Low-diversity and high-abundance fauna, characterized by opportunist species, during major part of the early and middle Eocene is evidence to it.

14
Fellowships Sanctioned

3.74 cr
Expenditure
(New and Ongoing)

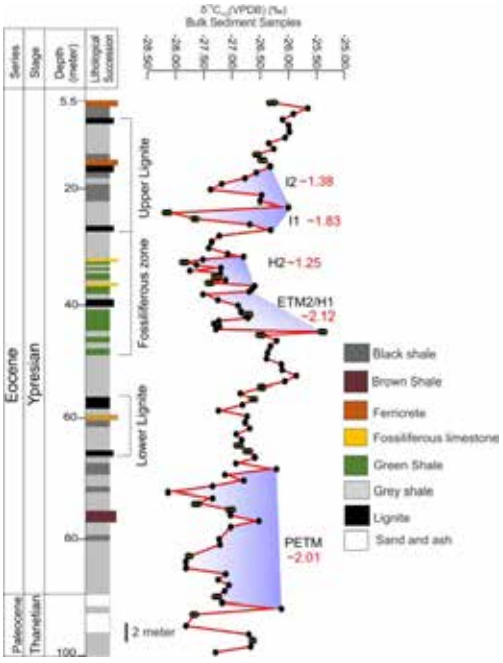
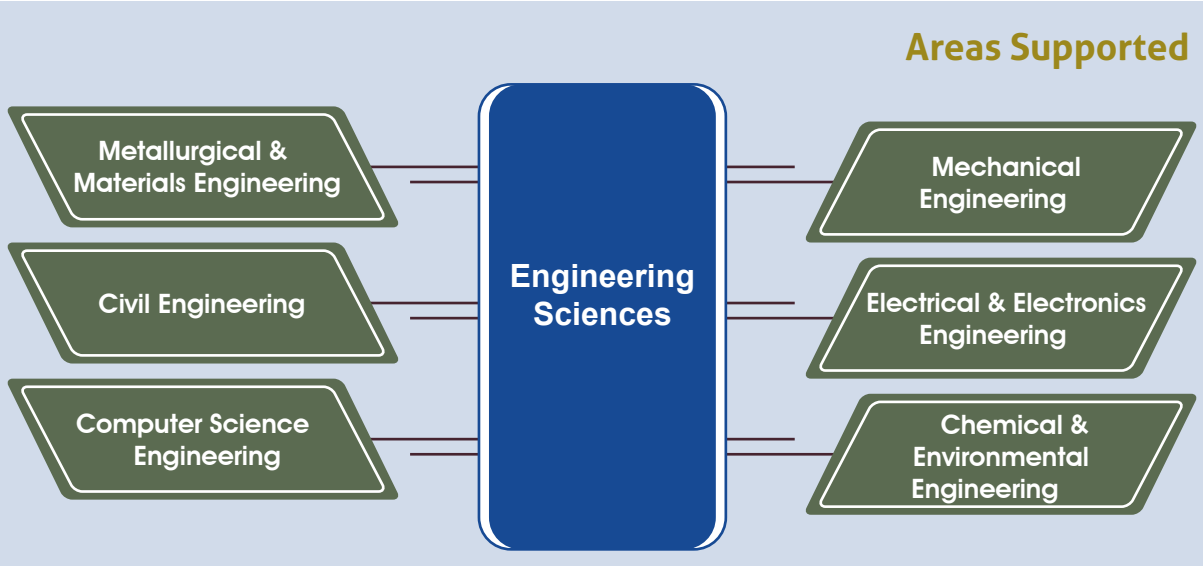


Fig. 4.22: Bulk sediment organic matter δ13C stratigraphy along with the hyperthermal events.

Fig.4.23: Newly recorded bivalve taxa from the Eocene of Kutch

4.2.6.3 Engineering Sciences

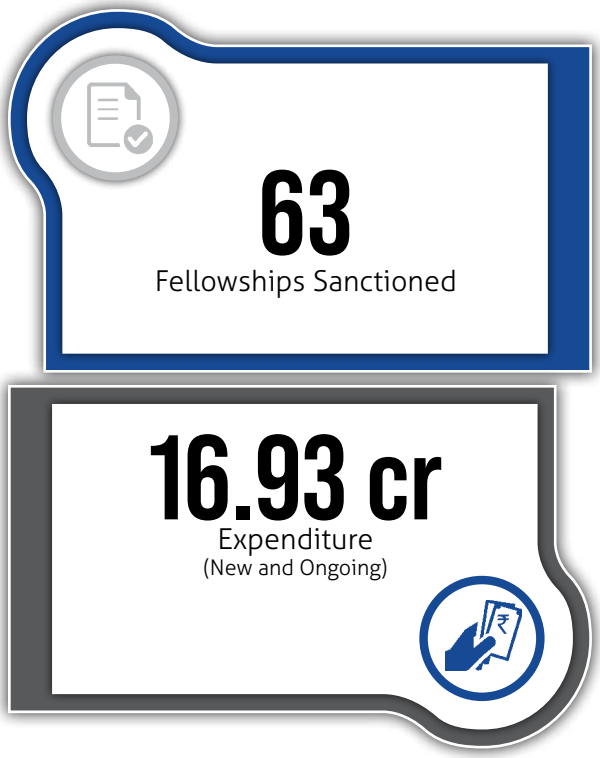
In the reporting period, 63 new fellowships were sanctioned. The areas supported under NPDF – Engineering Sciences are shown in the following figure.



Research Highlights

Exciton Manipulation in Nano-heterostructures of Layered Dichalcogenides and Group II-VI Semiconductors: It describes the different experimental methods used for the synthesis and characterization techniques used to know about the morphology and crystal structures of the

samples. The sulphur solution was added to the main solution to get octahedral nanoparticles. The solution was heated up to 140°C to get clear light brown solution under N_2. s-Oleate solution was injected at the same temperature to get the 2D nanostructures. Cs-Oleate solution was made by dissolving Cs2CO3¬ (0.136 g) in 0.4 ml OA and 7 ml of ODE at 120 °C under N_2. Small amount of tBuOH was added to solution to assist precipitation of the sample while centrifugation at 10K rpm. The particles were redispersed in toluene for further studies. Characterization techniques absorption spectra of the samples were recorded in a quartz cuvette of 2 mm path length using a Shimadzu UV-vis 2450 spectrophotometer at room temperature. Figure 4.24 (a) shows the absorption spectra of the synthesized nanostructures. Further, cary eclipse fluorescence spectrophotometer was used for the measurements of the photoluminescence (PL) as shown in Figure 4.24 (b). To find out size, shape, and crystal structure of the nanosheets, the research group performed transmission electron microscopy (TEM) imaging and atomic force microscopy (AFM). The TEM and AFM images are shown in Figure 4.25 and Figure 4.26, respectively, corresponding to different samples as mentioned in the figures. To get detailed insight of various ultrafast processes in the synthesized heterostructures, employed femtosecond pump-probe transient absorption (TA) spectroscopy at Indian Institute of Technology, Mandi. The excitation source was a Ti:sapphire regenerative amplifier seeded by an oscillator. Light (800 nm) from the amplifier having pulse width 35 fs and energy 4 mj per pulse was divided into two beams to generate pump and probe pulses. A fraction of 800 nm light was used to generate 480 nm and 560 nm wavelengths in a nonlinear optical parametric amplifier (TOPAS-Prime from Light Conversion). Another fraction of 800 nm light was focused on a sapphire crystal to generate white light continuum (probe). Iris and neutral density filters were used to obtain stable white light by adjusting the light intensity. To avoid low frequency laser noises, probe was split into two beams, reference and sample beams. A mechanical chopper operated at 500 Hz was used to create pump blocked and unblocked conditions for detection. Finally, pump and probe beams were



overlapped at the sample position. CCD arrays were used to record TA spectra after dispersion using a grating spectrograph. TA kinetics were recorded with two photodiodes having variable gain. To record TA kinetics, light from another TOPAS-Prime was used as probe. Relative time delay between pump and probe pulses was controlled with an optical delay line driven by stepper motor. TA data were fitted in OriginLab software with multi-exponential functions by taking account of instrument response function. All TA measurements were carried out in a 2 mm path length quartz cuvette. TA data were corrected for chirp by the chirp correction software from Pascher Instruments. For Z-scan measurements, drop casted film of the samples having thickness in the range of few microns (as measured with scanning electron microscopy) on a cover slip was used. During the experiment, sample was scanned in the plane of focused laser beam (focused using 10 cm focal length lens) having pulse width of 56 fs (at the focus) at 800 nm. The transmittance of the sample was recorded as function of sample position. The schematic of the setup is presented in Figure 4.27.

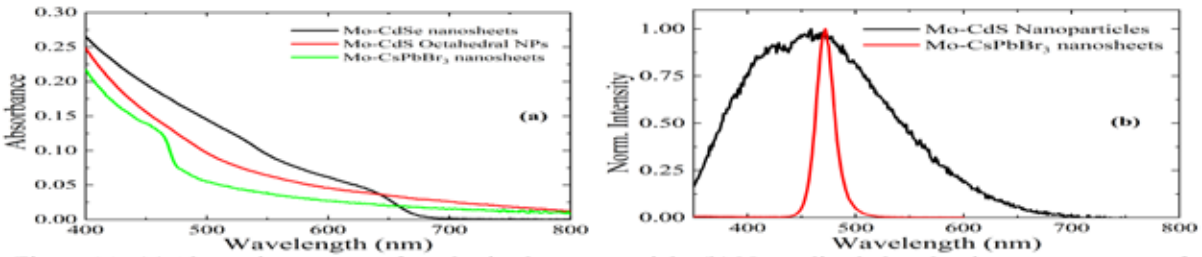


Figure 1A: (a) Absorption spectra of synthesized nanomaterials. (b) Normalized photoluminescence spectra of Mo-CdS octahedral nanoparticles and Mo-dopped $CsPbBr_3$ nanosheets.

Fig. 4.24: (a) Absorption spectra of synthesised nanomaterials. (b) Normalised photoluminescence spectra of Mo-CdS octahedral nanoparticles and Mo dopped $CaPbBr_3$ nanosheets.

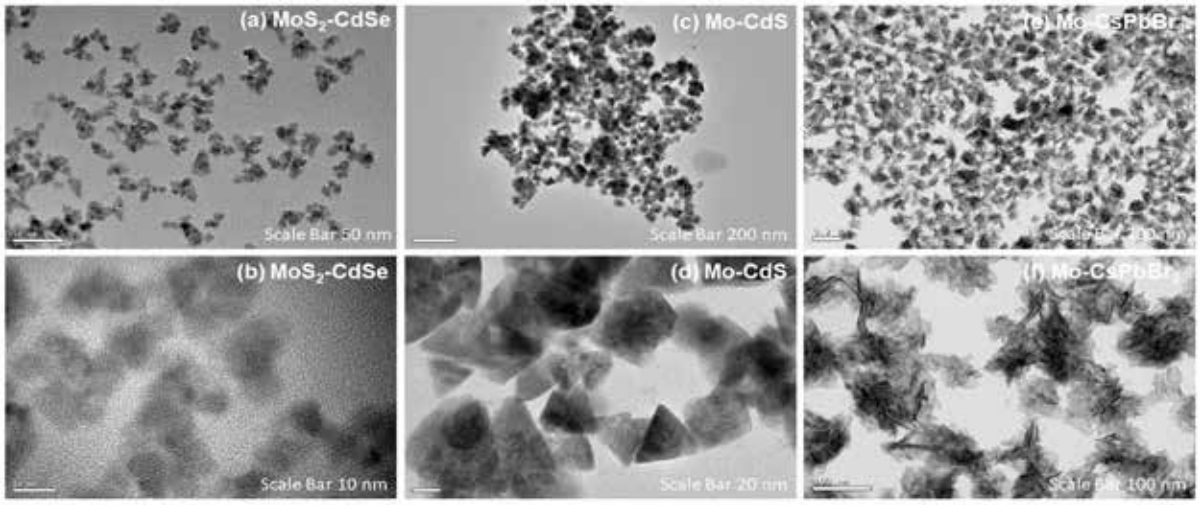


Fig. 4.25: TEM images of synthesised nanostructure. Scale bars are written separately for clarity.

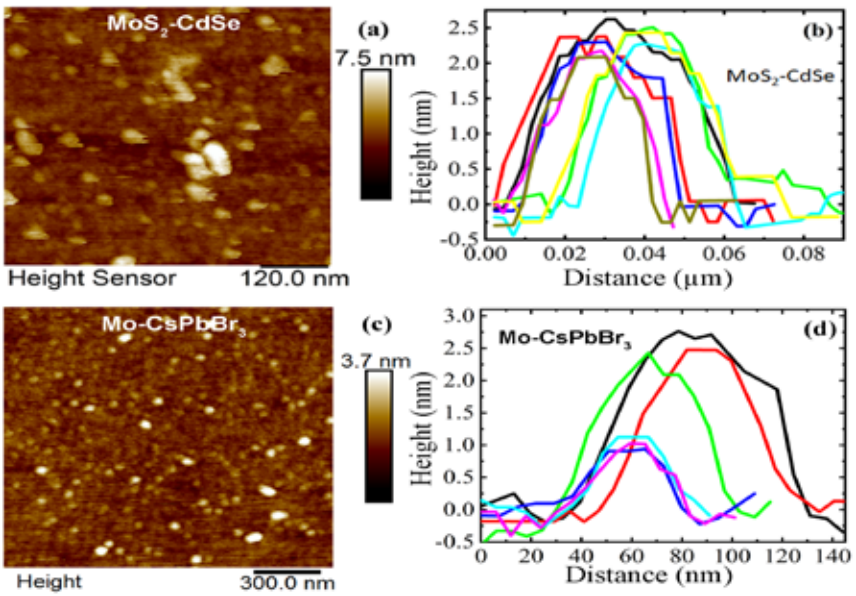


Fig. 4.26: (a,b) AFM image and high profile of 2D CdSe sheets grown over MoS_2 nanosheets. (c,d) AFM images of Mo doped $CsPbBr_3$ peroskite nanosheets and corresponding high profile of various sheets.

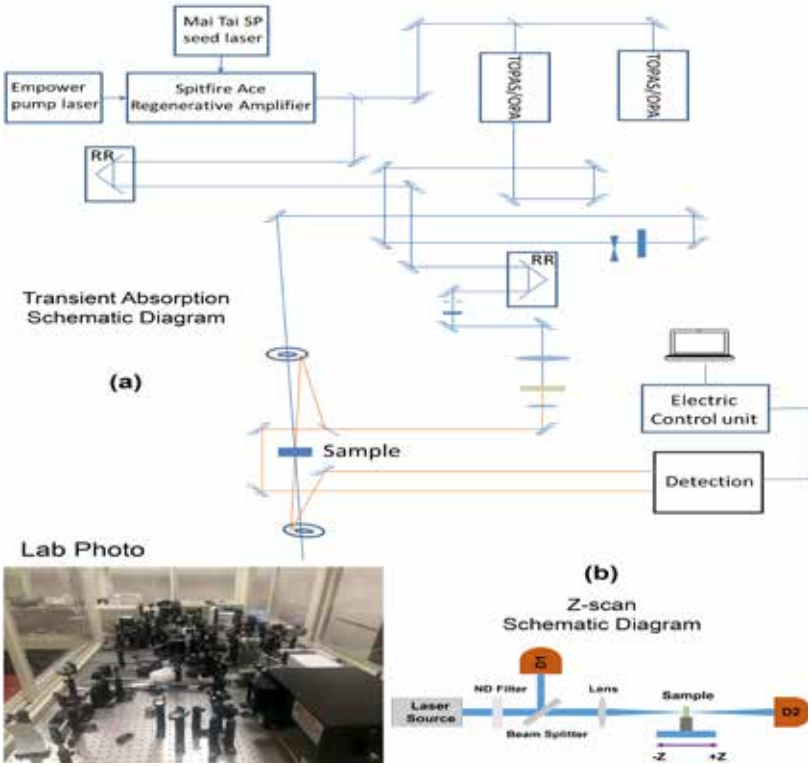
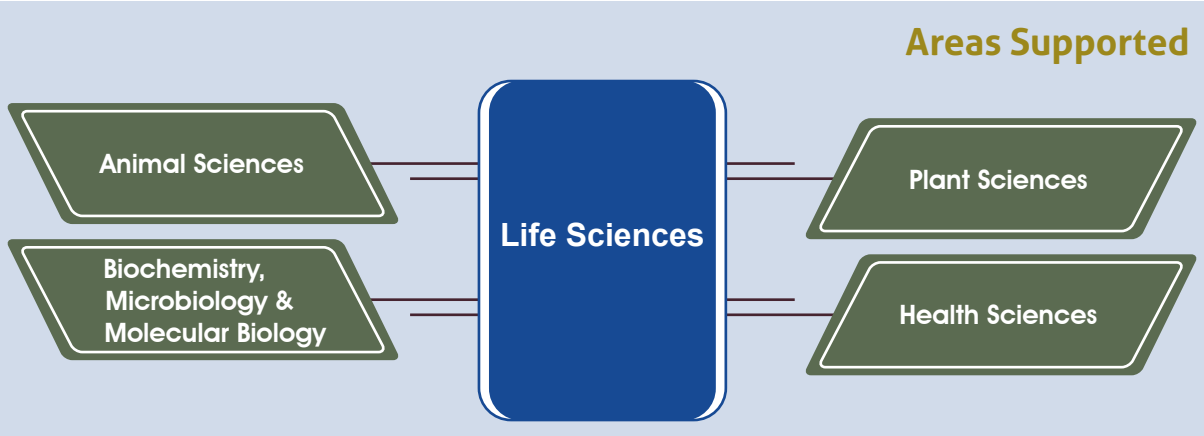


Fig. 4.27: (a) Schematic of femtosecond transient absorption (pump-probe)setup. (b) Schematic of femtosecond nonlinear optical z-scan measurement setup.

4.2.6.4 Life Sciences

In the reporting period, 86 new fellowships were sanctioned. The areas supported under NPDF – Life Sciences are shown in the following figure.



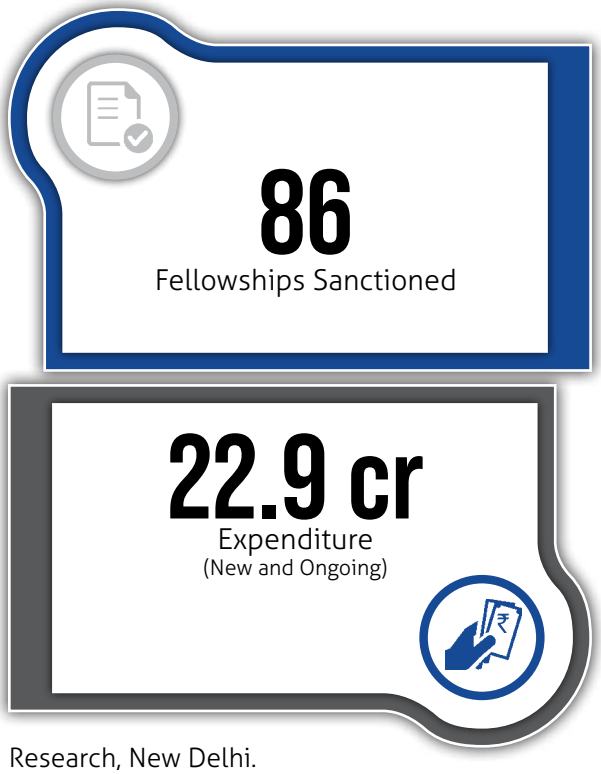
Research Highlights

Analysis of calcium regulated signalling during symbiotic interaction between *Arabidopsis thaliana- Piriformospora indica* : Screening of calcium regulated genes and cyclic nucleotide gated calcium channels (20 CNGCs) during *P. indica* interaction was performed. CNGC19 was significantly induced upon *P. indica* interaction which was further functionally characterized

during this mutualistic interaction. CNGC19 plays important role in balancing *P. indica* colonization and maintaining plant immunity for beneficial interaction.

CNGC19 and PEPRs regulated pathway was elucidated during *P. indica* interaction (Figure 4.28). Phytohormones (jasmonates) and defence metabolites (glucosinolates and callose) responsible for maintaining healthy interaction between host plant and *P. indica* were measured by various techniques. Thus, the function of CNGC19 calcium channel was established during perception and interaction with *P. indica*

The study has revealed the putative calcium channel CNGC19 as important player in *P. indica* mediated activation of downstream pathways in *Arabidopsis*. The group found putative calcium signalling induced plant defence pathway which is crucial in *P. indica*-mediated growth stimulation. This study will ease the path of further finding how growth promotion is achieved in *P. indica* and *Arabidopsis* symbiotic relationship. This work was carried out at National Institute of Plant Genome Research, New Delhi.



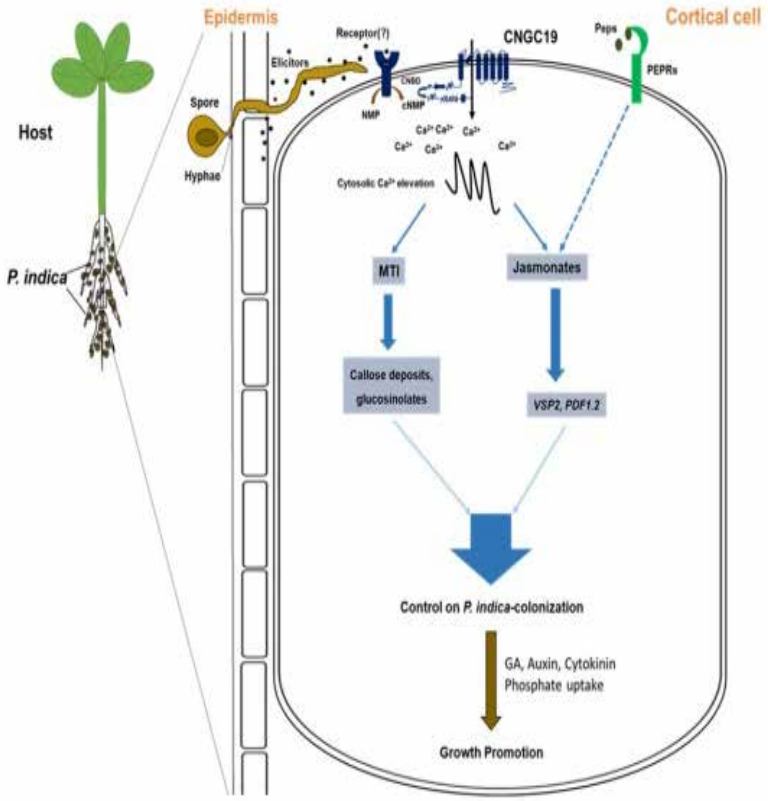
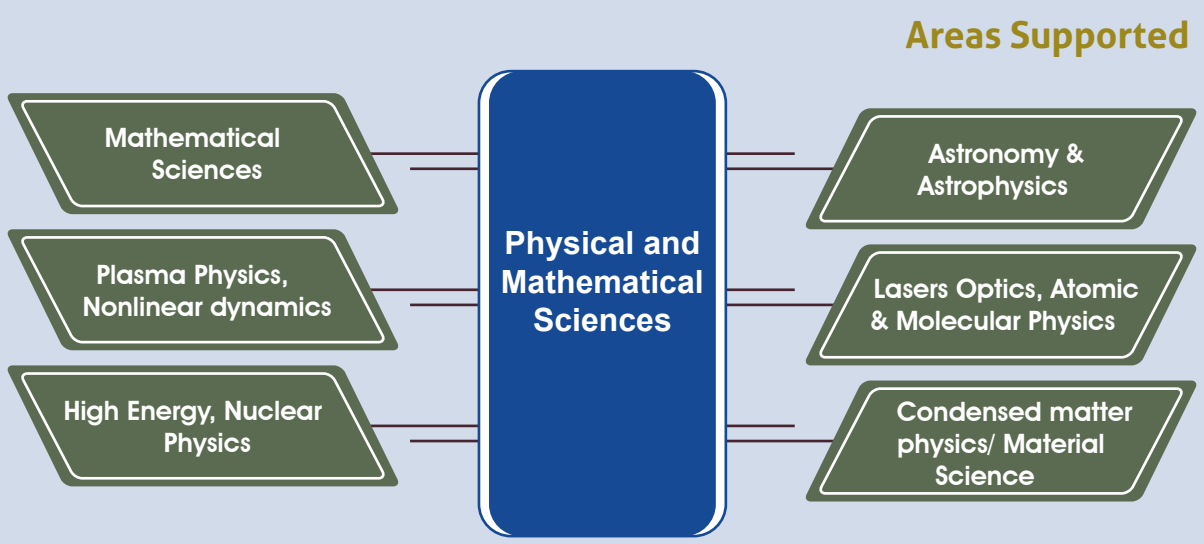


Fig. 4.28: Schematic illustration of CNGC19 role in *P.indica* interaction.

4.2.6.5 Physical and Mathematical Sciences

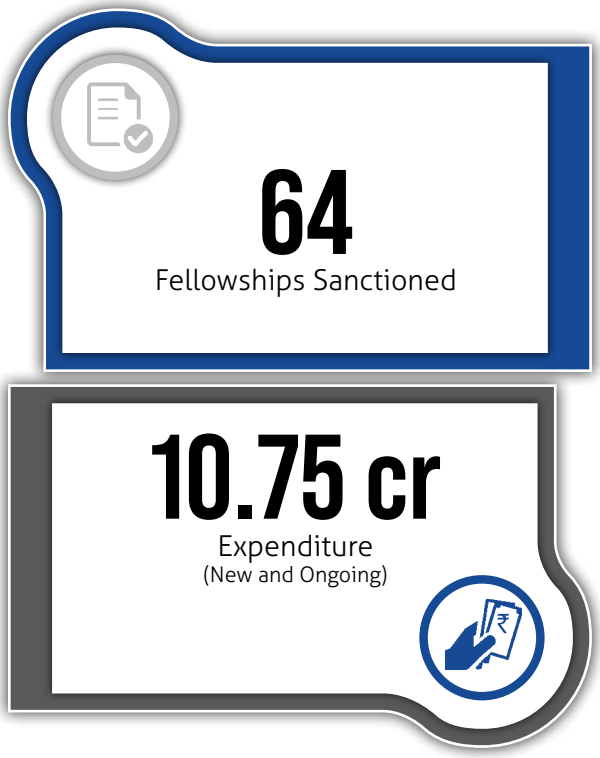
In the reporting period, 64 new fellowships were sanctioned. The areas supported under NPDF – Physical and Mathematical Sciences are shown in the following figure.



Engineering of highly efficient Perovskite solar cells integrated with photonic crystals: In this study it is observed that the perovskite solar cell structure coupled with photonic crystals (PC) structures will provide new insight and practical guidance to the design and optimization of PC-based perovskite solar cells. The proposed double graded index PC structures will offer to design tunable filters, mirrors sensors, detectors and other photonic devices.

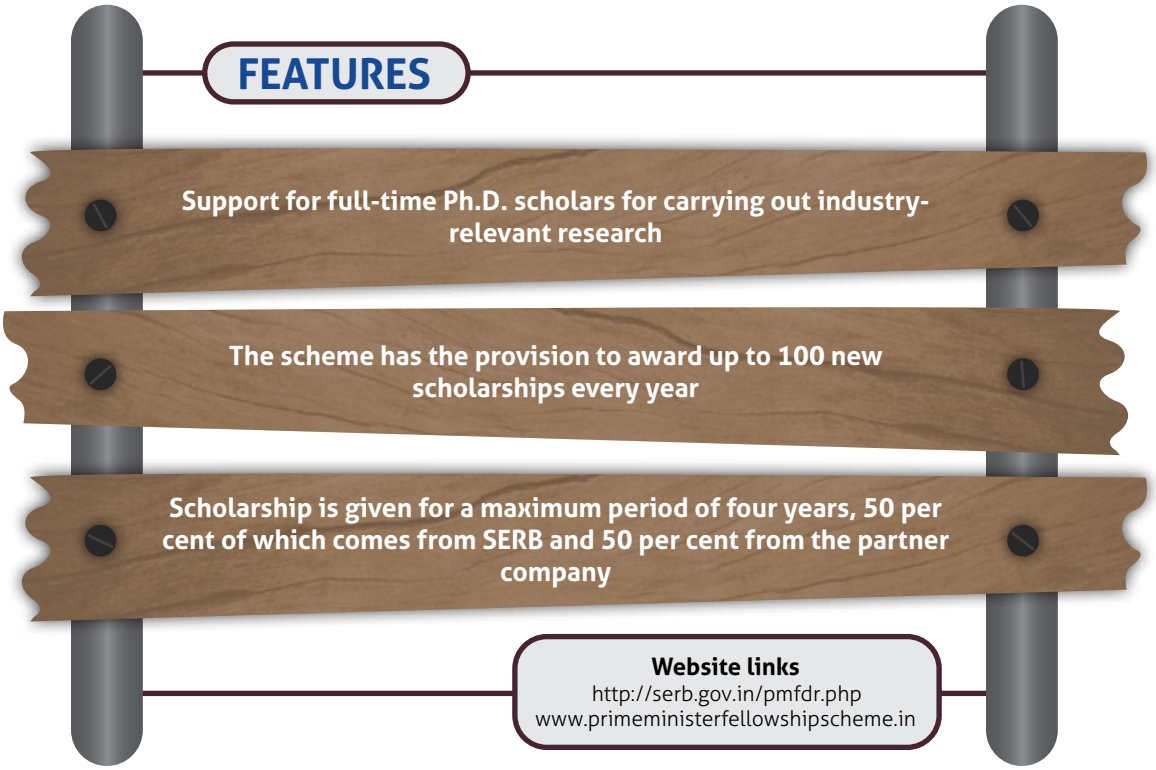
The inclusion of gold-nanoparticles of different sizes, and concentrations as light absorption enhancers in methyl-ammonium lead iodide perovskite films, with the aim of establishing some guidelines for the future development of plasmonic resonance-based perovskite solar cells has been investigated. It has been observed that the composite perovskite presents the high light absorption coefficient for low concentration of gold-nanoparticles with small particles size. This study is important for the selection of matched concentration and size of gold or other metallic nanoparticles to design the efficient plasmon-enhanced organic-inorganic halide perovskite based solar cells and other optoelectronic devices.

Engineering of thermally tunable THz photonic and omnidirectional band gaps has been demonstrated in 1D quasi-periodic PCs containing semiconductor InSb. Structures are taken in the form of different quasi-periodic. Photonic and omnidirectional bandgaps in the structures are strongly dependent on the temperature, thickness of the constituted InSb layers and generations of quasi-periodic sequences and types. This work was carried out at Indian Institute of Technology, Roorkee.



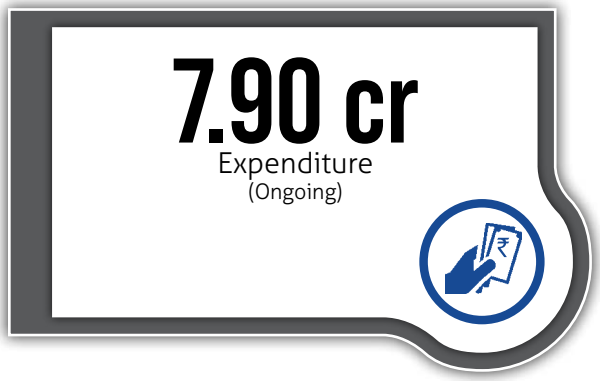
4.2.7 Prime Minister's Fellowship Programme for Doctoral Research

This scheme is aimed at encouraging young, talented, enthusiastic, and result-oriented scholars to take up industry- relevant research. Under this scheme, full- time PhD scholars get double the JRF/SRF as scholarship. While one-half of this scholarship comes from the government, the second half comes from a partner company which also works closely with the candidate on the research project. It is a prestigious fellowship initiated by SERB towards the advancement of university research in line with industry. The first batch commenced in 2013. The scheme is being implemented in partnership with CII and FICCI.



Research Highlights

Development of Soft Body Armour by Using Different High- Performance Materials: Research activity undertaken by one of the Fellows at Indian Institute of Technology Delhi, focuses on improving the impact performance in terms of back face signature (BFS) of soft body armour by using hybridisation techniques and indigenously developed disentangled polyethylene (DPE) tape. In this project the hybrid soft armour panel (SAP) was developed by using commercial high-performance material such as p-aramid woven fabric and UD laminates, UHMWPE UD laminates and polycarbonate sheet. The developed hybridised SAPs were cost-effective solutions with improved ballistic performance. Further, DPE tapes physical, thermal, and mechanical properties from polymer to highly drawn DPE tape were studied. DPE tape has comparable mechanical properties as existing high-performance materials. Basic advantage of DPE is that it is manufactured by solvent-free techniques, which is economical and eco-friendly compared



to gel spun fibres.DPE based structures were optimised and used for homogeneous and hybridised SAP configuration using the optimised laminates and foam. Cross-ply laminates-based SAP gives the highest ballistic resistance compared to woven based laminates. It was also noted that hybrid SAPs based on DPE laminates and foam shows the lowest BFS (12 mm) in 3.5 kg·m-2 areal density which meets the standard requirement and is lighter compared to existing SAP. Figure 4.29 and Figure 4.30 shows the homogeneous and hybrid SAP made from indigenous materials and technology.

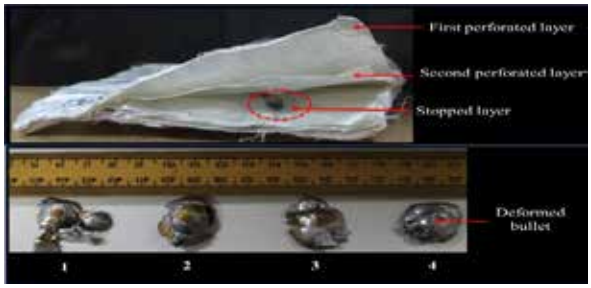


Fig. 4.29: Homogeneous SAP made from DPE tape laminates and deformed bullets

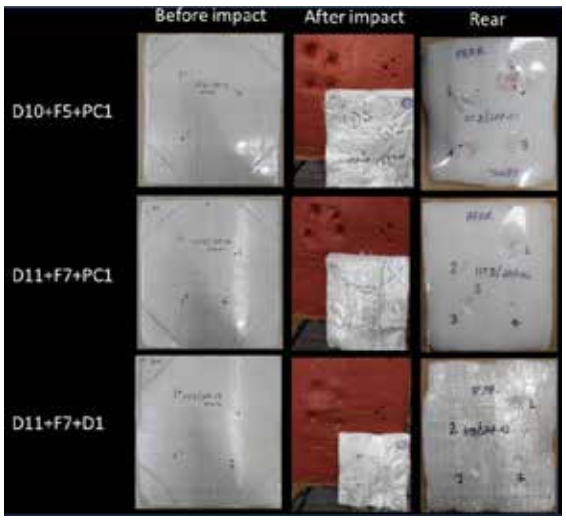


Fig. 4.30: Hybridised SAPs made from DPE cross ply laminates, PC and foam

Adversarial Robustness of Deep Neural Networks: The project aims to develope computationally efficient algorithms for improving the adversarial robustness of Deep Networks. While Deep Networks have demonstrated remarkable performance, they are vulnerable to crafted imperceptible noise called adversarial attacks. Adversarial training is the best-known defence that generates attacks by iteratively maximizing a suitable loss, and subsequently trains the model by minimizing loss on these attacks. While the use of multiple iterations of optimization for attack generation leads to stronger defences, it increases training time by 5-10x (Figure 4.31). Prior works have also shown that naively reducing the number of attack steps results in training instability leading to suboptimal robustness.

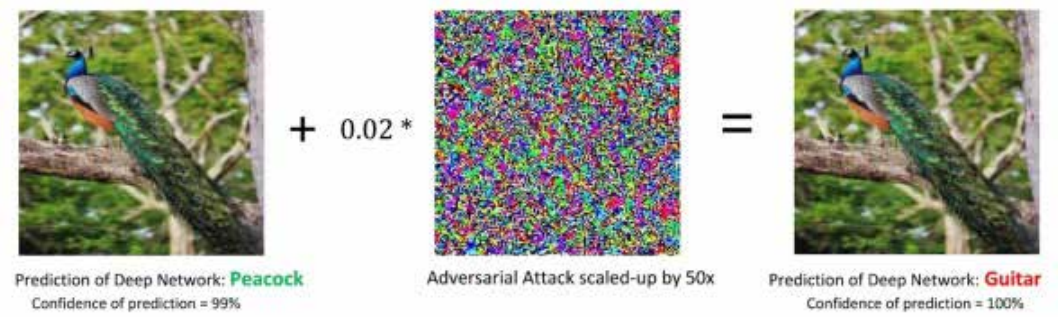


Fig.4.31: Addition of an imperceptible perturbation or Adversarial attack causes the prediction of the network to change from Peacock to Guitar. Images before and after attack look perceptually similar.

Further research on single step adversarial training coupled with regularizes to impose local smoothing of loss surface, using a varying epsilon schedule to improve the training stability and convergence, and dynamically switching between single and two step attacks to achieve an optimal trade-off between performance and computational complexity is being continued. They have proposed a novel single-step adversarial defence "Guided Adversarial Training", that imposes consistent feature representations between a clean and perturbed image to enforce local smoothing of loss surface thereby improving training stability and performance (Figure 4.32). This work is being carried out at Indian Institute of Sciences, Bengaluru.

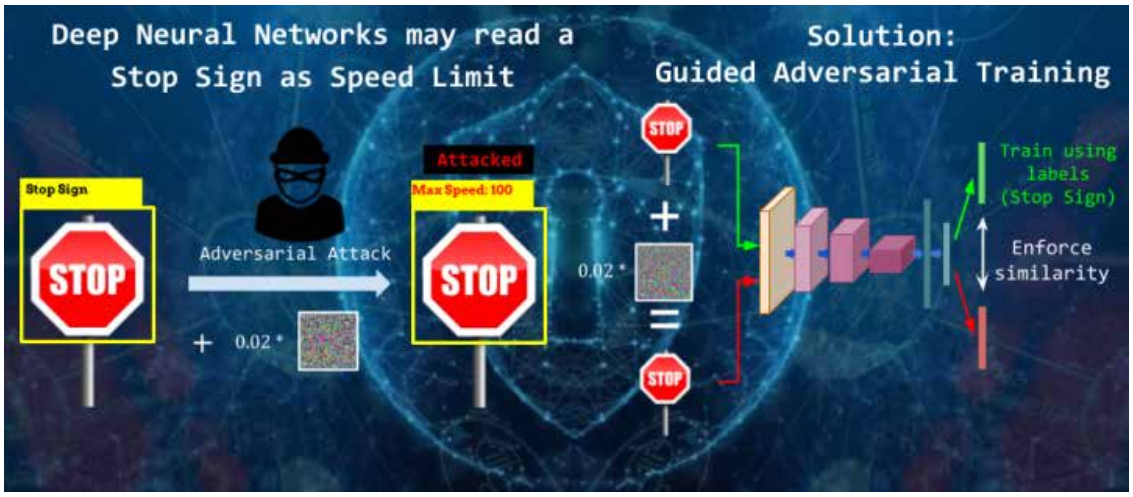


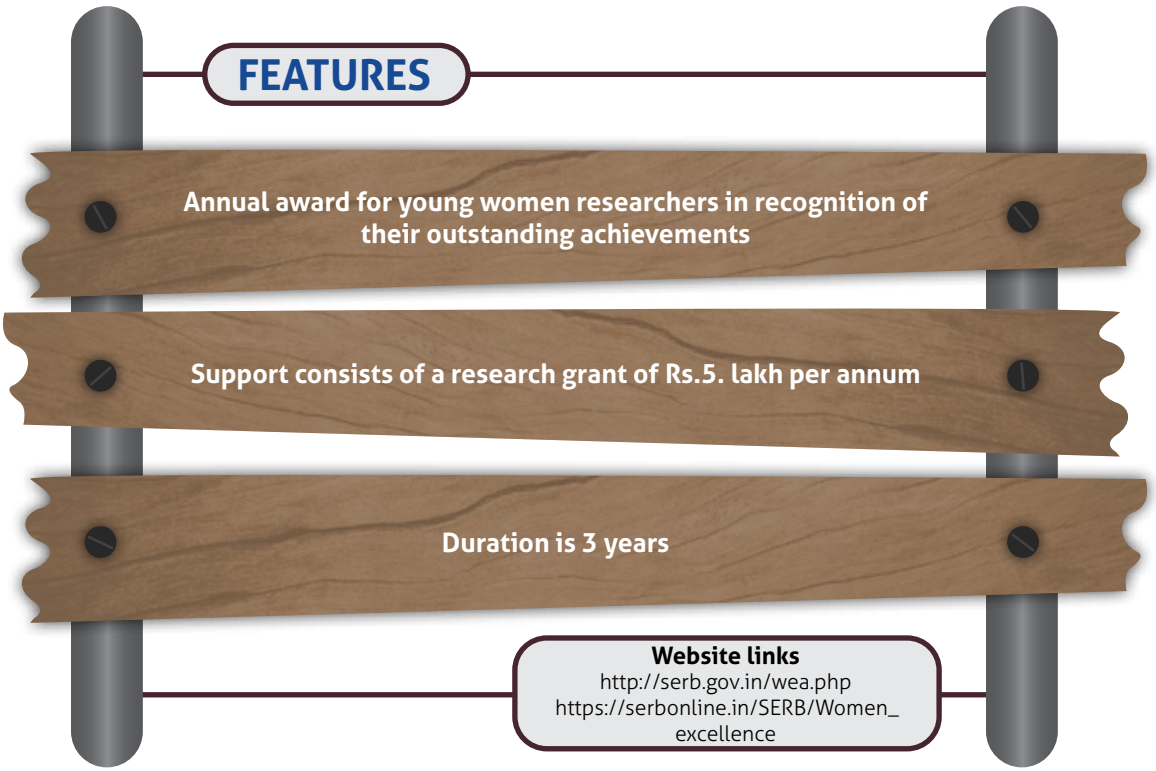
Fig.4.32: (Left) Adversarial Attacks can cause disastrous outcomes in critical applications such as self-driving cars.

4.3 Recognition for Women

4.3.1 SERB Women Excellence Award

SERB Women Excellence award was launched during International Women's Day i.e; 8 March 2013 to reward young women scientists who have excelled in science and got recognition from any of the following National Science Academics in India and are below 40 years of age.

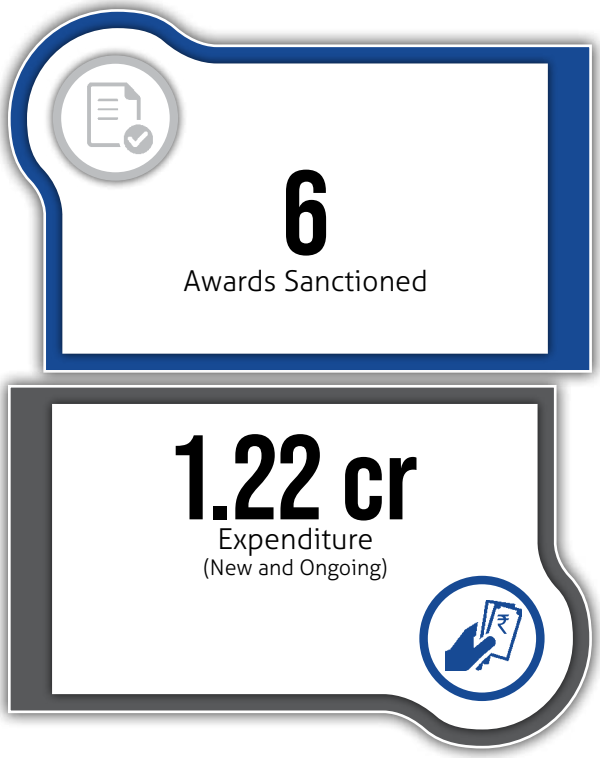
- Indian National Science Academy, New Delhi
- Indian Academy of Science, Bengaluru
- National Academy of Science, Allahabad
- Indian National Academy of Engineering, New Delhi
- National Academy of Medical Sciences, New Delhi
- National Academy of Agricultural Sciences, New Delhi



During the year 2021-22, 13 applications were received out of which 9 women scientists were recommended for the award and 6 were sanctioned. In this award Rs. 15 Lakh has been given to the awardee for three years. The awardees for the year 2021-22 were: Dr. Ruta Prabhakar Kale National Centre for Radio Astrophysics, TIFR, University of Pune Campus, Maharashtra, Dr. Ashima Bhaskar International Centre for Genetic Engineering and Biotechnology, New Delhi, Dr. Debashree Chakraborty, National Institute of Technology Karnataka, Dr. Mudrika Khandelwal, Indian Institute of Technology Hyderabad, Dr. Binita Pathak, Dibrugarh University, Assam, Dr. Nitika Sandhu, Punjab Agricultural University, Ludhiana, Dr. Chandni U, Indian Institute of Science , Bengaluru, Dr. Neha Khatri, CSIR-Central Scientific Instruments Organization, Chandigarh, Dr. Yogita K. Adlakha Translational Health Science and Technology Institute (THSTI), Faridabad.

Research Highlights

Climate induced Vegetation response in Majuli Island (world largest River Island) of Assam: A 150 cm deep sedimentary soil section from the Sakali wetland of Majuli Island has been palynologically studied to reconstruct the palaeovegetation and past climate in relation to the palaeoflood episodes in the Majuli Island of Assam. The co-existence approach was applied on the vegetation succession to decode the Mean Annual Temperature (MAT) and Mean Annual Precipitation (MAP) during four pollen phases (SW-I to SW-IV). Biotic response to the Medieval Warm Period was noticed in terms of 'Hydroclimatic variability' from the sediments of



Majuli Island. During 860 to 1450 CE (1090-500 cal. yrs. BP), the gradual revival of moist and dry deciduous tree elements was observed under increased warm and humid climatic conditions with advancement of fluvial activities. This phase was very well associated with the Medieval Climatic Anomaly (MCA) which occurred globally during 900 to 1300 CE. Interestingly during the interval from 860 to 1450 CE, the average values of maximum MAP were the highest recorded (≈2500 mm). The box plot was applied to the quantified data obtained from pollen frequency analyses which clearly revealed a significant variation and similarity in major vegetation groups (Figure 4.33). Inclination in cultural pollen taxa like Cereal, non-cereal, *Brassica* and *Coriandrum* indicates the intense anthropogenic activities in and around the Majuli Island (Figure 4.34). This work was carried out at Birbal Sahni Institute of Palaeosciences, Lucknow.

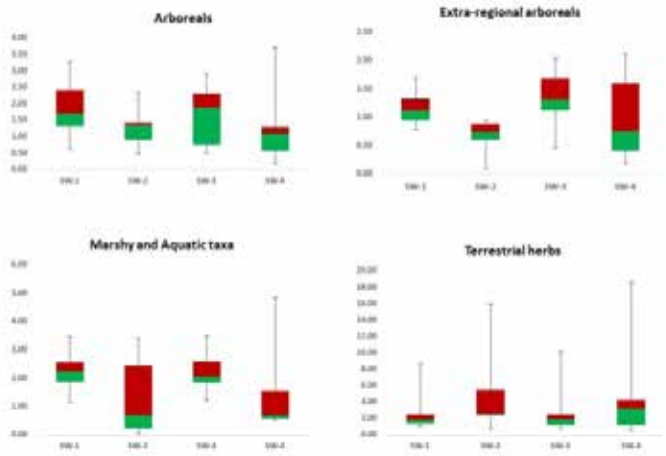


Fig.4.33: Box plots showing distribution of arboreal, non-arboreal (marshy, aquatic and terrestrial herbs) and extra-regional taxa in the sedimentary core of Majuli Island based on the fossil pollen records

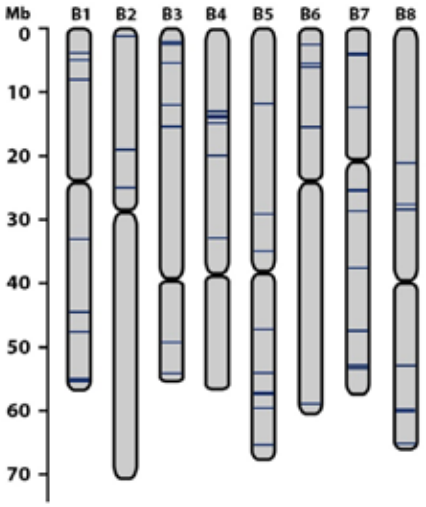


Fig. 4.34: Overall graphical representation of substituting regions of B genome chromosomes from *B. carinata* in *B. napus* ILs as indicated by blue color.

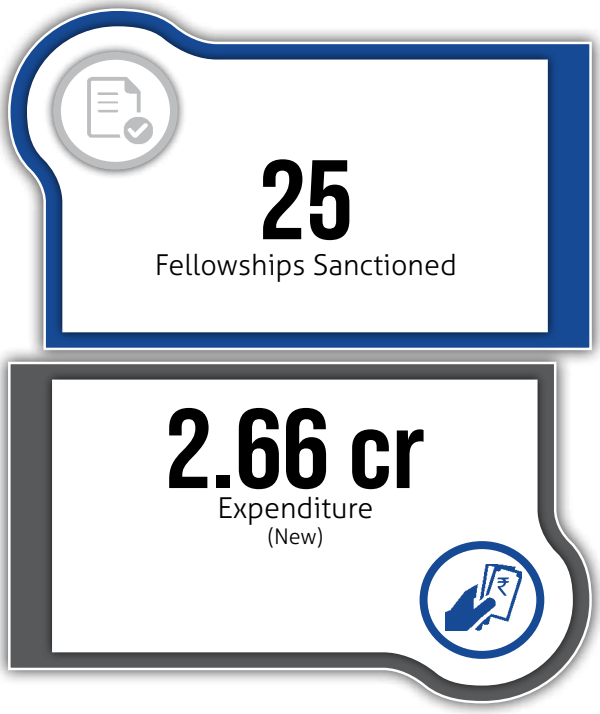
4.3.2 SERB POWER Fellowship

POWER Fellowship Scheme aims to identify and reward outstanding women researchers and innovators working in Indian academic institutions and R&D laboratories, in any branch of Science and Engineering. POWER Fellowship is a one time award for women researchers within 35-55 years of age. The scheme was initiated in 2020-21 and the first call was made in November 2020 to identify and reward outstanding women researchers and innovators working in the

area of Science and Technology. A total of 25 POWER Fellowships were awarded out of 137 nominations in the reporting period. Research Highlights of some of the proposed work that are supported are given below:

Research Highlights

Printed Sensors for seamless integration with Internet of things (IoT) enabled healthcare system: During this period, fellow at Indian Institute of Technology, Bombay have focused upon development of flexible - printed temperature and strain sensors. In humans, the variations in body temperature can be used to investigate physical activities, cardiovascular health, and several other health related problems because body temperature is one of the first defence mechanisms of human body in response to illnesses such as infectious diseases. Although inside body temperature is independent of the surroundings, the body surface temperature easily gets affected by this that poses challenges in monitoring the body temperature continuously. To overcome this challenge, graphene based flexible wearable and inkjet printed temperature sensors are fabricated so that real-time and sensitive measurement of temperature from various parts of the human body can be achieved. Figure 4.35(a) shows the picture of the sensor mounted on the human wrist. The inset shows the printed sensor. Figure 4.35(b) demonstrates the sensor response with the change in body temperature with high sensitivity of 0.06246/°C.



Flexible and wearable strain sensors that can detect small- and large-scale motion are important for monitoring several important parameters such

as pulse, breathing and also for robotic applications having sense of touch. The fellow has developed ultra-sensitive porous piezoresistive sensor using 3D printing where the sensor constitutes porous Poly-di-Methyl Siloxane (PDMS) coated with flake graphite to make micro-structured scales. Due to the foam structure and the micro-structured scales, the sensor is capable of detecting large-scale motion and small-scale human motion. Finger motion measurement is taken by placing the sensor on the interphalangeal joint of the index finger with a bandage. The signals are collected during the rapid flexing and slow flexing of the finger. The signals indicate rapid flexing with high amplitude of variation while slow flexing with lower amplitude of variation, as shown in Figure 4.36 (a). Similarly, a chest motion while breathing can be detected by placing the sensor on the chest. The sensor signals can differentiate the slow breathing and rapid breathing motion, as shown in Figure 4.36(b).

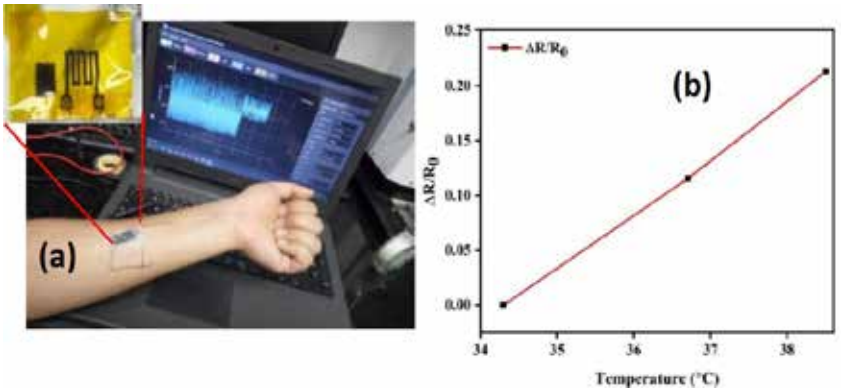


Fig. 4.35: (a) Mounting of graphene based temperature sensor on the wrist for body temperature measurement (b) Calibration plot showing linear relationship

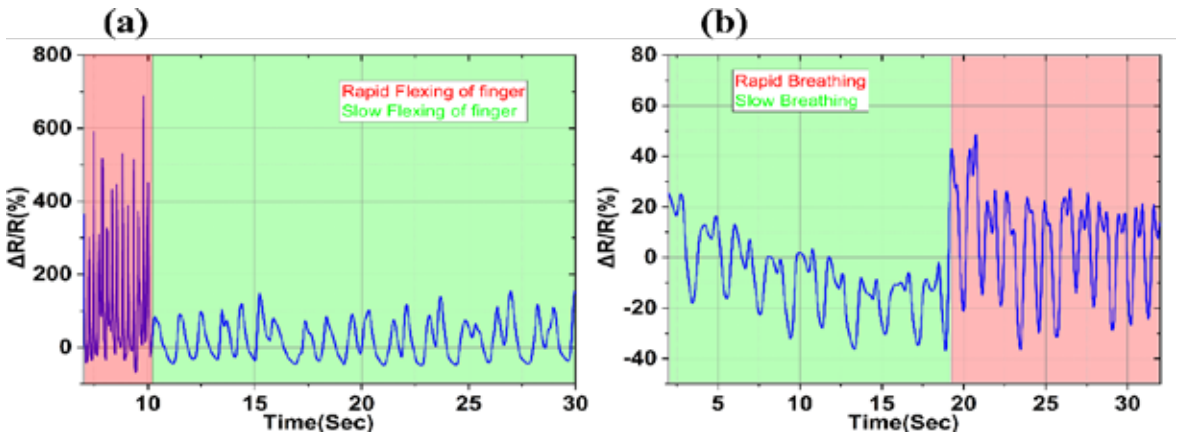


Fig. 4.36: (a) Flexible Strain Sensor response for different rates of finger flexing (b) sensor response for chest movement during breathing.

Development of entropically favoured through space intermolecular charge transfer assemblies: The fellow at Guru Nanak Dev University, Amritsar has designed and synthesized strong acceptor-weak acceptor system FN-TPy which undergoes solvent dependent self-assembly in mixed aqueous media to generate through space intermolecular charge transfer assemblies (Figure 4.37).

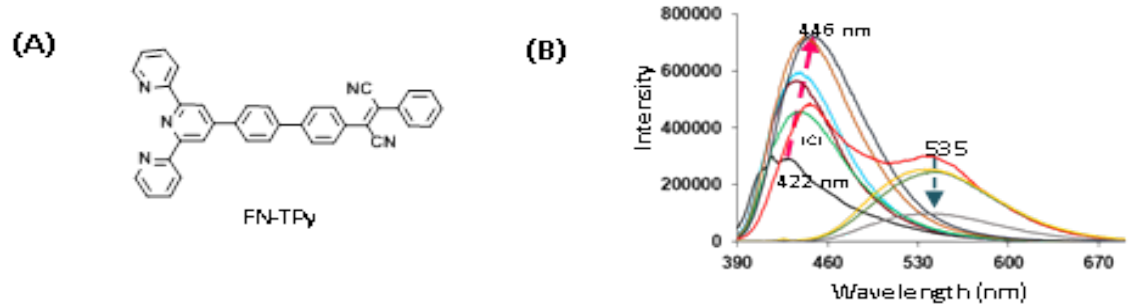


Fig. 4.37 (a) Structure of **FN-TPy (b)** fluorescence spectra showing the changes in the emission intensity of **FN-TPy** (5 μM) in different water fractions; λ_{ex} = 370 nm.

Various experimental studies support the morphological modulations of intramolecular charge transfer blue light emitting FN-TPy molecules to emission enhanced assemblies and to entropically favoured intermolecular charge transfer assemblies in mixed aqueous media (Figure 4.38).

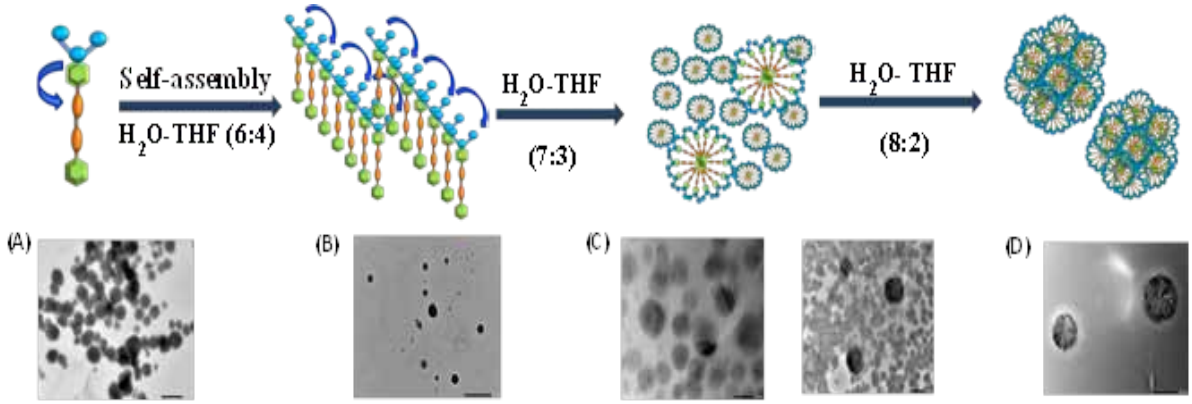


Fig. 4.38: Schematic illustration of changes in the packing arrangement of **FN-TPy** molecules in THF and THF/H_2O solvent mixtures and their respective TEM images in (A) THF (scale, 500 nm); (B) in 60:40 (H_2O/THF) (scale, 500 nm) (C) in 70:30 (H_2O/THF) (scale, 200 nm, 10 nm) and (D) in 80:20 (H_2O/THF) (scale, 500 nm).

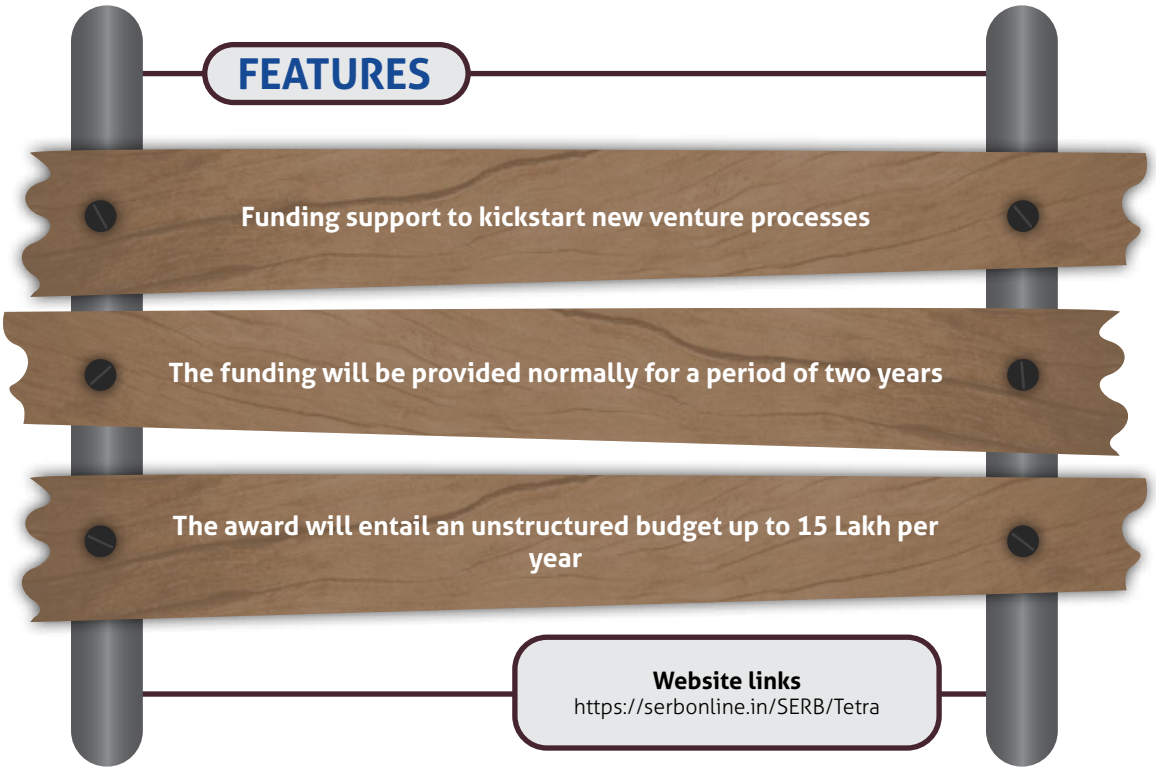
As prepared through space charge transfer assemblies of FN-TPy exhibit strong absorption in the visible region and show sufficient potential to activate aerial oxygen to generate reactive oxygen species (ROS). The FN-TPy assemblies exhibit excellent potential for regulated oxidation of benzyl alcohols to benzaldehyde and benzaldehyde to benzoic acid under visible light irradiation and aerial conditions.

4.4 Enabling Innovation and Technology Development

4.4.1 SERB Technology Translation Award (SERB-TETRA)

SERB-TETRA (Technology Translation Award) is a new scheme for catalyzing technology translation in academic setting. SERB-TETRA will challenge scientists executing SERB grants, such as CRG, to establish an effective, functional, and synergistic working collaboration with an industry partner to elevate their breakthrough results and technologies to TRL level 5 and beyond. It is envisaged that a well-defined strategy to augment research innovation, via technology incubators, will add value to the CRG and other funding mechanisms supported by SERB.

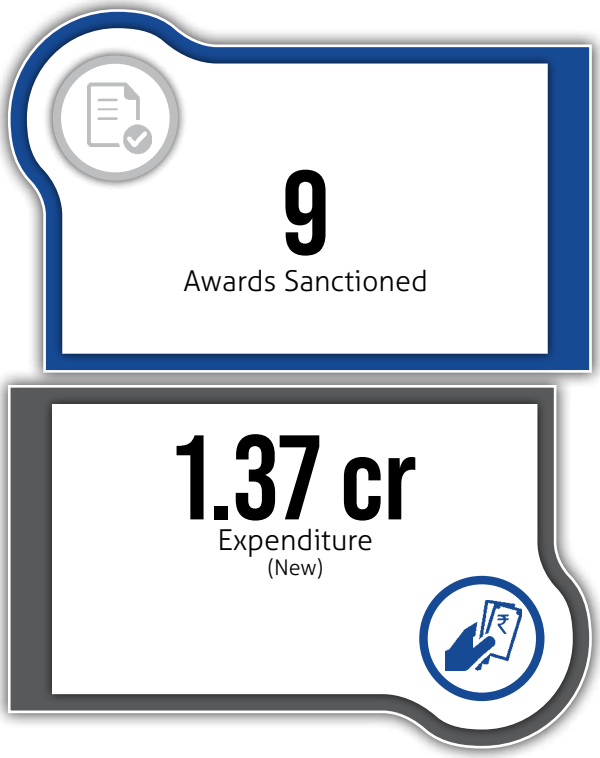
Second call for proposals under SERB-TETRA was made during September-October 2021. Total of 43 proposals were received out of which 10 were selected for the award.



Research Highlights

Multi-functional chemical agents, and the method for protein modification: The research group at Indian Institution of Science Education and Research, Bhopal developed chemical methods capable of selective single-site modification of native proteins. The group established comprehensive knowledge to regulate diverse features in post-translational protein engineering, including control over reactivity, chemo selectivity, site-selectivity, site-modularity, residue-modularity, protein selectivity, organelle specificity, and cellular specificity. After establishing the organic and physical organic principles and theories for engineering the proteins, research team successfully delivered homogeneous antibody-drug conjugates for directed cancer chemotherapeutics and antibody-fluorophore conjugates for image-guided surgery.

The research work on the LDM® platform proved that it is possible for the chemical technologies to go beyond the reactivity order defined by the proteins to enable their modular and precise engineering. Like any other new field, the analytical and other support tools were not established (Figure 4.39). The group has developed multiple products and kits to meet these requirements. Since it remains the only modular method to date, this chemistry has garnered immense global attention from the sectors of biology and medicine. The comprehensive patents on these contributions and a few others are already licensed



to his start-up, Plabeltech Private Limited (https://plabeltech.com/). The company has partnered with SERB Precision Antibodies engineering Centre for the pre-clinical development ADCs and AFCs to address targeted image-guided tumour surgery and directed cancer chemotherapeutics.

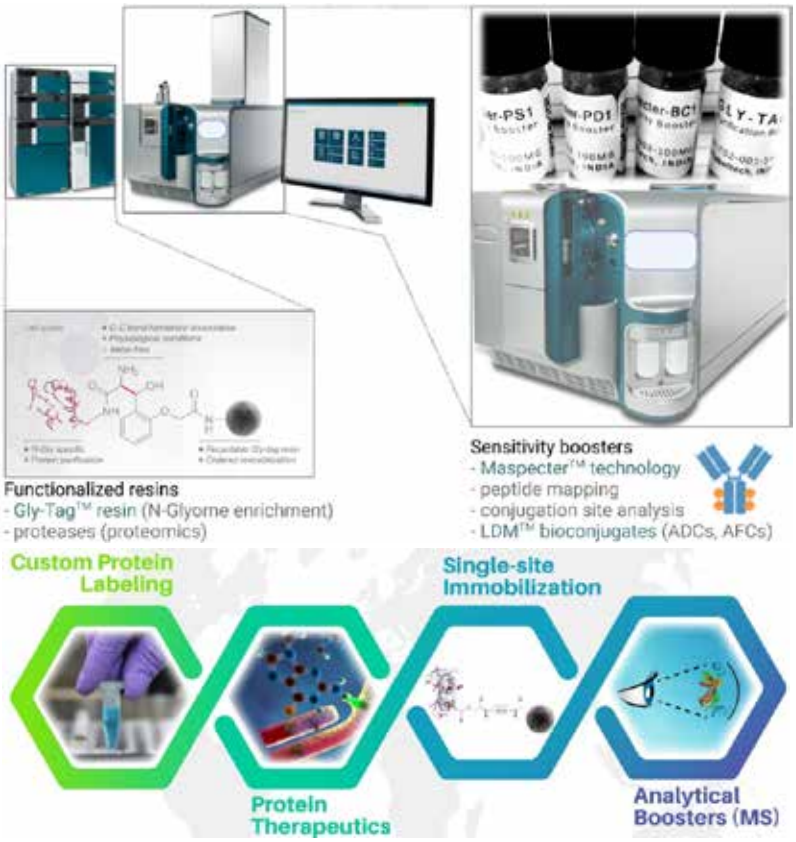


Fig. 4.39: Chemical technologies for precision engineering of proteins and antibody conjugates.

Exoskeleton Device for Upper Limb Rehabilitation: The Virtual reality based tasks had been developed using the python-based software 'Vizard' (®WorldViz Llc, CA USA), creating a virtual environments consisting of a series of VR-task. The designed module has been developed at Indian Institute of Technology, Delhi was tested on healthy subjects (n=40) and the objective key parameters based on the tasks had been identified and the subjective feedback has been taken. The participant and virtual environments were connected using a Logitech joystick (Logitech Extreme 3d Pro, Lausanne). The top and side views of the joystick adopted for the study are shown in Figure 4.40. The motions of the joystick are useful for executing and learning the most useful functional movements required for independently performing activities of daily living (ADL). The joystick motions are projected into 3D environment, causing a simulated motion of a 3D vehicle model that is present in the virtual world. To make the environment more interesting, challenging, and encouraging for subject, each of these motion challenges was given at multiple levels. Each of healthy volunteers and patients received a 90-minute session of VR tasks. All of the participants were instructed to operate and control the joystick with only their wrists and finger movements, with limited use of proximal joints. At the end of each level, the performance level is displayed quantitatively (score) and qualitatively (progress bar), the metrics for this has also been designed in-house. Figure 4.41 shows the snapshots of the virtual environment and GUI designed at various time points of task execution.

After the development of VR tasks, one of the important challenges was to identify the key performance indicators (ex. Trajectory Plots-Figure 4.42) associated to the designed joystick-VR rehabilitation tasks in order to assess the performance of the subjects and stroke patients. Healthy individuals' distal joint function parameters will be used as a baseline against which patients with stroke will be assessed.

Due to COVID outbreak, clinical recruitment of patients with stroke is at a very low pace. Total twelve patients with stroke (n=12) were screened and only two patients (n=2) could be enrolled in the study under inclusion criteria in the last one year.

All the healthy subjects (n=40) and patients (n=2) tolerated one 90 minutes session of VR task without any complaints. A customized VR-based platform with multiple levels of training for motor rehabilitation of wrist and finger was designed, with quantifiable parameters to evaluate the progress of subjects. The results demonstrated the variations of three objective quantitative parameters and qualitative trajectory plots obtained from the healthy subjects and two patients (for both unaffected and affected hands). VR tasks have been optimized and the therapy protocol has been established for Indian scenario. The intervention and the therapy protocol can be now used to design the future clinical intervention.

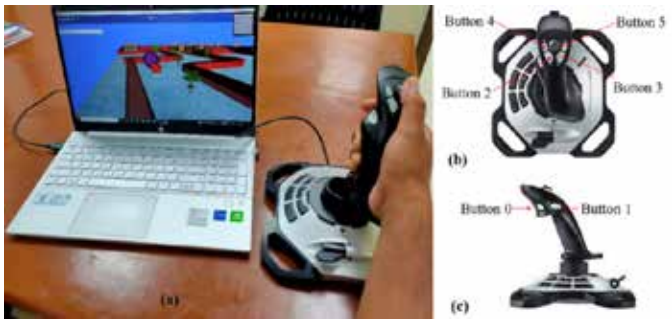


Fig. 4.40: VR setup with joystick and the subject performing the tasks, (b) Top view of the joystick, (c) Side view of the joystick.

Fig. 4.41: (a) Obstacles and task environment, (b) GUI and visual feedback on success

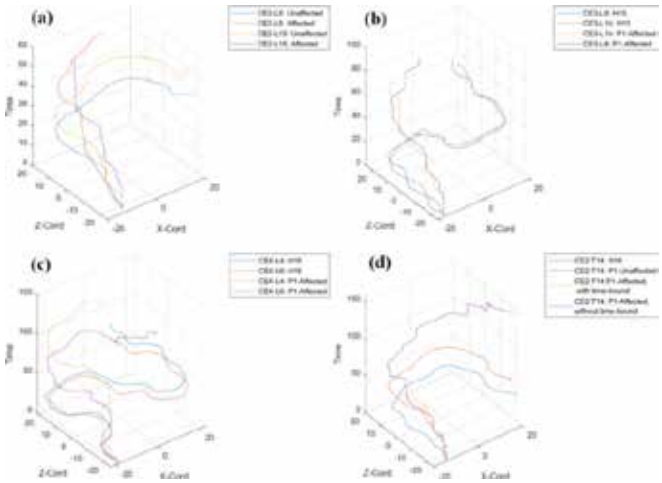


Fig. 4.42: Trajectory plotted (a) for Patient 1's unaffected and affected hands for task levels CE2-L8 and L15, (b) for a healthy subject and Patient 1's affected hand for task levels CE3-L8 and L14, (c) for a healthy person and Patient 1's affected hand for task levels CE4-L4, and L6, (d) for a healthy subject and Patient 1's affected hand with and without time-bound conditions for task level CE2-L14.

5

SYNERGETIC PROGRAMMES

Synergetic programmes aid to create a globally competitive research environment in the country for accelerated development of scientific and technological progress.

With an intention to strengthen the research in our country, SERB is implementing intra and International partnership programmes in collaboration with other Ministries, Departments and Industries which will aid to connect the need with the expertise thus enabling ground breaking research and leading to the solution of complex problems. Outreach and SERB connect with researchers and a robust ePPMS platform is enormously helpful to cater the needs and linkages with research fraternity.

Presently two partnership programmes, Impacting Research, Innovation and Technology (IMPRINT) and the Uchhatar Avishkar Yojana (UAY) are being implemented jointly with the Ministry of Education (previously Ministry of Human Resource Development).

To build national capacity in frontier areas of Science and Engineering, which are of interest to India, SERB provides research opportunities such as Overseas Visiting Doctoral Fellowship for young researchers and VAJRA Faculty Scheme to attract the expertise of overseas scientists as visiting faculty to undertake high quality collaborative research in public funded academic and research institutions in India.

5.1 National Partnership Programmes

5.1.1 Impacting Research Innovation and Technology (IMPRINT-II)

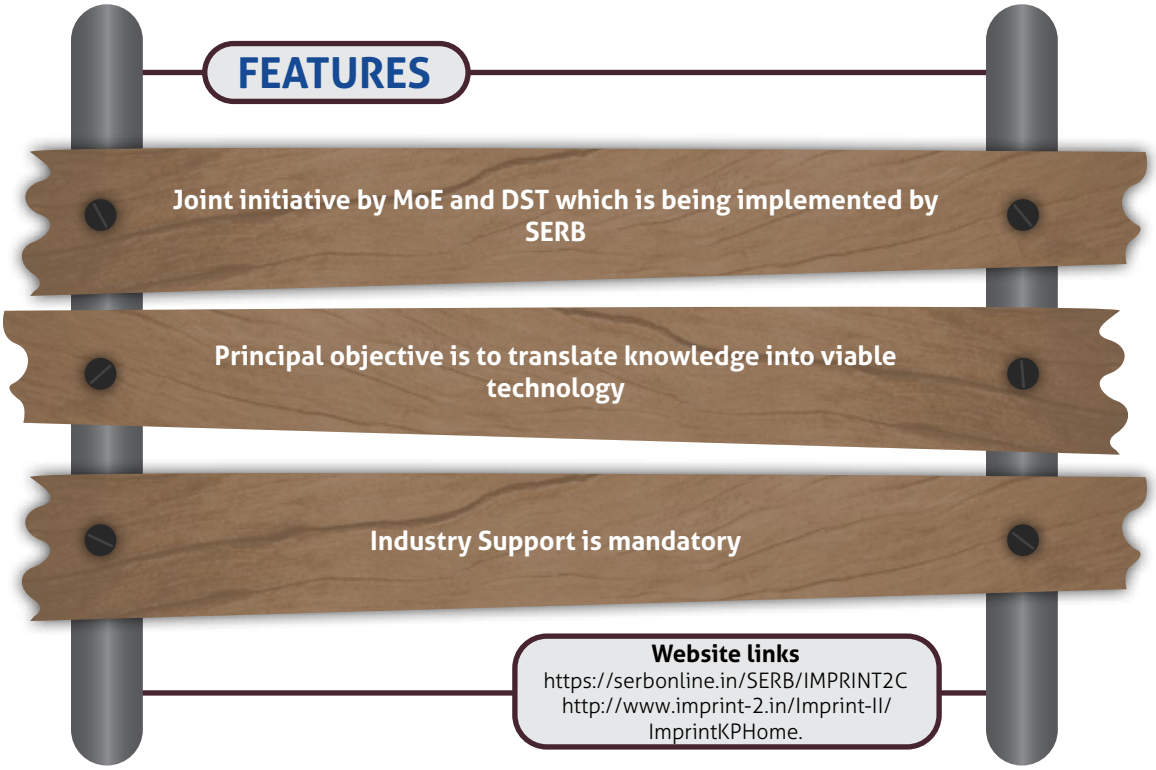
A National programme called IMPacting Research, INnovation and Technology IMPRINT-II has been initiated by MoE in partnership with DST/SERB. The principal objective of IMPRINT-II is to address all major engineering challenges faced by the nation by translating knowledge into viable technology product/process (IMPRINT-IIA&B). Ten technology domains have been identified under IMPRINT that could substantially impact the quality, safety and security of life both in urban and rural areas, namely: (1) Healthcare, (2) Energy, (3) Sustainable Habitat, (4) Nano Technology

3.63 cr
Expenditure
(Ongoing Projects)

hardware, (5) Water resources and river systems, (6) Advanced materials, (7) Information and Communication Technology, (8) Manufacturing, (9) Security and Defence, and (10) Environmental Science and Climate change.

The next round of IMPRINT-II, called IMPRINT IIC (Societal Mission Projects) was launched aiming to seek proposals related to 20 highly specific technology development themes of major societal relevance/benefit, selected from the areas identified by various ministries.

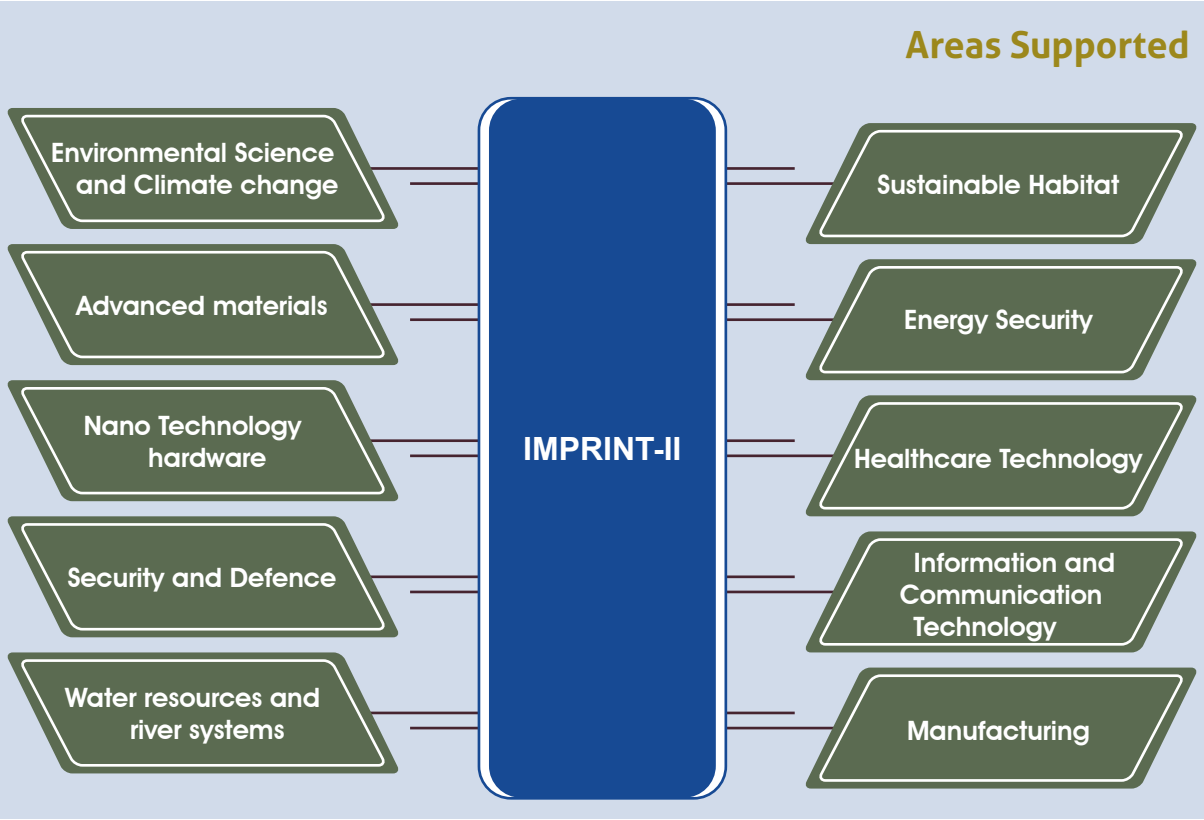
In these projects, at least 25% of the project cost has to be supported by the industry out of which at least 10 % of the project cost should be in cash. (IMPRINT-IIC.1)



Later a modified consortium approach was initiated in the IMPRINT-IIC (IMPRINT-IIC.2) programme to include strong and complementary expertise from across different disciplines to address major technological breakthrough in designated areas of societal/industrial importance. A total of 43 proposals were submitted under different domains against this initiative. Following the peer review process, 18 proposals were initially shortlisted and finally, after a rigorous evaluation process, 8 proposals were recommended for financial support.

Research Highlights of some of the projects supported under IMPRINT-II are given here.

A Low Cost, Portable and High-Quality Device (Prototype) for Food Quality Assessment Based on Microscopic Image and Deep Learning: Under the domain "Information and Communication Technology" an innovation is made and a low-cost portable and high-quality device for vegetable quality assessment system was developed. To achieve the goal, microscopic images were considered which provided micro level details of a vegetable sample. In this research, a microscopic image capturing system using smart phone camera was developed. A deep learning-based algorithm was also developed on android platform to analyze the captured microscopic images of a vegetable. The overall system becomes portable, easy to use, low-cost but provide high quality assessment. The image analysis techniques were performed by advanced data-driven deep learning methods. In this purpose, a light-weight deep neural architecture, was developed especially for low-end smartphone.



A system prototype was developed and tested for vegetable (potato) and it worked satisfactorily. A picture of the image capturing system is displayed in Figure 5.1 and of the Compact System in Figure 5.2. The innovation was filed for Indian patent with Patent Application No. 202231017953.

Two large microscopy datasets of plant cell biology (potato tuber) were generated specially for deep learning applications. These datasets include stain and unstained images which were captured by traditional bright-field and low-cost microscopy. These datasets published in *Scientific Data (Nature)* and *IEEE Transactions on NanoBioscience* which are made public for future research of microscopy image processing in deep leaning framework for computer as well as android platform.

The work was carried out at Indian Institute of Information Technology, Guwahati.

Fig. 5.1: Microscopic image capturing system

Fig. 5.2: Compact System

Development of Refreshable Braille Cells: In another project under "Information and Communication Technology" a device with Refreshable braille displays (RBDs), to empower the blind and the deaf-blind with opportunities in education and employment, is being developed. Refreshable braille displays (RBDs) are electromechanical devices that enable people with visual impairment access digital content through a tactile interface without having to print everything on paper. The device comprises of an array of Braille cells, wherein each cell represents one Braille character and houses a set of Braille dots that are controlled by individual actuators. In the current scenario, a variety of texts are now available in digitized form, which includes books, newspaper, magazines etc. But people with visual impairment have very limited means to access digital text. They rely mainly on screen reading software, which requires engagement with yet another primary sensory organ - the ear, isolating them from their surroundings. Assistive Technologies which are needed in large numbers by blind people are not market driven. The technology will help blind people to get educated and employed thus transforming social and economic burden into social and economic prosperity. The broad objective is to develop affordable, indigenous technology/product benchmarked to the international standards with a market in India and abroad. PI has developed improved and indigenous shape memory alloy-based Braille cell technology for use in Refreshable Braille Display Devices.

Key Achievements:

- Braille cells with improved reliability, manufacturability and assembly has been achieved (Figure 5.3 showing the improved process design and Figure 5.4 showing improved product design).
- Technology has been transferred to industrial partner.
- Pilot production achieved with manufacturing of 140 units of Braille modules.

Fig. 5.3: Improved Process Design

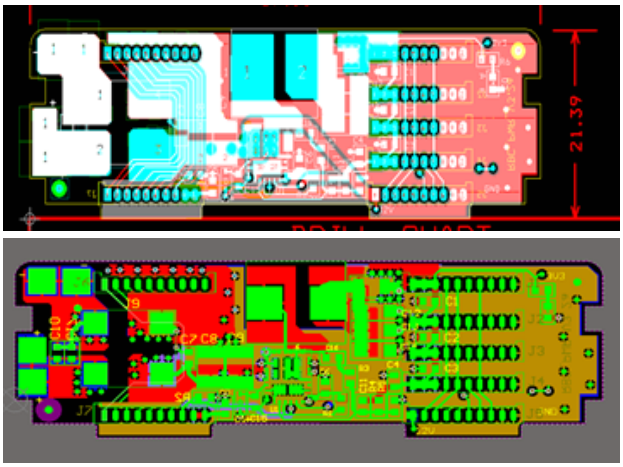


Fig. 5.4: Improved Product Design

The work is being carried out at Indian Institute of Technology, Delhi.

Development of Indigenous Corrosion Monitoring Systems for Reinforced Concrete (RC) Structures Using Eddy Current and Ultrasonics: The sensor output is phase shifted with respect to the transmitter by an amount proportional to the conductivity of the metal surface, and is measured accurately using a phase sensitive detection circuit to estimate the severity of corrosion. The amplitude of the sensor output could also be exploited to estimate rebar depth and diameter. Another sensing method uses an ultrasonic system using water- proof ultrasonic piezoelectric wafer transducers (PWTs) at concrete-steel interface for real-time monitoring and assessment of corrosion growth. The technique used relies on high frequency ultrasonic guided waves that travel long distances, a large area can be interrogated using a few PWTs to identify the location and severity of corrosion growth.

Pulse eddy current system functioning was validated with testing on rebar samples cast in concrete and subjected to accelerated corrosion. Indian patent application has been filed on this technology (Figure 5.5). FPGA based ultrasonic

transducer system functionality has been validated on artificially corroded rebars (Figure 5.6).

Validation of finite element numerical model that serves as a digital twin for accelerated corrosion with experimental data is in progress in the project under the domain "Nano Technology Hardware"

Separately, in this project an additional technology for in-situ monitoring of sacrificial zinc anodes used in cathodic protection systems was developed. This was achieved through electro-mechanical impedance measurements of these sacrificial anodes instrumented with piezoelectric transducers (Figure 5.7). Indian patent application No. 202121019388 has been filed on this technology.

The work was done at Indian Institute of Technology, Bombay.

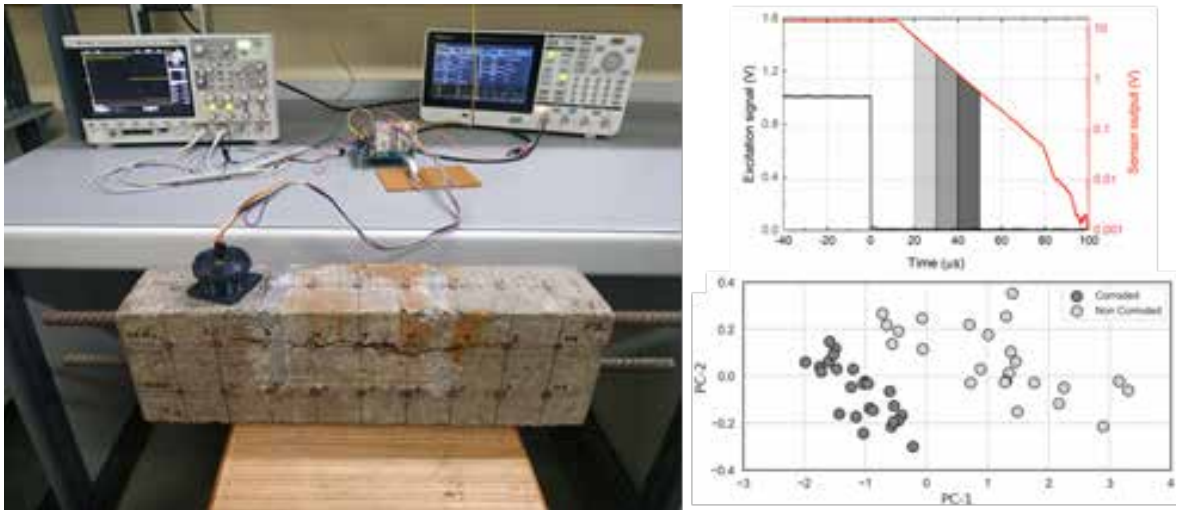


Fig. 5.5: (Left) Photograph of experimental setup with compact eddy current probe for testing corroded rebar samples. (Right) The technique developed utilizes area under the curve of various portions of the time domain sensor output recordings. These features are then analyzed using principal component analysis to distinguish between corroded and non-corroded portions of rebars, with lift off distance as high as 55mm.

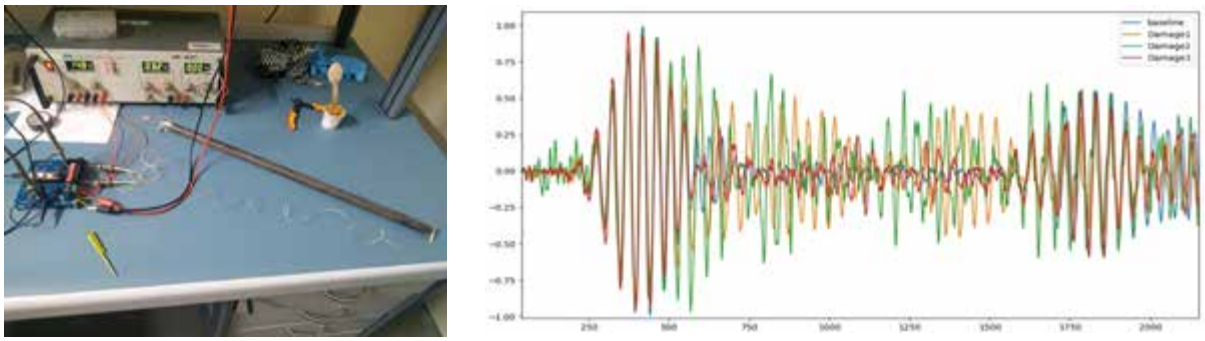


Fig. 5.6: (Left) Photograph of piezoelectric transducers connected to a rebar, and actuated by compact FPGA board developed in this project. (Right) time domain recordings captured by the FPGA system, for various rebars with artificially induced corrosion (mass loss).

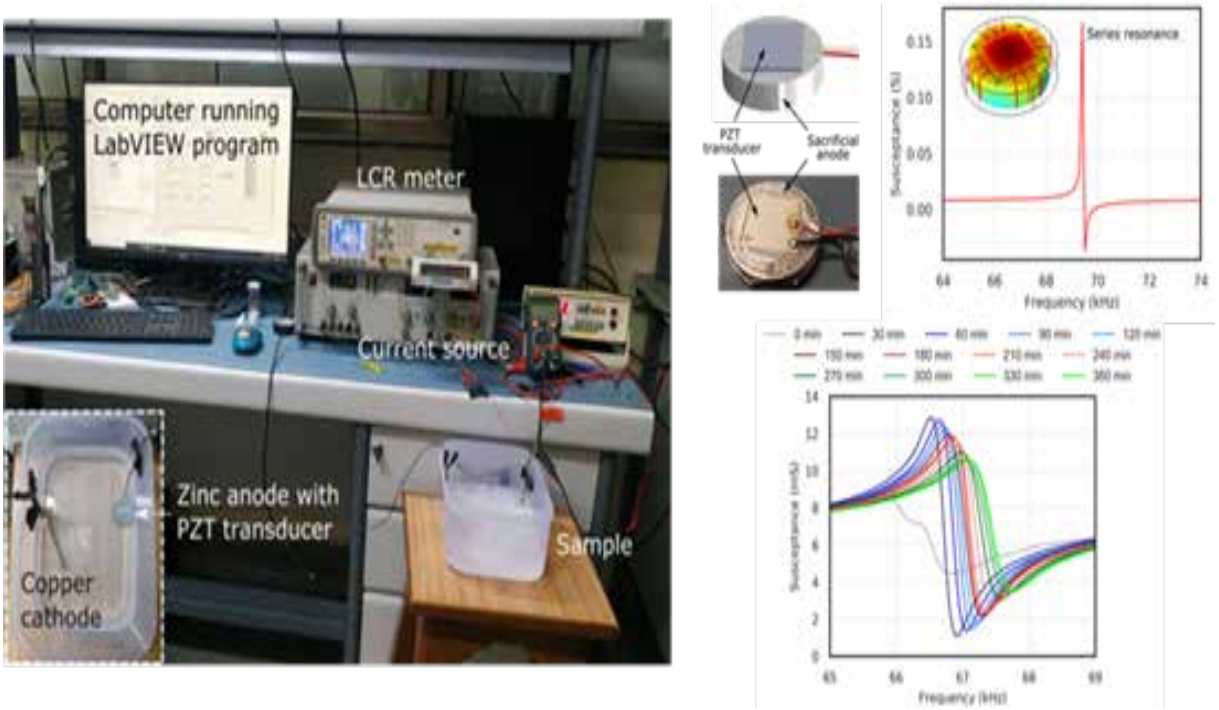


Fig.5.7: (Left) Photograph of experimental setup to induce accelerated corrosion in sacrificial anode, monitored using electro-mechanical impedance. (Top right) Zinc anode instrumented with PZT transducer, and simulation profile of radial expansion mode. (Bottom right) Experimental data showing change in susceptance spectra due to impressed current of magnitude 0.35A applied for varying time duration to introduce accelerated corrosion in the anode.

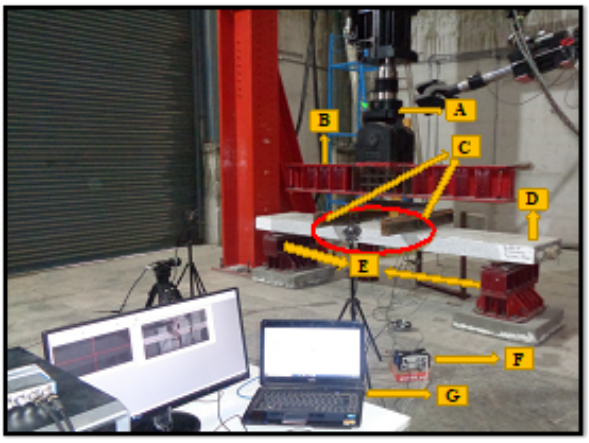
Development of Innovative and Sustainable Low-Cost Light-weight Precast Hollow Core Structural (LWPHCS) Systems for Affordable Housing: In one of the projects under "Sustainable Habitat" a fibre-reinforced structural lightweight concrete (SLWC) using sintered fly ash aggregate (SFA) as coarse aggregate was developed.

With a rapid increase in urbanization and growing housing needs, there is a pertinent need for the development of alternative building technologies which are cost-effective, energy efficient for production, construction, and maintenance. SFA is manufactured from fly ash, an industrial by-product, thus making SLWC a sustainable building material. SLWC of density 1800 kg/m3 was developed with and without the addition of synthetic polyolefin (macro and micro) fibers to achieve a target compressive strength of 40 MPa. After understanding the mechanical properties of SLWC made of SFA and fibers, they were used to manufacture structural Lightweight precast hollow core slabs (SLWPHCS). Material level tests, carried out for understanding the stress-strain relationship under compression, split tensile strength and fracture behavior under flexure. Full-scale tests done on structural lightweight precast hollow core slabs (SLWPHCS) shown in Figure 5.8. Flexural and shear tests done on SLWPHCS indicate that SLWPHCS has adequate strength and stiffness. The study shows that the sectional dimensions need to be further optimized to improve the performance and prevent premature bond failures. Also, to achieve full compaction in full-scale elements and better bond with steel rebars, cement content in the developed concrete mix must be increased. In addition, the edge distances and thickness around the hollow cores need to be slightly increased to prevent premature failure modes.

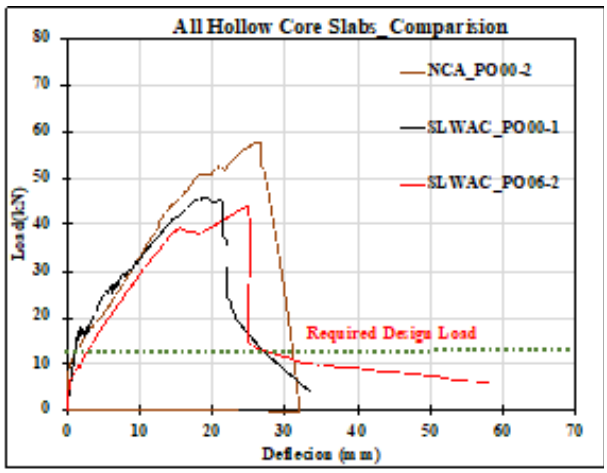
Key Achievements:

- Developed Lightweight concrete mix can be used for various other applications.
- Tests on SLWPHCS shows tremendous potential for precast applications.

The work is being carried out at Indian Institute of Technology, Hyderabad.



A=1000 kN servo-controlled actuator, B=Spreader I-Beam, C=Loading I- Beams, D=Hollow Core Slab, E=Support I- Beam, F=DAQ and G=Computer



Load - Deflection Behaviour Hollow Core Slabs

Fig. 5.8: Full-scale tests on structural lightweight precast hollow core slabs (SLWPHCS)

Sanitation in Circular Economy - An integrative modular onsite toilet treatment for Recovery of NPK fertilizer, Carbon and Water: Under the domain" Environmental Science and Climate Change" a pilot scale system has been set up with a capacity to process 100 l /hour of undiluted urine from waterless urinals of the male toilets located at the ED building of IIT Madras. The nitrogen in feed urine was recovered in the form of ammonia through a steam distillation process, and phosphorus in urine was precipitated in the form of struvite by adding a magnesium salt solution. A steam generator of capacity (4KW) was used for the distillation process in a packed bed with a mixture of packing materials made of stainless steel in a short distillation column of length 1.3 meters. The steam generator was equipped with a temperature sensor to monitor and control the temperature of the steam. The generated steam close to 102°C was passed through the bottom of the distillation column, and urine was sprayed through a nozzle from the top of the packed column.

Simultaneous mass and heat transfer led to ammonia extraction from urine to steam in a counter-current fashion. This steam + ammonia mixture was then condensed to a distillate (product ammonia) in a dual shell and tube heat exchanger system that cooled down the temperature to 30±2°C to obtain a 3-4% concentrated ammonia solution. To the left-out urine from the distillation process, magnesium chloride salt was added to precipitate struvite in a dual cone reactor. The pilot system was operated with various urine to steam ratios to compare nitrogen recovery and energy consumption. Similar pilot scale plant was set up at PSGiTech to study the nutrient recovery potential from Cow Urine.

A pilot scale system of 500 l/day capacity is fabricated currently to be implemented at Taramani, Chennai near a high footprint area in collaboration with Loo Café. Loo café has around 451 public restrooms around India and are opening up in Chennai, Tamil Nadu. The Café is attached with Toilets in way that it works as a comfort stop, so far in the implementation. The firm closely works with the central government on the Swachh Bharath vision are building aspirational toilets. They intend to set up atleast 1000 toilets across India including cafes in J&K, Northeast, and low access regions of the country. As a part of the project, the PI's outreached with the founders of the Café proposing for a pilot study at LooCafe, tharamani, Chennai. The founders of firm are aligned with the vision of the project and its outcome. The engagement is

formalized with the closure of the MoU. Ecofert system is the outcome of the research work (Figure 5.9 (a & b) Public toilets and Schematic of Ecofert unit). Prototype of the system is fitted in the toilets of the Engg. Design building, Indian Institute of Technology, Madras (Figure 5.9c). This comes under Swatch Bharat Mission.

The work is being carried out at Indian Institute of Technology, Madras.

Fig. 5.9(a): Public Toilets

Fig. 5.9(b): Schematic of Ecofert Unit

Fig. 5.9 (c) : Retro-fitted waterless urinals

5.1.2 Uchhatar Avishkar Yojana (UAY)

The Uchhatar Avishkar Yojana (UAY) has been launched by the Ministry of Education (MOE) with a view to promote innovation of a higher order that directly impacts the need of the industries, thereby improving the competitive edge of Indian Manufacturing capabilities. The industry-sponsored, outcome - oriented research projects were funded. While MOE funds 50% of the project cost, industry and other participating Ministries share the balance project cost (25% each). SERB is partnering with MOE in funding UAY projects. Partial funding support is being provided to a total 39 projects under UAY-Phase-I and Phase-II.

Research Highlights

Development of Cold-Spraying Based Additive Manufacturing Process for Industrial Application : Additive manufacturing is promising technology for synthesizing specialized and complex geometries with reasonable production volume and reduced production time. It is against this background, the idea of employing cold spray technology sprung up. The potential use of cold spray as an additive manufacturing is pioneering work in India. A state-of-the-art cold spray facility (50 bar, 1000°C has been established at IIT Ropar (Figure 5.10), with an active support of Generic Electric (GE), India as an Industrial Partner and Shiv Nadar University, as Collaborator. The cold spraying process has been established as an additive manufacturing technology for developing thick layers and geometries of various alloys such as Ti, Ni/Cr and Ni-based superalloys. The know-how can be used in different industries and sectors (Energy, Aviation, Oil and Gas, Locomotives and Healthcare). The research group is able to develop generic process plan which can produce stand-alone products with the desired integrity and overall performance characteristics. The facility is now extended to several institutions and industries as a National Facility.

Fig. 5.10: Cold Spray Facility at IIT Ropar

Plasmonics-based Highly Sensitive Gas Sensors and Sensing System: The research group at IIT Delhi fabricated plasmonic sensors using different nanofabrication methods followed by thin film deposition. Standard nanolithography processes such as electron beam followed by metal deposition and lift-off were employed to first develop the plasmonic nanostructures. Developed plasmonic nanostructures using large-area nanofabrication methods such as metal deposition and annealing as well as in-situ metallic nanostructure fabrication at higher substrate temperatures using thermal evaporation or pulsed laser deposition to form the plasmonic nanostructures and coated them with the gas adsorbent layers using pulsed laser deposition (Figure 5.11).

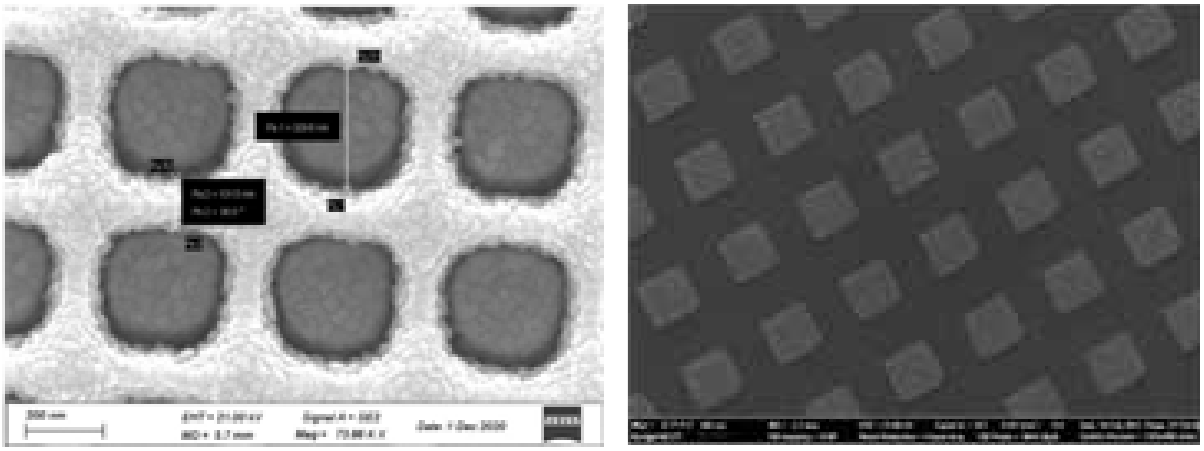


Fig. 5.11: SEM image of a plasmonic nanostructure fabricated by developing nanostructures in silicon and over-coating with Au and Pd, and and SEM image of a plasmonic sensor chip by EBL.

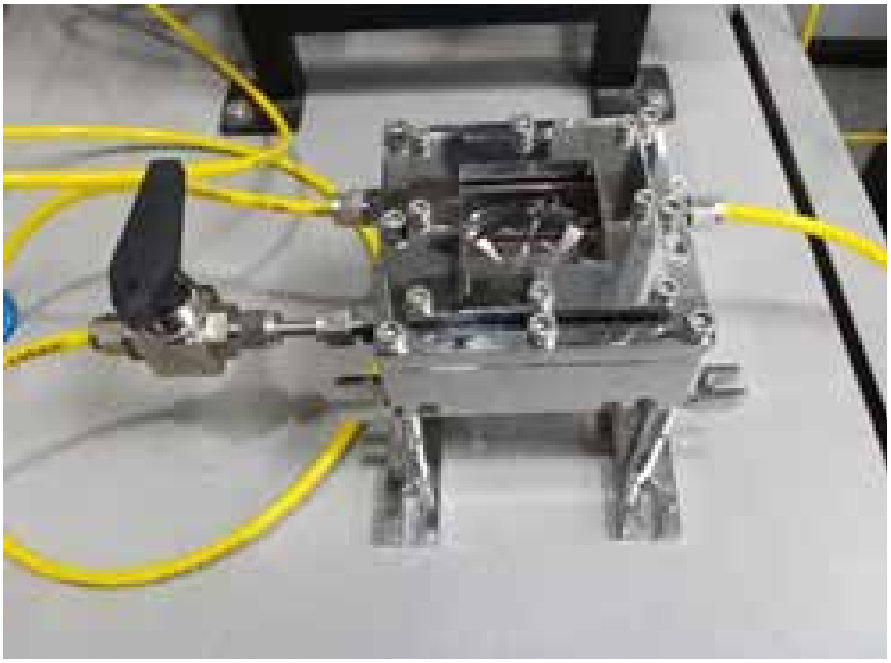


Fig. 5.12: Gas sensing system employed for gas sensing

The group also developed test chambers for gas sensing. The development of a multi-gas sensing system, with the capability to controllably inject small amounts of multiple gases and detect them inside the chamber, was carried out (Figure 5.12). The fabricated gas sensors were tested using the testing chambers and sensitivity determined.

The group also developed electronic gas sensors based on thin films (such as ZnO) and metallic nanoparticles fabricated on top of the thin films. Two terminal devices were developed in which relative change in current/resistance with gas concentration was measured.

5.2 International Linkages

5.2.1 International Visiting Advanced Joint Research (VAJRA) Faculty Scheme

VAJRA Faculty Scheme aims to tap the expertise of overseas scientists including Non-resident Indians (NRIs) & OCIs. It offers adjunct / visiting faculty positions to overseas scientists / R&D professional to undertake high quality collaborative research in public funded academic and research Institutions in India. The Scheme facilitate collaborative research in frontier areas of S&T including the interdisciplinary areas of national priorities such as energy, water, environment, health, security, nutrition, waste processing, advanced materials, high performance computing, cyber-physical systems, smart machines, and manufacturing etc. and stimulate the latent potential of our academic and research sector.

During the reporting period 37 accomplished scientists have been offered VAJRA Facultyship out of which 19 were sanctioned.

Significant research leads out of the engagements are given below:

Vajra Team at IIT-Delhi developed method for obtaining tree inventory in India regions for i-Tree eco model.To analyse the environmental and economic benefits of south Delhi (India), a complete inventory of trees was developed using i-Tree Eco modelling software. Following feature values are estimated like carbon storage, pollution removal, Carbon Sequestration, Oxygen Production, most dominant species, tree cover number of trees in the study area and understanding of an urban forest's structure, function and value to promote management decisions that will improve human health and environmental quality. The team has validated their approach with various publicly available data and found that it lies within the acceptable limits. Table 5.1 is the iTree suite output using developed framework.

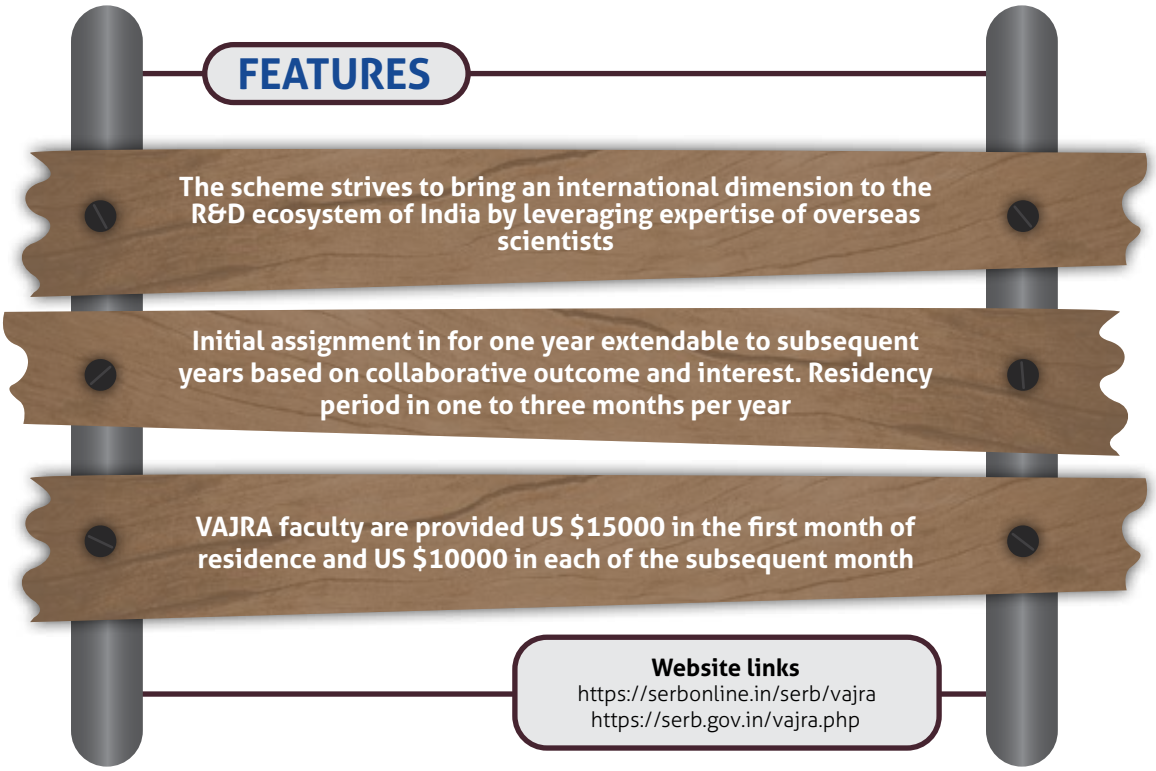
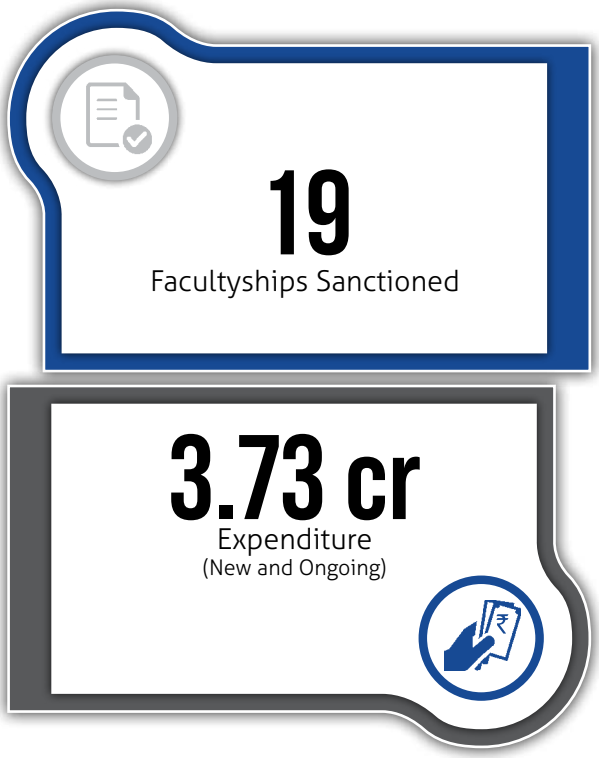


Table 5.1: iTree model of South Delhi output

Feature	Estimate
Dominant species	Prosopis juliflora,Morus alba , Leucaena leucocephala,Grevillea robusta Azadirachta indica, ficus religiosa , Polyalthia longifolia,
Most common species of trees	Prosopis juliflora, Leucaena leucocephala,Polyalthia longifolia
Number of trees	58645
Tree cover	833.119 hectares
Pollution Removal	178.53 mT
Carbon storage	302.81 thousand mT
Carbon sequestration value	232.69 mT/year
Oxygen production	620.42 mT/year
Percent of trees less than 15.2 cm diameter*	%

A Vajra Team at IIT – Bhubaneswar is Investigating recent changes in the currents and eddies in the northwestern Bay of Bengal where a gap-filling methodology is developed for HF radar surface currents data. This methodology will be helpful for operational oceanography and data assimilation in the numerical models. A coupled bio-physical ocean modeling setup has been configured in the Bay of Bengal to analyze the biogeochemical cycles over the ocean. This high-resolution ocean product will help study the fine-scale ocean structures and input for the operational atmospheric models. Identifications of Lagrangian coherent structures were found to be a powerful technique for studying the dynamics of the Evolution of Mesoscale eddies. The impact of global warming was reported through satellite observations for surface oceans. Recent changes in the subsurface in five regions of the Indian Ocean from Argo data was identified in another study. Diurnal Variation of Biophysical Parameters in the Upper Mixed layer was found to be promising results to validate the ocean models and to be useful for improvement in numerical models. Shifting of the tracks of the post-monsoon cyclones to the west in the Bay of Bengal increases the chances of cyclones interacting with the warm boundary current and eddy regions. Hence, the cyclones reached the higher than very severe cyclone stages in recent times.Finally, a preliminary study identified the marine heatwaves in the Bay of Bengal their links with IOD and ENSO phases and their impact on the surface chlorophyll (productivity).



5.2.2 SERB OVERSEAS VISITING DOCTORAL FELLOWSHIP (SERB OVDF)

The scheme aims to build national capacity in frontier areas of Science and Engineering, which are of interest to India by providing research training to PhD students admitted in the Indian institutions in overseas universities / institutions of repute. It also aims to provide opportunity to performing Indian research students to gain exposure and access to top class research facilities in academia and labs across the world thus creating opportunities to build long-term R&D linkages and collaborations with accomplished scientists and technologists from around the world. The SERB OVDF also envisages to tap the expertise gained by these young scientists to strengthen/initiate national programmes in their domain knowledge.

During the reporting period 25 students were awarded SERB - Purdue University Overseas Visiting Doctoral Fellowship and 10 students were awarded SERB – University of Alberta Overseas Visiting Doctoral Fellowship.

FEATURES

The student should have registered for full-time Ph.D. degree in any of the recognized Institutions / Universities in India in STEM.

The duration of the research training is upto a period of 12 months.

Monthly fellowship of US$ 2000, one-time Contingency/ Preparatory allowances of Rs. 60,000/- and round-trip air fare are provided.

Website links
https://serbonline.in/serb/ovdf

Significant research leads out of the engagements are given below:

- A combined research work of AcSIR-Central Scientific Instruments Organization, Chandigarh and Purdue University Developed PEDOT: PSS sensor (conducting polymer) on platinum interdigitated electrode. Sensor testing for three different analytes released from Li-ion batteries i.e., Ethanol, Ethyl methyl carbonate and Methyl formate. Detection of toxic and flammable gases and volatile organic compounds (VOCs) released from Li-ion batteries during thermal runaway can generate an early warning. A submicron (~0.15 µm)-thick poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT: PSS) sensor film is coated on a platinum electrode through a facile aqueous dispersion. The resulting sensor reliably detected different volatile organic compounds (VOCs) released during the early stages of thermal runaway of lithium-ion batteries (LIBs) even at low concentrations. The single-electrode sensor utilizes impedance spectroscopy to measure ethyl methyl carbonate and methyl formate concentrations at 5, 15, and 30 ppm independently and in various combinations using ethanol as a reference.

47
Fellowships Sanctioned

8.08 cr
Expenditure
(New and Ongoing)

- Under the research visit between Sree Chitra Tirunal Institute for Medical Sciences and Technology, Kerala and Purdue University, the research work was aimed to detect toxicity

limits of TNTs in C6 glial cells and compare the limits with co-polymer functionalized TNTs. They are currently synthesizing TNTs in two phases via a cost-effective and simpler approach based on hydrothermal principle. After characterization in terms of morphology, size, geometrical distribution and functional groups, tested the materials for in vitro toxic response using C6 glial cells. Major endpoints evaluated included cytoskeletal integrity, lysosomal stability, mitochondrial membrane potential, enzymatic activity, and nuclear stability. TNTs were prepared in a series of concentrations (0,5, 10, 20, 40, 80, 160, and 320 μγ/mL). The results indicated toxic responses starting from 160 μγ/mL. Similarly, also completed an in vivo acute toxicity study in Wistar rats using a TNT concentration of 10 mg/kg body weight. Major endpoints analyzed were gross pathology, hematology, evaluation of antioxidants, blood biochemistry, urine analysis, and immunotoxicity. Biodistribution of the TNTs in the major organs (e.g., brain, liver, spleen, and kidney) was studied using ICP-MS. Toxicokinetics of the injected material was analyzed using Raman spectroscopy.

6

COVID-19 R&D INITIATIVES

The pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) led to public health catastrophe with substantial mortality and morbidity across the globe. SERB supported R&D activities in response to the outbreak of COVID-19 contributed significantly interms of understanding the evolution of SARS-CoV-2 infection and plausible therapeutic intervention and also the dynamics of the humoral immune response during and after recovery from COVID-19. The studies supported in the direction of diagnostics resulted in the development of inhouse antigen and antibody-based COIVD-19 detection kits and prototypes.

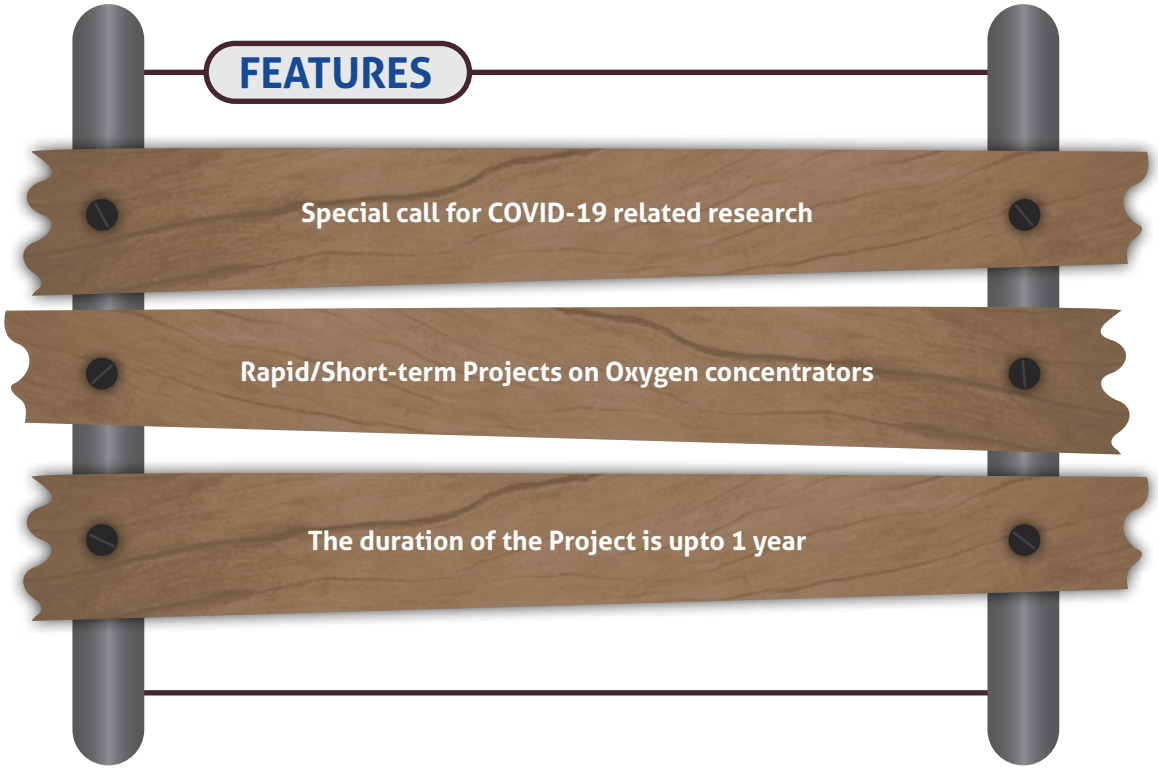
As the global COVID-19 pandemic continued in the form of new variants and considering the emerging health care requirements during second pandemic, SERB announced a special call to catalyse R&D on critical components and innovations concerning Make-in-India Oxygen concentrators.

The details of the special call and the highlights of ongoing COVID-19 related R&D activities are highlighted in this chapter.

6.1. Special call on Critical Components and Innovation in Oxygen Concentrators (New)

Considering emerging healthcare requirements to combat the COVID-19 epidemic, SERB announced a special call to catalyze R&D on critical components and innovations concerning Make-in-India Oxygen Concentrators. The call seeks investigation and innovation in the development of (individual/portable) oxygen concentrators in the domains of alternate materials and mechanisms for oxygen separation; design, development, and manufacturing of critical components such as valves and oil-less compressors, design improvements for greater performance, AI optimized oxygen flow devices, and oxygen-level IoT sensors etc. The proposals were invited from scientists in regular service from educational and research institutes/ laboratories, universities, and medical institutions, start-ups and industries.

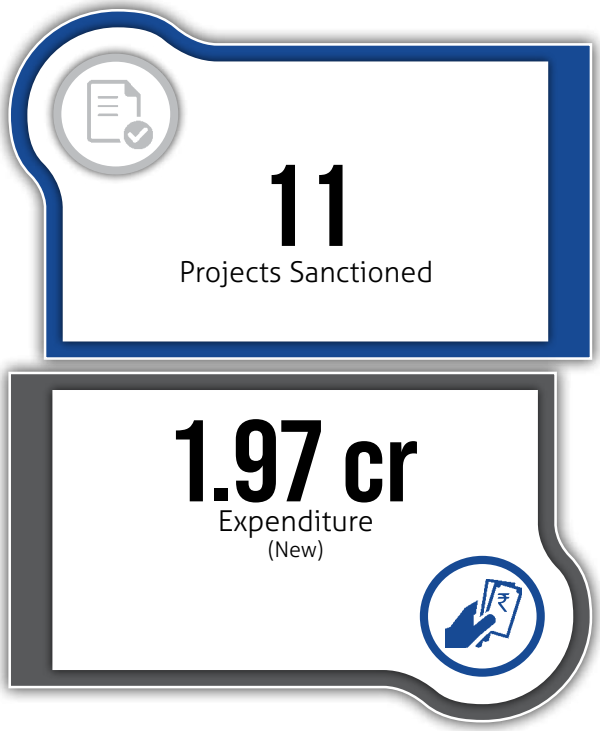
Under this CRG-COVID-19 special call, 130 proposals were received, and 11 proposals were supported for one year.



Highlights of some of the Projects supported are given below:

Oxygen conserving device for oxygen concentrators and standalone oxygen cylinders

The project is to develop an electronic based oxygen conserving device to optimize the usage of oxygen given to a patient on oxygen therapy. The device is based on the principal of providing only optimal amount of oxygen to the patient and delivering this bout of gas only during the time of the breathing cycle when the oxygen is absorbed by the lungs. The oxygen conservation device will serve two purpose: a) Extend the life time of oxygen cylinders, thereby helping to avoid their frequent refilling hence the associated cost and inconvenience and b) efficient use of oxygen generated by a concentrator will result in reducing the capacity/size of its components, hence the concentrators can be more portable and less expensive. The above benefits will be especially useful for patients on long term oxygen therapy. Oxygen cylinders and oxygen concentrators are two of the most important ways to deliver oxygen at the point of care. While concentrators have high initial setup costs, the cylinders are relatively cheaper. However, even at the minimal flow rate of 2 l/min a 2000 l oxygen cylinder needs to be replenished every day. Therefore, depending on duration of the therapy the total cost may run upwards that of the concentrator. With respect to the oxygen concentrators, it is critical to make them more portable so that the patients on long term therapy can remain mobile in order to



maintain the quality of their lives. For minimizing the cost and inconvenience associated with the frequent refilling of cylinders and for increasing the portability of oxygen concentrators it is important that there is minimal wastage of oxygen delivered by these devices and maximum percentage of it is used for blood oxygen saturation. Since the time spent in inhalation is around 1/3rd the time spend in exhalation and also since during the latter half of inhalation cycle the oxygen fills up the dead space and is not absorbed by the alveolus, the continuous oxygen flow devices waste a minimum 5/6th of the oxygen supplied. This means less than 1 l of oxygen generated by a concentrator operating at the rate of 5 l/min is actually used. Therefore, ideally a concentrator can serve its purpose even at reduced oxygen generation rate if all the generated oxygen is optimally used. This lower oxygen generation rate will in turn enable the reduction of the expensive and bulky hardware components in a concentrator such as the pumps and zeolite, therefore enabling the concentrator to be more portable and less expensive. In the proposed oxygen conserving device investigator would be sensing the inhalation cycle of a patient on oxygen therapy. A pulse of oxygen will be released only during part of breathing cycle when the gas is absorbed by the lungs. Taking feedback of the blood oxygen level of the patient using oximetry the amount of oxygen in this pulse will be adjusted. It is estimated that around 5 to 10x oxygen saving can be achieved using the proposed device. The work is in progress at Indian Institute of Technology, Delhi.

Intelligent pulse flow respiratory device based on photoplethysmogram (PPG) and surface electromyogram (sEMG) sensory fusion for optimized delivery of oxygen from oxygen concentrators in COVID-19 dyspnea

In the current project investigators will develop device based on PPG and sEMG for optimized delivery of oxygen in COVID-19 patients with dyspnea. Continuous flow of oxygen commonly used drastically reduces the oxygen usage efficiency leading to higher wastage and increased load to oxygen concentrators. On the contrary pulse mode delivery of oxygen higher oxygen usage efficiency is ensured since in such mode a bolus of oxygen is released just before the inhalation process based on patients respiratory trend. Pulse mode oxygen delivery are not popular till date since they require an exact synchronization of breath rate though few foreign manufacturers have incorporated the idea in their pulse mode oxygen concentrators. In order to focus on efficient use of oxygen and enhance fidelity of pulse flow oxygen delivery investigators proposed to develop a pulse flow respiratory device which would be capable of delivering oxygen by sensing the exact time of inhalation employing PPG and sEMG attached to patient's finger and chest region respectively supported by intelligent algorithms. Nevertheless the proposed device will have a size equal to human palm and will have capabilities for use with oxygen concentrators as well as oxygen cylinders. The project is under progress at CSIR- Central Mechanical Engineering Research Institute, Durgapur.

6.2 Special call on COVID-19 (Ongoing)

6.2.1 CRG Short Team Special call on COVID-19

6.2.1.1 CRG-Chemical Sciences

Evaluating the potential antiviral efficacy of functional carbon quantum dots loaded with Ketorolac salt against SARS-CoV-2.

One of the emerging applications is establishment of carbon quantum dot as antivirals agents against porcine reproductive and respiratory syndrome virus (PRRSV), herpes simplex virus type 1 (HSV-1) and most importantly against SARS-COV. Similarly, Mexen quantum dots (MXQD) has recently garners interest for drug delivery. DDX3 belongs to the DEAD-box proteins, which is extremely important for viral replication and DDX3 inhibitors show antiviral activity against specifically positive-

sense single-stranded RNA viruses. But the role of DDX3 in SARS-CoV-2 replication is yet to be explored. Recently Ketorolac (NSAID) salt identified as an inhibitor of human RNA helicase DDX3. Similarly, RK33 is also identified to be another inhibitor of DDX3 by other groups.

The 3 different types of Mxene quantum dots (MX-QD-4,5 or 6) had been synthesized and RK33 was loaded in to the quantum dots. Further, it had been evaluated the anti-SARS-COV-2 effect of Mxene quantum dots loaded with RK-33 (Figure 6.1). The RT-PCR data suggested that Mxene quantum dots alone had no anti-viral activity, but Mxene quantum dots loaded with RK33 showed robust anti-SARS-COV-2 activity. It was interesting to observe that the IC50 of RK33 has decreased 3-4 fold once it was loaded in Mxene quantum dots. Other than RT-PCR for quantifying viral genes, PI performed the gold standard plaque assay, which also suggests increased anti-viral effect of Mxene quantum dots loaded RK-33. Overall, these study indicated for the first time that DDX3 inhibitor RK33 (loaded in Mxene quantum dots) significantly blocks the replication of SARS-COV-2. The study was done at Institute of Life Sciences, Bhubaneswar.

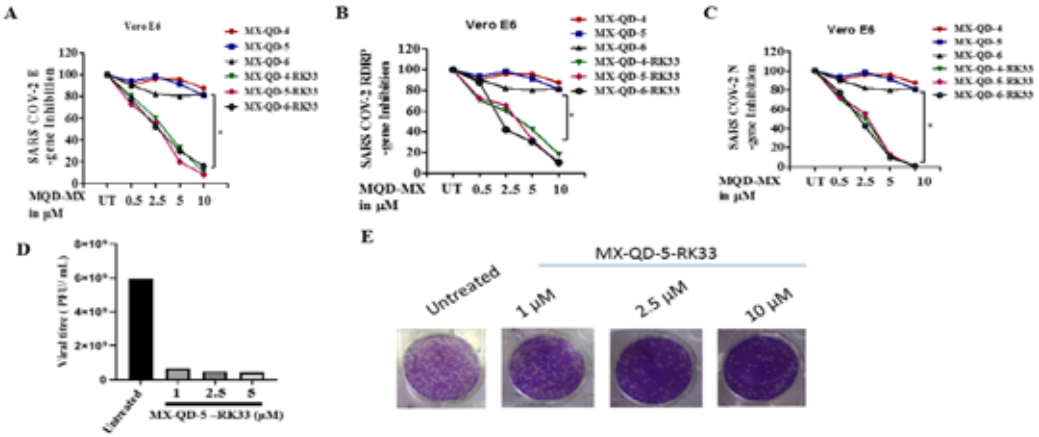


Fig. 6.1: Mxene quantum dots loaded RK33 blocks SAR-CoV-2 infection in VERO6 cells: (A-C): Mxene quantum dots (three types 4,5 and 6) loaded RK33 were treated to Vero cells infected with SAR-CoV-2 virus and qRT-PCR was performed to score E, RDRP and N-gene, respectively.(D). Viral titer was determined in Vero E6 cells infected with SAR-CoV2 virus and treated with Mxene quantum dots loaded RK33. E) Vero cells were treated as described in panel D and plaque assay was illustrated.

Extremely Water Repellent Coating for Anti-Viral Application

The purpose of this work was to explore preventive measures and find remedial approaches to combat COVID-19 infections in health care settings. The objectives were highly focussed on multiple areas like viral decontamination of inanimate surfaces, disinfectant and hand sanitizer, and anti-viral coatings. Regular tissue paper and damp cotton fabric are not recommended to use as face mask as tissue paper readily disintegrates on aqueous exposure, and it is extremely difficult to keep the cotton based mask dry in humid condition. However, simple and economic superhydrophobic coating on tissue paper can provide both the stability to the tissue paper and it will also prevent the penetration of water. Further, such coating on cotton fibres would keep the mask dry for long duration.

A facile and rapid synthesis process has been introduced for developing a durable and extremely water repellent coating that keep the interface clean and dry. Moreover, the association of appropriate metal-oxide nanoparticles with extreme water repellence allowed to develop an antiviral coating.

In this context, even the association of Cu_2O nanoparticles with a lattice spacing of 0.26 nm which corresponds to the (111) plane was associated with such coating, where the Cu_2O nanoparticles loaded superhydrophobic coating showed high cell viability (95%). The small molecules derived coating was successfully deposited on various fibrous and porous substrates. Different commercially available masks (cotton mask, jute mask, nan-woven mask) were successfully decorated with such antiviral-superhydrophobic coating Figure 6.2 A-F. Such coating was found to be efficient for its antiviral performance (93 % within 1 h, Figure 6.2). In addition, the coating has the ability to keep the inherently hydrophilic substrate dry and clean—

even after accidental aqueous spillage, which is important to prevent the viral-contaminations effectively at practical settings. The study was done at Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru.

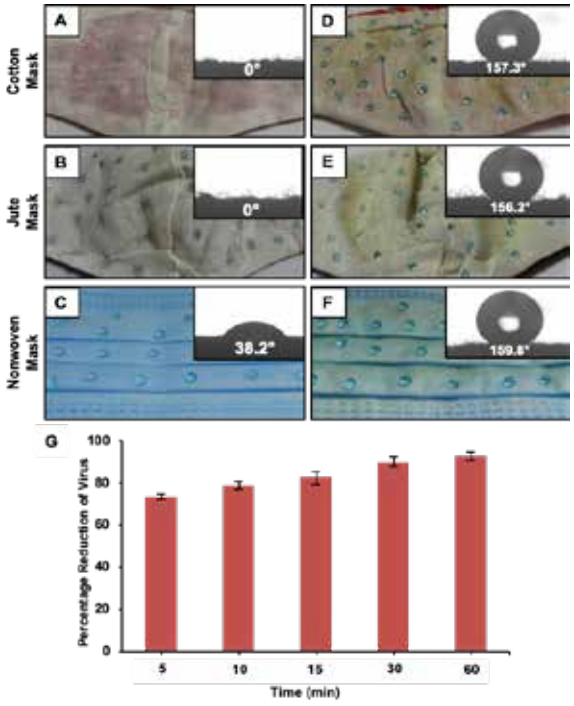


Fig. 6.2: Antiviral- superhydrophobic coating A-F: Digital and contact angle image (in set) of beaded water droplets on the bare (A, B, C) and coated (D, E,F) natural and synthetic fibrous substrates including cotton (A,D), jute (B,E) and non-woven fabric (C,F). G) Graph accounting the percentage virus reduction over the time of exposure to prepared coating.

6.2.1.2 CRG- Life Sciences

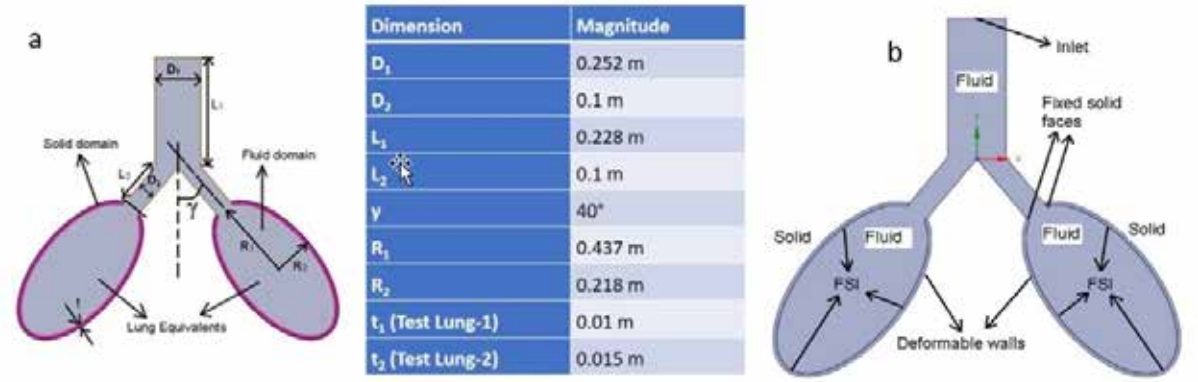
Nanopore sequencing-based rapid monitoring of Covid-19 nucleic acids in the drains of Pune River:

The fragments of SARS-CoV-2 are known to be shredded in through faeces and such reports are published from western countries. The present study was able to detect the fragments of SARS-CoV-2 RNA in sewage samples using RT-PCR assay. Positive Sewage RNA samples from open drain entering river during December 2020 to March 2021 were directly sequenced to understand mutations in the wastewater samples. ARTIC v3 based amplicon strategy was used and sequenced on Nanopore sequencer. The analysis revealed 108 mutations across six samples categorised into 39 types spaning whole genome of SARS-CoV-2. The study found the occurrence of mutations associated with Delta variant lineage in March-2021 samples, simultaneously also reported as a Variant of Concern (VoC) responsible for the rapid increase in infections. The study also revealed four mutations; S:N801, S:C480R, NSP14:C279F and NSP3:L550del not currently reported from wastewater or clinical data in India but reported worldwide besides reporting a novel mutation NSP13:G206F mapping to NSP13 region. Notably, S:P1140del mutation was detected in December 2020 samples while it was reported in February 2021 from clinical data, indicating the instrumentality of wastewater data in early detection. This is the first study in India to demonstrate utility of sequencing in wastewater-based epidemiology to identify mutations associated with SARS-CoV-2 virus fragments as an early warning indicator system. The wide-spread transmission of SARS-CoV-2 can make it challenging to test every individual in densely populated countries. The total number of individuals exposed to SARS-CoV-2 based on the detected viral gene copies per litre and viral particle shedding per individual to then suggest that sewage based surveillance can be an effective approach to study the infection dynamics and management of the SARS-CoV-2 spread.

The study was executed at CSIR-National Chemical Laboratory, Pune.

Single Ventilator Design Modification for Optimal Multi-patient use: A CFD study

The current study is a first of its kind to develop a dual test lung/simulator using the Fluid-Structure Interaction (FSI) computational approach with an elastic airbag structure which will particularly bring down the time and cost associated with the manufacturing of a test lung.



Dimension	Magnitude
D_1	0.252 m
D_2	0.1 m
L_1	0.228 m
L_2	0.1 m
γ	40°
R_1	0.437 m
R_2	0.218 m
t_1 (Test Lung-1)	0.01 m
t_2 (Test Lung-2)	0.015 m

Fig. 6.3: (a) Characterization of 2-dimensional geometry of dual lung simulator with elastic airbags (b) Boundary Conditions and domains for the simulation set-up

The 2-dimensional dual-lung simulator used in the present work consists of an inverted Y-piece (Figure 6.3). The bifurcation angle of the Y-piece is denoted by γ. The thickness of the solid domain is varied (10 mm and 15 mm) to vary the compliance of the lung named as test lung-1 (TL-1) and test lung-2 (TL-2), respectively by considering age and compliances of different people. For the numerical study, the flow is assumed to be laminar and viscous having ideal air characteristics. All the meshing and computations are performed in the ANSYS Workbench R2021 using the partitioned FSI-approach. The model tested for ventilator waveform volume controlled input which shows similar response to ventilator output pressure (Figure 6.4).

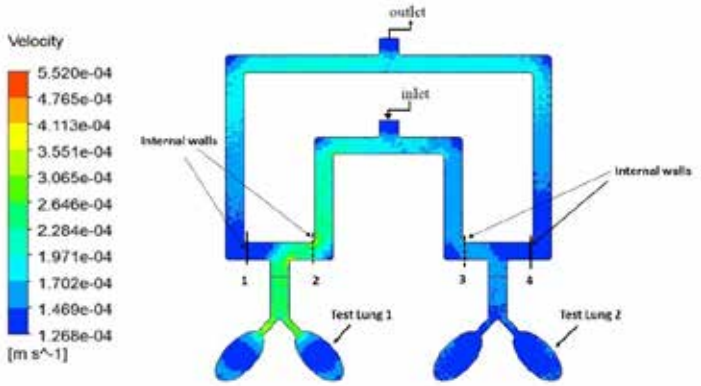


Fig. 6.4: Velocity pattern through splitting flow with similar compliance of lungs.

For splitting of ventilators two similar compliance test lungs has been attached to the breathing cuircuit such as it contains internal walls 1,2 for test lung 1 and internal walls 3,4 for test lung 2. The wall 2 and 3 during the inhalation allows the air flows till end of inspiration (i.e. 2.5 sec) after that these walls 1,2 restricts the air flows and walls 1,4 allows air follow the path to outlet till the end of exalation completeing 5 sec time to one respiratory cycle. The study was done at Indian Institute of Technology, Delhi.

6.2.2 IRHPA Short Term Special Call on COVID-19

Immuno-epigenetics study of the humoral immune response in COVID-19 patients from India

2.39 cr
Expenditure
(Ongoing)

The COVID-19 pandemic has evolved with variable trajectory in diverse geographical locations. Pre-existing immunity acquired from common cold and human Coronaviruses (HCoVs) could have substantial implication in the immunological and epidemiological outcome of the pandemic. Because of the diverse geo-distribution and prevalence of HCoVs, there may be a varying impact of pre-existing immunity on the SARS-CoV-2 infection. Multi-centric study has been initiated to understand the traits of pre-existing immunity and its impact on the virus spread and pathogenesis, disease outcome and the establishment of protective immunity in COVID-19. In this study investigators showed that almost 70% of the examined Indian cohort showed very high levels of SARS-CoV-2 reactive CD4+T cells, which are present prior to the COVID-19 pandemic (Figure 6.5). The prior presence of T cells strongly responds to the COVID-19 virus and limits the virus burden and also reduce the course of symptomatic infection.

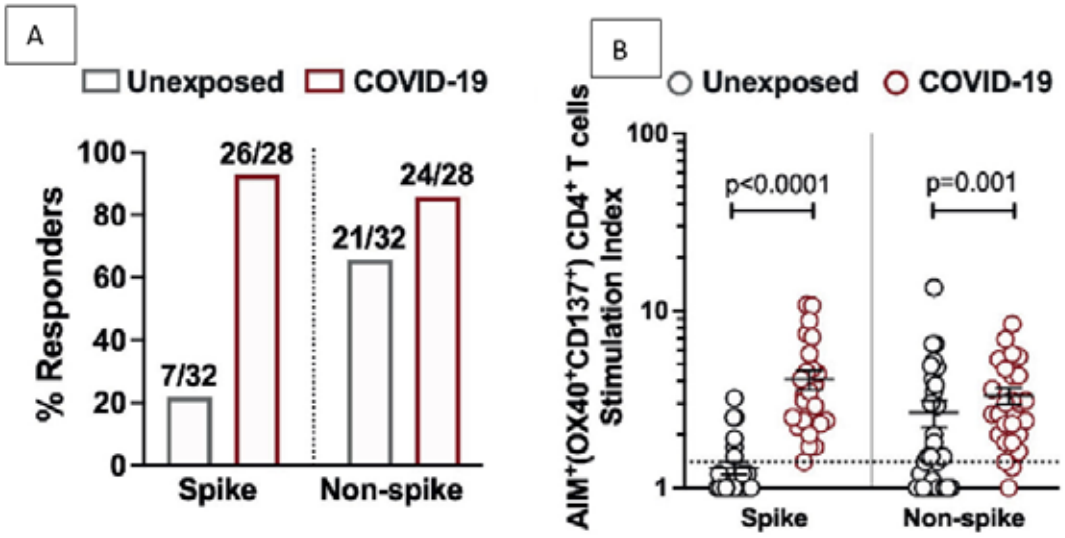


Fig. 6.5: SARS-CoV-2 specific CD4+T cells in unexposed donors and recovered COVID-19 patients. (A). Frequency of responders to spike and non-spike peptides pools in unexposed and COVID-19 recovered subjects. The value on bars denotes the number of responders/total number of donors tested. (B). Stimulation index quantitation of the CD4+T cells in unexposed versus COVID-19 cases.

Further to test the durable immunological memory in patients recovered from mild COVID-19 disease investigators analyzed the frequency of each isotype-specific antibody secreting B cell population in unexposed subjects and the COVID-19 patients upto 5 months (Figure 6.6 A).

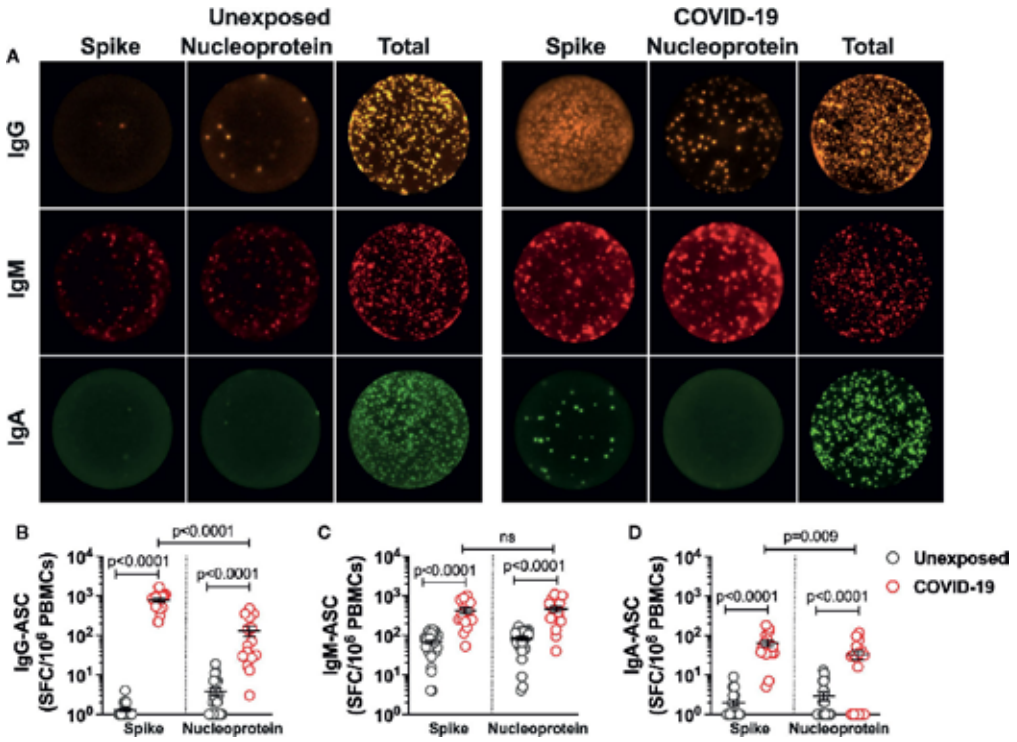


Fig. 6.6: SARS-CoV-2 specific memory B cells in recovered COVID-19 patients. (A). Representative images of IgG, IgM and IgA secreting B cells in unexposed subjects and recovered COVID-19 patients. Graphs depicting the magnitude of antibody secreting B cells specific to the SARS-CoV-2 spike glycoprotein and nucleoprotein (expressed as spot forming cells (SFC) in 10 ^ 6 PBMCs) for (B). IgG-ASC (C). IgM-ASC and (D). IgA-ASC, in unexposed subjects in (grey circle) and COVID-19 patients (red circle).

Investigator found that the magnitude of IgG antibody secreting cells (ASCs) was the highest among three subsets analyzed. All the studied subjects showed 6-fold higher spike specific IgG-ASCs over the ASCs specific to Nucleoprotein (Figure 6.6 B). Although the frequency of Nucleoprotein and spike-specific IgM-ASCs were significantly higher than the unexposed subjects, it was not significantly different in the COVID-19 recovered patients (Figure 6.6 C). Plasma cells secreting IgA were present in the least frequency in COVID-19 recovered patients and was only detected in the half of the unexposed study groups (Figure 6.6 D).

The study clearly showed the pre-existing immunity in the unexposed donors further the memory of $CD4^{+}$T cells and B cells in mildly infected COVID patients are predominantly associated with the spike protein of virus. The study was performed at National Institute of Immunology, Delhi.

Structural and Mechanistic studies to understand SARS-CoV-2 ingress into human cells and its therapeutic intervention.

SARS-CoV-2 infection is mediated by the receptor-binding domain (RBD) of the spike glycoprotein on the viral surface through binding to the cell-surface receptor angiotensin-converting enzyme 2 (ACE2). This is followed by subsequent cleavage of the spike protein by the transmembrane serine protease 2 (TMPRSS2), membrane fusion, and the release of the viral RNA into the host cell.

The inefficiency of the existing vaccines against newer strains of SARS-CoV-2 poses a huge challenge in controlling this pandemic and paves the way for developing a new class of pre-exposure prophylactics. The X-ray and cryogenic-electron microscopy (cryo-EM) structures of the SARS-CoV-2 spike protein bound to ACE2 revealed that the N-terminal helices of the ACE2 receptor mainly engage with the RBD of SARS-CoV-2. Therefore, structure-guided designing of secondary structural mimics of α-helices has been a sought-after strategy. However, most ACE2-derived single helical peptides are not potent enough as they are inefficient in targeting such complex topologies at protein-protein interaction (PPI) interfaces, hindering their clinical development.

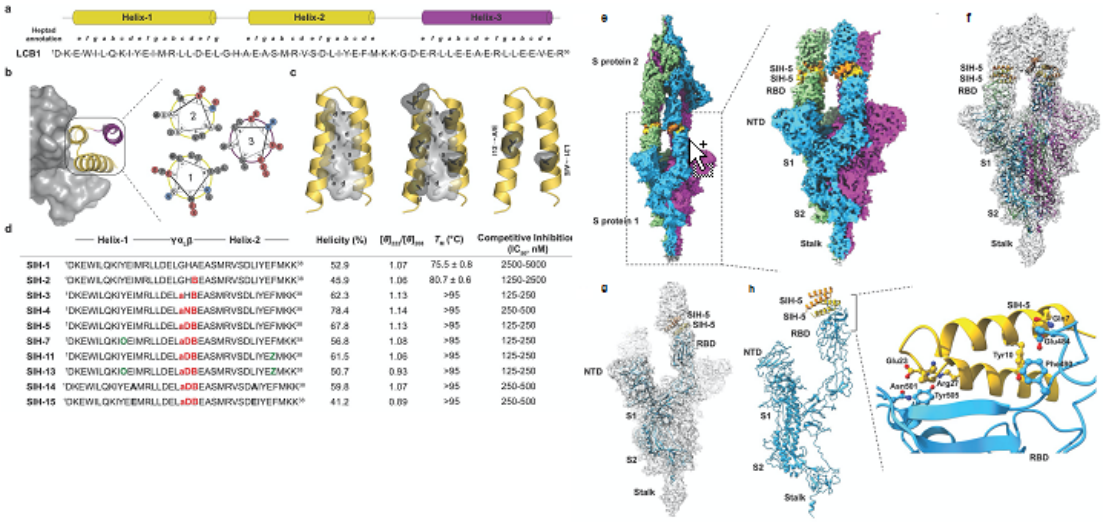


Fig. 6.7: Rational design of dimeric helix-hairpin. a, Sequence and secondary structure map of LCB1. b, Cryo-EM structure of SARS-CoV-2 RBD in complex with LCB1 (7JZU). Helices 1 and 2 make direct contact with the RBD of SARS-CoV-2 and helix 3 (magenta) stabilizes LCB1 by packing against helices 1 and 2 (yellow). c, Removal of helix-3 exposes the hydrophobic residues at g positions in helices 1 and 2 (dark gray) and increases the width of the hydrophobic face. The hydrophobic residues (I12 and L31) that are substituted to obtain SIH-14 and SIH-15 are shown. d, Sequences, helicity, thermal stability, and potency of the helix-hairpin peptides. Synthetic helix-hairpin peptides induce dimerization of spike protein. e, Solid representation of cryo-EM 3D model of 3-RBD up dimeric spike protein in the presence of SIH-5. The three protomers of spike protein are colored in blue, green, and purple, respectively. The SIH-5 protomers are colored in yellow and orange. The right panel shows an enlarged view of cryo-EM 3D model of a single 3-RBD up spike protein along with the dimeric SIH-5. f, Transparent representation of cryo-EM 3D model fitted with the calculated atomic model. g, Transparent representation of a single protomer of spike protein with dimeric SIH-5 fitted with the calculated atomic model. h, Left panel shows the single protomer of spike protein with dimeric SIH-5 of the calculated atomic model. Right panel shows the enlarged view of spike protein RBD region (blue) bound to dimeric SIH-5, single protomer is shown (yellow). The interacting residues are highlighted in sticks.

Helix-turn-helix motifs or helix-hairpins, a unique class of proteomimetics, are particularly well-suited for this purpose (Figure 6.7). Investigators were particularly interested in designing dimeric helix-hairpins that present two identical faces for interacting with the target, thereby engaging larger surface area of the latter. To dimerize the helix-hairpins, Investigators paid critical attention to the appropriate sculpting of the interfacial residues forming the heptad repeats in either helix with hydrophobic/hydrophilic residues. Additionally, to induce the proximity of the two helices connecting the interhelical loop, they optimized the amino acids in the loop.

The computationally designed three-helix-bundle miniprotein LCB1 by Baker and coworkers served as a starting point. In the current design led to the development of SIH-5, which prevents the binding of SARS-CoV-2 onto cell surface ACE2 by dimerizing the spike protein (Figure 6.7). The dimerization of the spike protein on the surface of virions leads to noncovalent crosslinking of the individual spike proteins and enhanced blocking of the RBD through avidity effects. This significantly contributes to virus neutralization as observed for dimeric SIH-5 against monomeric analogs. It is worth noting that the head-to-head dimerization of spike trimer has also been identified in the SARS-CoV-2 kappa variant of concern (B.1.617.1). However, unlike in the SIH-5 induced spike trimer dimerization that inhibits the viral entry into cells, the labile dimer in the kappa variant has been suggested to increase the viral fitness against neutralizing antibodies by masking the antibody-accessible region of RBD. Thus, the spike trimer dimerization is a unique mechanism to tune the viral fitness. The novel binding mode of SIH-5 allowed us to achieve potent virus neutralization. The in vivo efficacy of the dimeric helix-hairpin devoid of toxicity suggests the potential for their development as an alternate class of therapeutics.

The exceptional stability of these target–ligand–ligand–target complexes reminiscent of irreversible covalent inhibitors would encourage the exploration of this unique class of proteomimetics to target PPIs while achieving the favorable pharmacology displayed by targeted covalent inhibitors. The ongoing study was performed at Indian Institute of Science, Bengaluru.

6.2.3 MATRICS Short Term Special call on COVID-19

Modelling and Forecasting of COVID-19 pandemic.

In this study the first and second waves of COVID-19 infections in India has been analysed. The investigation was based on the data analytics to study the early available data of the pandemic (first wave) and proposed that the COVID-19 epidemic in all countries follows similar evolution behaviour. In any localised region, introduction of the coronavirus led to a sudden exponential rise in the number of infected. This exponential regime was then followed by distinct time periods where the infections grew at the rate of 't^{n-1}' before becoming constant and then finally exhibiting a gradual decrease in the number of daily infections.

It was suggested that community transmission and/or asymptomatic carriers might have been responsible for the transition from exponential to power-law regime. Figure 6.8 shows a schematic diagram of such growth where I(t) refer to cumulative infections, and (t), its derivative, represents the daily cases. In the earlier model data of different countries were considered to predict their future trajectories. The study was extended a step further and compared the predictions from this model to that of an extended SEIR model and a delay differential equation-based model.

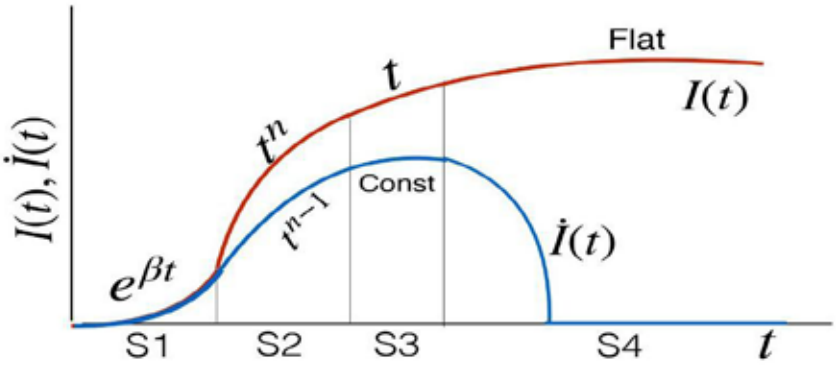


Fig. 6.8: For COVID-19 epidemic: Schematic plots for I(t) (red curve) and its derivative I'(t) (blue curve) vs. t. S1, S2, S3, S4 represent the four stages of the epidemic: exponential growth in count (), power law growth (tn), linear growth (t) and flat.

A new forecasting technique was proposed further in which a curve has been constructed that emulates the universal nature of the cumulative infection curves of different countries. Figure 6.9(a) shows normalized infection curves of eight countries. The data is taken till saturation of first wave of infections. One can clearly see that the "universal curve" thus formed by taking average of these countries agrees very well with the other plots. The Indian infection curve has been overlapped over this universal curve using appropriate normalization.

Figure 6.9(b) shows the degree of overlap between infection and infection rate for these two cases. This sort of analysis can be used to develop a general sense of the current trend of the pandemic. For example, the plot clearly shows that at the time this data was taken (5th October, 2020), India had already transitioned into the linear regime. In hindsight, one can claim that this to be true since infections in India had peaked at September 16, 2020 and then there was a steady drop afterwards. The predictions made in the study are comparable to those of the supermodel.

This study was done at Indian Institute of Technology, Kanpur.

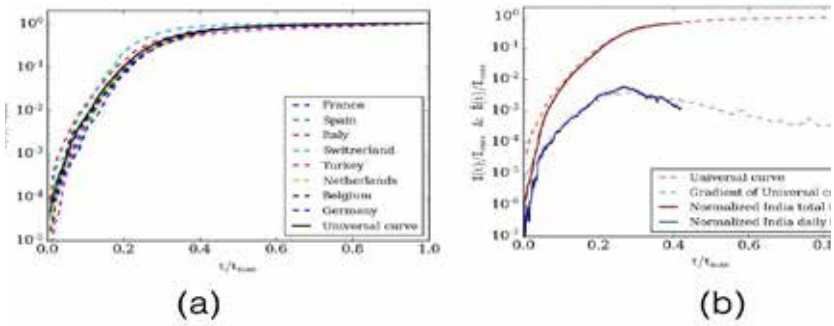


Fig. 6.9: (a) The black solid line in the top figure shows the universal behaviour of the pandemic across 8 countries before the onset of a second wave of infections. (b) The plot exhibits comparisons between the cumulative and daily infection curves of India and the universal curves. The red lines represent the normalized cumulative cases (I(t)/Imax) while the blue lines depict its derivative (ˆI(t)/ Imax).

Development of computational and visualization software for evaluating GPCR targeting drugs with the aim of mitigating coronavirus infection level

In this project, a mathematical framework that depicts the interplay between viral infection and innate as well as adaptive immune response in lung epithelial cells. They have also demonstrated the utility of the model in assessment of various treatment strategies for patients with different levels of disease severity.

A two-stage immune activation (Innate and adaptive) was modelled in this study. Dynamic validation of viral load and IL6 levels at various disease stages was done for the prediction of the heterogeneity in the levels of disease severity. Figure 6.10 shows the prediction of the late phase dynamics of disease progression (>20 days) in severe/ critical patients in terms of macrophage, T cell and pro inflammatory cytokine level.

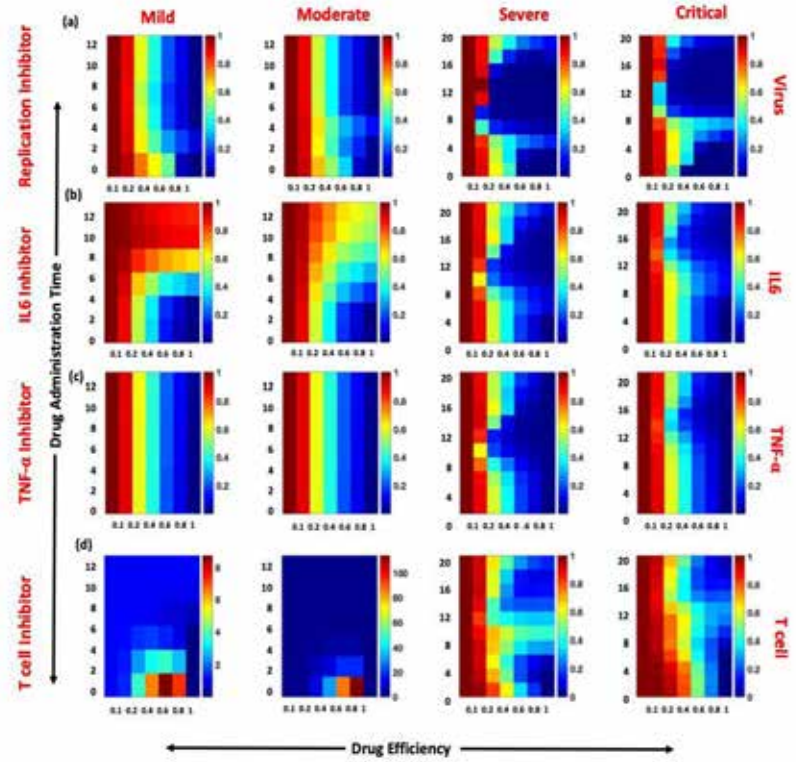


Fig. 6.10: Heatmaps comparison of varying drug efficiency and time of drug initiation in mild, moderate, severe and critical cases when (a) drug targeting virus replication is introduced thus varying virus dynamics, (b) drug inhibiting IL6 is introduced thus affecting IL6 dynamics , (c) drug inhibiting TNF-α is introduced thus affecting TNF-α dynamics and , (d) drug inhibiting both T cell activation and IL6 production is introduced thus affecting both T cells and IL6 dynamics.

To study the effect of antiviral drug the model was extended by multiplying the potential drug target parameters one at a time with a factor (1-ε) where 0<ε<1, which determined the drug efficiency (a value of 1 implies 100% drug efficacy). In order to show a proof of concept that the model can be used for assessment of drug efficacy in clearing the viral infection, the model simulations were performed by varying drug efficiency and time of drug administration (Figure 6.11 and Table 1) for mild, moderate, severe and critical cases. The results show that the drugs targeting viral replication (remdesivir, favipiravir) are most effective when introduced early in the course of disease. On the contrary the drugs blocking cytokine production, thus reducing the occurrence of cytokine storm are more effective when introduced during later infection phase in severe and critical cases.

The work is done at Indian Institute of Technology, Hyderabad.

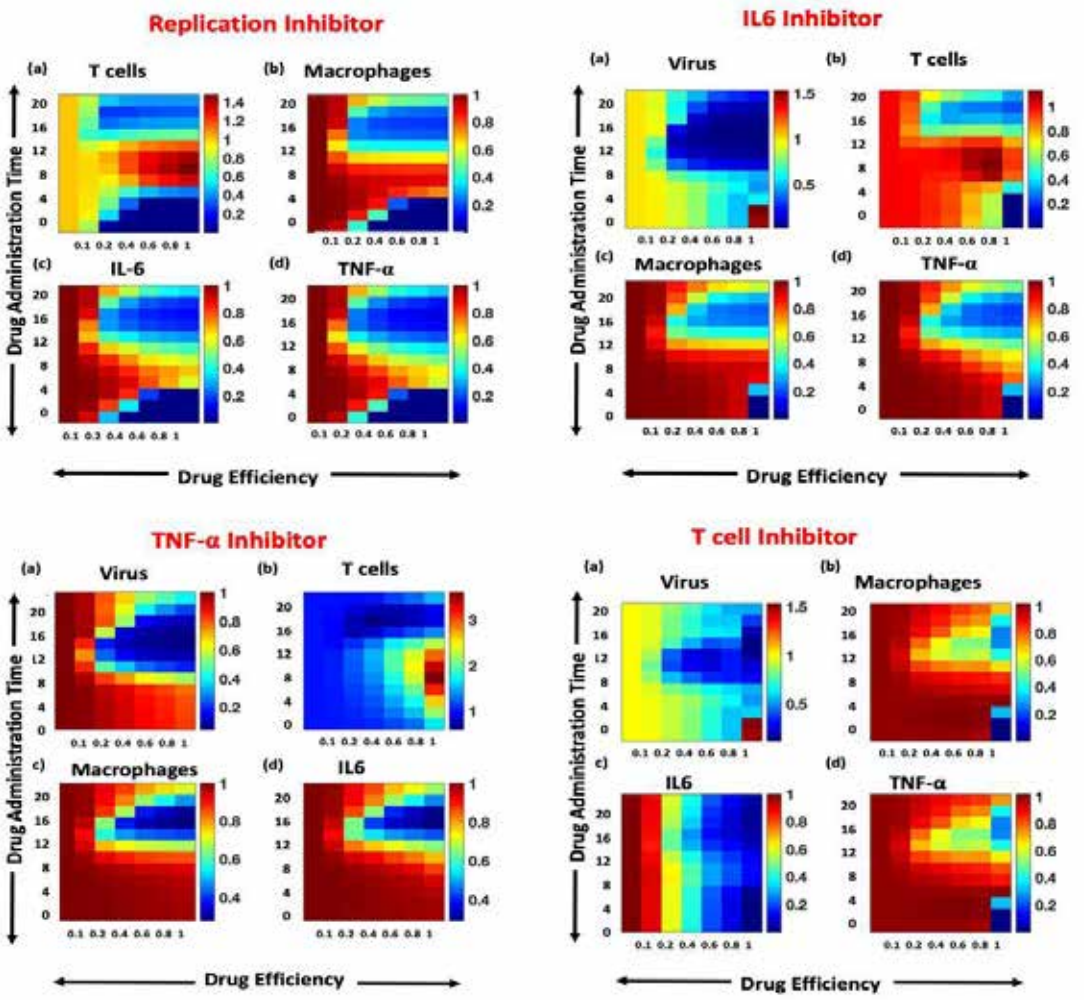


Fig. 6.11: A, B, C, D: Heatmap showing the area under curve (AUC) comparison of four different variables of the model (virus and immune cells such as T cell, macrophages, etc) for critical cases with varying drug administration time and efficiency for drugs inhibiting viral replication, IL-6, TNF-α and T cell production.

Table 1: Summary of model prediction for the area under the curve of different model variables in response to the employed treatments initiated either in the early phase (day 3-5) of the disease or later (day 12-14) for mild, moderate, severe and critical cases.

Critical Case	Anti-IL6		Anti-TNF		Melatonin		Replication inhibitor	
	Early	Late	Early	Late	Early	Late	Early	Late
Virus	0.49	0.02	0.85	0.12	0.56	0.38	0.02	0.02
T cells	0.62	0.58	0.54	0.81	0.24	0.12	0.01	0.55
Macrophage	0.92	0.28	0.97	0.32	0.99	0.62	0.1	0.25
IL6	0.09	0.05	0.97	0.32	0.1	0.08	0.02	0.22
TNF	0.92	0.21	0.09	0.02	1.01	0.57	0.02	0.19

Severe Case	Anti-IL6		Anti-TNF		Melatonin		Replication inhibitor	
	Early	Late	Early	Late	Early	Late	Early	Late
Virus	0.27	0.21	0.25	0.17	0.42	0.23	0.02	0.06
T cells	0.42	0.21	0.79	0.28	0.09	0.25	0.11	0.18
Macrophage	0.79	0.28	0.82	0.29	0.82	0.32	0.29	0.09
IL6	0.08	0.49	0.71	0.31	0.15	0.23	0.21	0.07
TNF	0.28	0.09	0.07	0.05	0.81	0.33	0.2	0.18

Moderate Case	Anti-IL6		Anti-TNF		Melatonin		Replication inhibitor	
	Early	Late	Early	Late	Early	Late	Early	Late
Virus	0.74	0.86	0.98	0.83	0.81	0.95	0.15	0.09
T cells	0.78	1.08	1.28	1.29	0.53	1.08	0.31	1.02
Macrophage	0.87	0.99	0.99	0.99	0.88	0.99	0.88	0.98
IL6	0.13	0.09	0.98	0.95	0.18	0.56	0.89	0.57
TNF	0.91	0.99	0.1	0.11	1.04	0.99	0.9	0.98

Mild Case	Anti-IL6		Anti-TNF		Melatonin		Replication inhibitor	
	Early	Late	Early	Late	Early	Late	Early	Late
Virus	0.56	0.81	0.98	0.93	0.83	1.01	0.18	0.11
T cells	0.78	0.99	1	1.22	2.57	0.58	0.32	1
Macrophage	0.92	1	0.99	1	0.92	0.99	0.82	0.99
IL6	0.16	0.88	0.99	1	0.16	0.7	0.75	0.89
TNF	0.9	0.99	0.1	0.11	1.1	0.96	0.82	0.99

6.3 SERB Webinar

SERB organized international webinar on **"Introduction to PSA Technology and its Role in Long-term Oxygen Solution for Hospitals"** talk delivered by Dr. Ravinder K Bansal, former chairman, chief executive officer and co-founder of AirSep corporation to sensitize the scientific community on latest development on oxygen generator and concentrators strategies using Pressure swing adsorption (PSA) technology. Eminent scientists, expert members and young scientists participated and deliberated on the technology and its potential for oxygen generation and concentration.

7

SUPPORT FOR SCIENCE AND TECHNOLOGY EVENTS

For the growth of researchers as well as for advancement of science, dissemination and exchange of scientific knowledge are important. To provide productive opportunities for the research community to come together to discuss issues of common interest and foster new collaborations, SERB supports Science and Technology events through its schemes, Assistance to Professional Bodies & Seminar / Symposia, International Travel Support (ITS), and Accelerate Vigyan.

7.1 ASSISTANCE TO PROFESSIONAL BODIES AND SEMINAR/SYMPOSIA

SERB extends partial financial support, on selective basis, for organizing technical meetings, seminars, conferences, and workshops events (National as well as International). Academic institutions, research laboratories, professional bodies, and other non-profit organizations engaged in promoting scientific research are eligible for financial support under the scheme. The support is mainly given to encourage participation of young scientists and research professionals in such events along with nominal support for pre-operative expenses like announcements brochures, etc.

The primary focus of the scheme is to support events having strong orientation towards scientific research in the areas of basic sciences, engineering, technology, agriculture and medicine. The scientific/technical contents of the events, thematic relevance, contextual impact, and extent and level of participation are key components for deciding the support worthiness and quantum of support for individual events.

In the financial year (2021-22), seminar / symposia scheme received 535 applications towards partial support from all the States / UTs across the country in various fields of Science and Technology, out of which 123 applications were recommended for financial support (Table 7.1). In addition, 23 applications were received towards partial support from Professional Bodies / Institutes / Societies for publication of Journals, out of which, 19 applications were recommended for support. Out of 359 considered applications, 123 applications in different subjects/disciplines were recommended for support (Table 7.2)

SUPPORT FOR SCIENCE AND TECHNOLOGY EVENTS

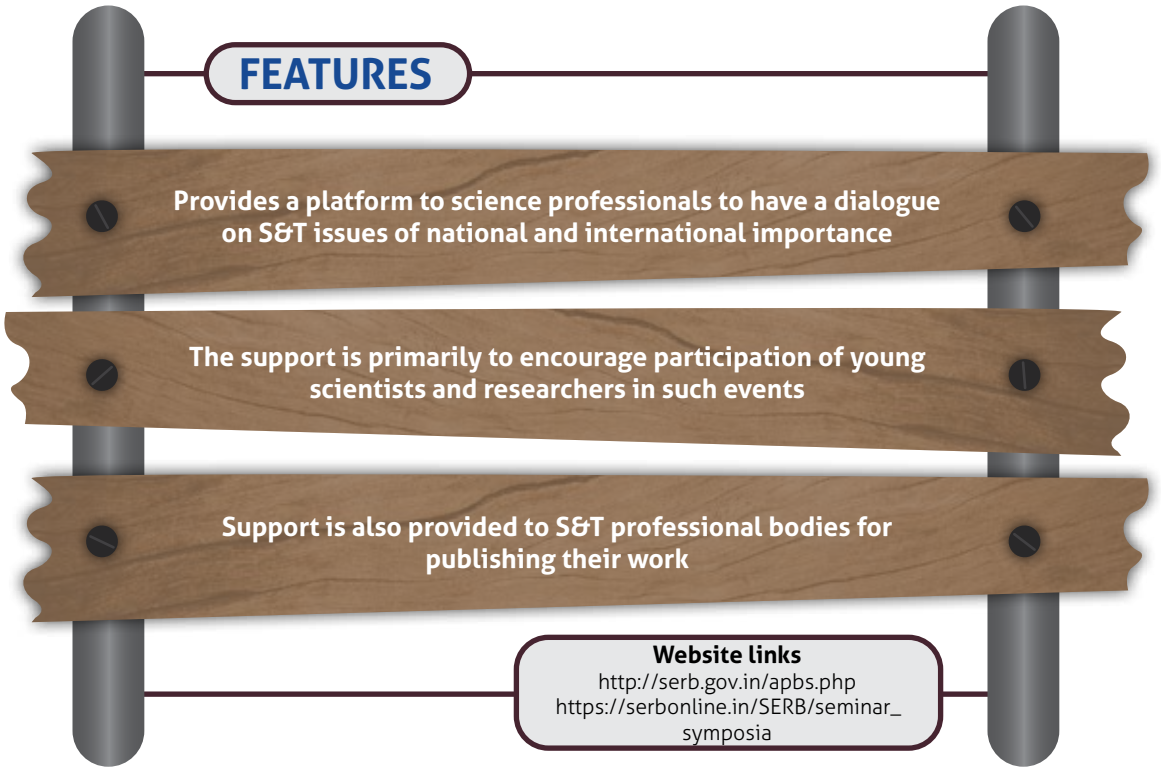


Table 7.1: Support provided in 2021-22

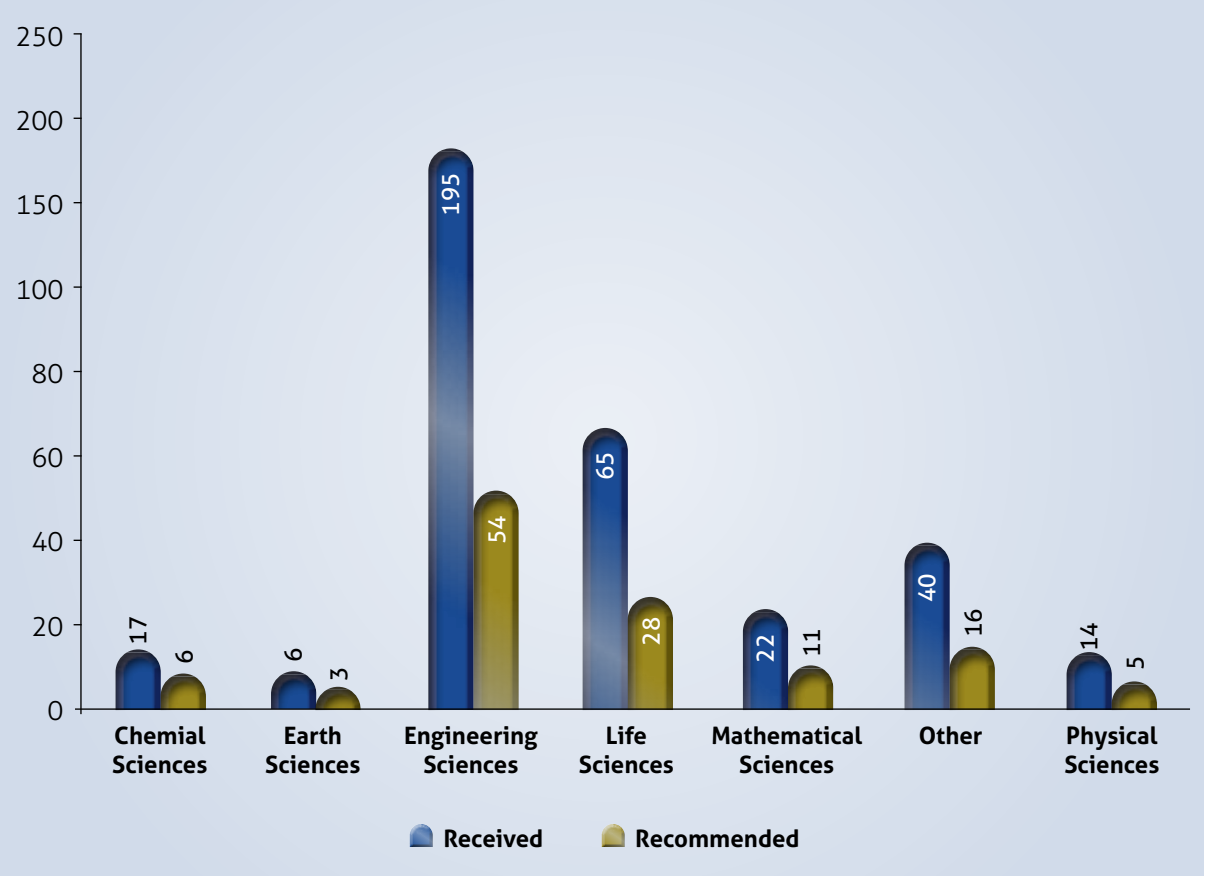
S. No.	Items	Seminar / Symposia	Professional Bodies
1.	Application Received	535*	23
2.	Application Recommended	123	19

* Note that due to COVID-19 the scheme was not operational during the first and second quarter but were receiving applications. Therefore, the total no. of applications vary(Table 7.2).

Table 7.2: Subject- wise summary of received & recommended Applications (2021-22):-

S.No.	Broad Subject Area	Received	Recommended
1.	Chemical Sciences	17	06
2.	Earth Sciences	06	03
3.	Engineering Sciences	195	54
4.	Life Sciences	65	28
5.	Mathematical Sciences	22	11
6.	Others	40	16
7.	Physical Sciences	14	05
	Grant Total	**359**	**123**

Subject-wise summary of received & recommended applications



7.2 INTERNATIONAL TRAVEL SUPPORT (ITS) SCHEME

International Travel Support (ITS) scheme provides financial assistance to Indian researchers for presenting a research paper in an international scientific event (conference, seminar etc.) held abroad. Support is also provided to young scientists (age limit below 35 years as on date of start of the event) for attending training programmes, Short-term schools, and Workshops. For eminent scientists (more than 35 years), support is also provided to chair session or to deliver keynote address.

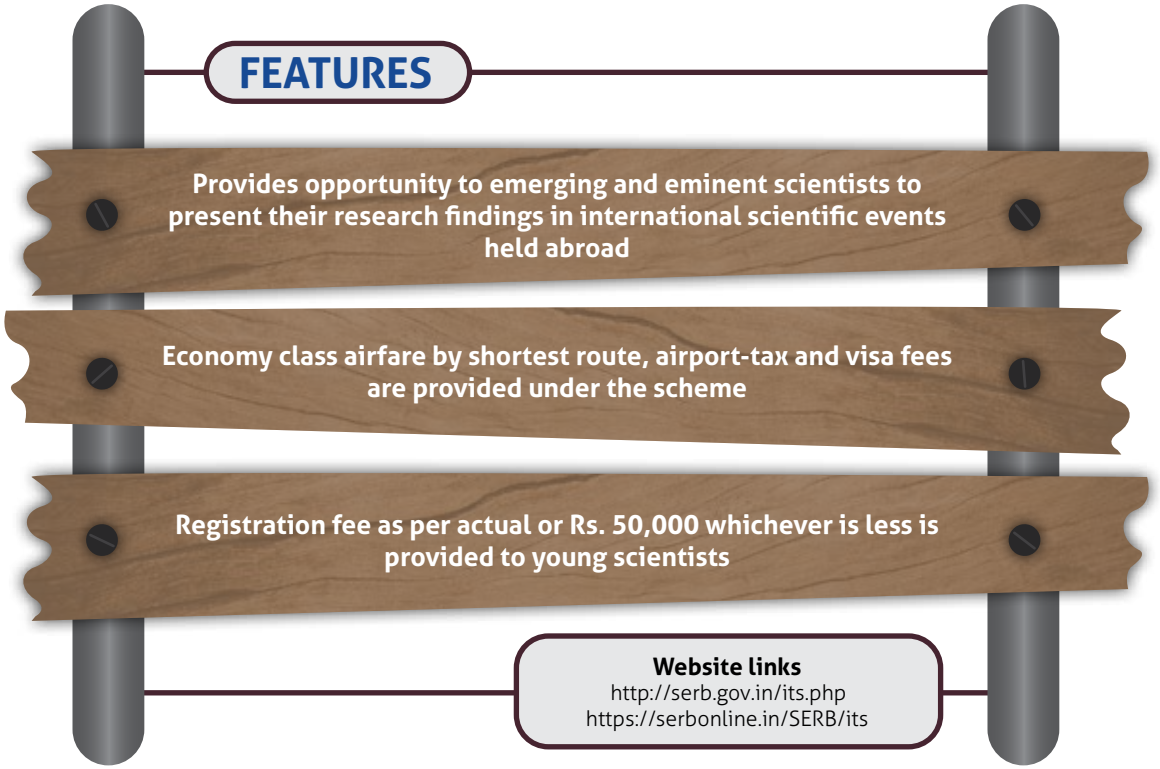
During the financial year (2021-22), ITS Scheme received 682 applications for various Conference/ Workshop towards partial support from all the States/ UTs across the country in various fields of Science and Technology. Out of which a total of 201 participants were recommended for support for presenting their scientific and technical findings (Table 7.3). 201 applications in different subjects/disciplines were recommended for support among them 179 were Young Scientists and 22 were Senior Scientists. (Table 7.4)

Table 7.3. : Recommended number of applications during year 2021-22: -

S.No.	Items	Conference/Workshop
1.	Application Received	682*
2.	Application Recommended	201

* Note that due to COVID-19 the scheme was not operational during the first and second quarter but were receiving applications. Therefore, the total no. of applications vary (Table 7.4).

SUPPORT FOR SCIENCE AND TECHNOLOGY EVENTS



The participants were supported to attend various conferences held at different countries across the world, among them countries are United States of America (111), United Kingdom (11), France (11), Germany(8), Italy (5), Spain (10), Singapore (1), Japan (3), Canada (2) and Austria (15). The important events supported under the Scheme are: American Physical Society Division of Fluid Dynamics, SPIE Photonics West, Gordon Research Conferences & Seminar, 2022 MRS Spring Meeting & Exhibit, Asia-Pacific Conference on Combustion (ASPACC), American Geophysical Union Fall Meeting 2021, Experimental Biology, European Materials Research Society, 2021 MRS Fall Meeting & Exhibit, EGU General Assembly 2022.

Table 7.4. : Subject- wise summary of received &recommended Applications (2021-22):-

Sr. No.	Name of Discipline	Received Proposals	Recommended Projects	Gender		Category	
				M	F	Senior Scientists (>35 Years)	Young Scientist (<35 Years)
1.	Engineering Sciences	147	49	36	12	2	47
2.	Life Sciences	200	85	45	39	13	72
3.	Chemical Sciences	25	11	6	5	2	9
4.	Physical Sciences	54	32	20	12	4	28
5.	Earth & Atmospheric Sciences	55	21	15	6	1	20
6.	Mathematical Sciences	10	3	2	1	0	3
	Grand Total	**491**	**201**	**126**	**75**	**22**	**179**

Table 7.5. : Institute- wise summary of received & recommended Applications (2021-22): -

S.No	Institution Type	Received Proposals	Recommended Projects
1.	Industry/ NGO	7	1
2.	Laboratory	10	2
3.	State/Central government Institution	328	131
4.	Private College/University	80	30
5.	State/Central- College/University	66	37
Grand Total		**491**	**201**

7.3 ACCELERATE VIGYAN (AV)

Accelerate Vigyan (AV) strives to provide a big push to high-end scientific research and prepare scientific manpower which can venture into research careers and knowledge-based economy. The aim of the scheme is to expand the research base, with three broad goals - consolidation / aggregation of all national scientific training programs, initiating High end Orientation Workshops and creating opportunities for Research Internships.

This scheme is primarily to focus on young researchers from universities, colleges, private academic institutions, and newly established institutes with an aim to give an opportunity to them to spend quality time in the pre-identified premier institution, labs / organizations of esteemed research environment and positively reinforce their strengths, so that they acquire the requisite skills and vision for undertaking future research assignments requiring high standards.

During the reporting period, total 740 applications were received for High End Workshop (Karyashala) and Training & Skill Internship (Vritika). Total 107 and 84 applications were sanctioned, respectively for High End Workshop and Training & Skill Internship.

Website links
www.acceleratevigyan.gov.in

8

PATENTS AND PUBLICATIONS

8.1 PATENT FILED / GRANTED

Patents resulting from research and supported by SERB (Patents filed/granted during FY 2021-2022)

Scheme	Number of Patents filed
Core Research Grant	93
Early Career Research Award	50
Impacting Research Innovation and Technology (IMPRINT-2)	36
Empowerment and Equity Opportunities for Excellence in Science	23
Start Up Research Grant (Young Scientist)	3
National Post Doctoral Fellowship (N-PDF)	4
Teachers Associateship For Research Excellence (TARE)	9
Start-up Research Grant	28
Short-term special call on COVID-19	9
J C Bose Fellowship	6

8.2 PUBLICATIONS

Publications resulting from SERB funded projects/fellowships (Paper Published during FY 2021-2022)

Scheme	SCI	Non-SCI	Total
Core Research Grant	3508	595	4103
Early Career Research Award	1261	338	1599
Empowerment and Equity Opportunities for Excellence in Science	551	203	754

Scheme	SCI	Non-SCI	Total
National Post-Doctoral Fellowship (N-PDF)	249	51	300
MATRICS	537	145	682
Start Up Research Grant (Young Scientist)	63	9	72
Start-up Research Grant	639	292	931
Impacting Research Innovation and Technology (IMPRINT-2)	155	91	246
Teachers Associateship for Research Excellence (TARE)	137	36	173
Short-term special call on COVID-19	37	4	41
Distinguished Investigator Award (DIA) Scheme	15	2	17
MATRICS Short-term special call on COVID-19	15	16	31
Intensification of Research in High Priority Areas (IRHPA)	33	3	36
Scientific and Useful Profound Research Advancement (SUPRA)	1	2	3
Women Excellence Award	6	2	8
Ramanujan Fellowship	26	3	29
J C Bose Fellowship	137	11	148

8.3 HUMAN RESOURCES DEVELOPMENT

Manpower sanctioned under different schemes / programmes during FY 2021-22

Scheme	JRF / SRF	Other than JRF / SRF	Total
Core Research Grant	796	299	1095
Start-up Research Grant	319	88	407
Empowerment and Equity Opportunities for Excellence in Science	177	56	233
Short-term special call on COVID-19	10	1	11
SERB-POWER Grant	65	25	90
Scientific and Useful Profound Research Advancement (SUPRA)	38	20	58
Intensification of Research in High Priority Areas (IRHPA)	51	38	89

9

ADMINISTRATION

The Administration of any organisation plays a vital role in meeting its objectives. All efforts are made to ensure that SERB gets the institutionalised environment for producing results and targets. SERB provides motivation to the work force and makes them conceive their goals.

9.1 Administration and recruitment

Out of 20 sanctioned scientific posts, 19 posts are already filled up and action to fill up of one post of Scientist-G (Level-14) is in advanced stage. Action to fill up two vacant posts of Section Officer (level-6) was also initiated and the Screening Committee meeting was held on 27th and 28th February, 2021 for shortlisting of candidates. The Selection Committee meeting was held on 24th July, 2021 and the committee recommended two candidates to be appointed as Section Officer (SO) in SERB. One candidate joined in SERB as SO and other candidate did not join. Necessary action has been taken to fill up the post, which is progress.

9.2 Implementation of Official Language

The Science & Engineering Research Board (SERB), since its inception has been implementing the guidelines issued by the Department of Official Language, Ministry of Home Affairs. Hindi Week was celebrated in SERB from 14th to 21st September, 2021. For the promotion of Official Language, various activities were organized for the staff/officers both Hindi and non-Hindi speaking. Cash prizes and certificates were distributed to the winners to motivate the officers and staff of SERB to adopt and promote usage of Hindi in official work.

In order to enhance the working knowledge of the officers/staff in Hindi, three Hindi Workshops were organized on 10.08.2021, 21.12.2021 and 24.03.2022. The experts shared their experience, expertise, knowledge and appraised about the rules, regulations and guidelines of official language. Large number of officers and staff participated in the said Workshops.

Quarterly meetings of Official Language Implementation Committee were held on 16.03.2021, 09.09.2021 and 23.11.2021 to

review the progress of use of Hindi language in SERB and the Quarterly Reports were sent to Department of Science and Technology (DST) on time.

9.3 Right to Information Act, 2005 (RTI)

The provisions of RTI Act, 2005 are being followed and requisite information is provided to the Applicants under the RTI Act. A total of 50 applications were received during the financial year 2021-22. Out of which, 6 were received as transfer from other public authorities u/s 6(3). Four appeals were also received during the year and disposed of by the Appellate Authority. A total fee of Rs. 440/- was received by SERB for providing information under the RTI Act, 2005 during the year 2021-22.

9.4 Vigilance Awareness

Vigilance Awareness Week was observed by SERB from 26th October, 2021 to 1st November, 2021. The theme of the week was "Independent India @ 75:Self Reliance with Integrity". All officers/ staff of SERB took integrity pledge to abide by the principles of honesty and integrity to fight against corruption on 26th October, 2021.

9.5 Internal Complaints Committee (ICC) – Women

Internal Complaints Committee (ICC) – Women, has been functioning in SERB since 2017. The Committee meets regularly and discussion on relevant issues are held. Composition of the committee, complaint procedures and the related information are available in the website of SERB.

9.6 Audited Annual Statement of Accounts

As per the provisions laid down in Section 13 of the Science and Engineering Research Board (SERB) Act, 2008, the Annual Accounts of the Board are required to be prepared in the prescribed format and audited by the Comptroller and Auditor General of India (C&AG) or by their appointed auditors annually. Accordingly, the annual accounts for the financial year 2021-22 have been prepared and audited by a team of auditors from C&AG. The duly audited financial statement and annual accounts for the financial year 2021-22 form a part of the Annual Report.

ANNUAL STATEMENT OF AUDITED ACCOUNTS FOR THE YEAR 2021-22

Amount in Rs.

Balance Sheet as at 31.03.2022

	Schedule	Current Year	Previous Year
CORPUS / CAPITAL FUND AND LIABILITIES			
Corpus / Capital Fund	Schedule 1	34,54,69,814.81	37,48,47,492.89
Reserves and Surplus	Schedule 2	-	-
Earmarked / Endowment Funds	Schedule 3A, 3B, 3C, 3D, 3E & 3F	7,49,39,093.79	16,06,98,603.59
Secured Loans and Borrowings	Schedule 4	-	-
Unsecurred Loans and Borrowings	Schedule 5	-	-
Deferred Credit Liabilites	Schedule 6	-	-
Current Liabilites and Provisions	Schedule 7	7,08,77,619.96	9,56,90,664.18
Total		**49,12,86,528.56**	**63,12,36,760.66**
ASSETS			
Fixed Assets (Net)	Schedule 8	11,90,08,574.00	9,38,21,609.00
Investments-From Earmarked / Endowment Funds	Schedule 9	-	-
Investments-Others	Schedule 10	-	-
Current Assets, Loans, Advances etc.	Schedule 11	37,22,77,954.56	53,74,15,151.66
Miscellaneous Expenditure			
(to the extent not written off or adjusted)			
Total		**49,12,86,528.56**	**63,12,36,760.66**
Significant Accounting Policies	Schedule 26		
Contingent Liabilities and Notes to Accounts	Schedule 27		

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

CA Pulkit Agrawal
(Partner)
M. No. 431102
Date : 06.05.2022
Place : New Delhi

V.P.C.A. AND ASSOCIATES DELHI Chartered Accountants

For Science and Engineering Research Board

Secretary
SERB
Date :
Place : New Delhi

Director-Finance
SERB

Amount in Rs.

Income & Expenditure Account for the Year Ended on 31.03.2022

	Schedule	Current Year	Previous Year
Income			
Income from Sales / Services	Schedule 12	-	-
Grants / Subsidies *	Schedule 13	8,95,29,55,499.00	7,38,61,24,868.00
Fees / Subscriptions	Schedule 14	-	-
Income from Investments	Schedule 15	-	-
Income from Royalty, Publication etc	Schedule 16	-	-
Interest Earned	Scheduel 17	-	-
Other Income	Schedule 18	1,53,81,245.00	85,73,214.00
Increased/(Decrease) in stock of Finished Goods and Works-in-Progress	Schedule 19	-	-
Total (A)		**8,96,83,36,744.00**	**7,39,46,98,082.00**
Expenditure			
Establishment Expenses	Schedule 20	12,87,10,551.00	11,62,11,902.00
Other Administrative Expenses	Schedule 21	10,75,14,109.62	10,74,38,334.39
Expenditure on Grant, Subsidies etc	Schedule 22	8,82,21,23,847.18	8,70,78,09,946.00
Interest	Schedule 23	-	-
Depreciation (Net Total at the Year end)	Schedule 8	1,53,81,235.00	85,73,064.00
Total (B)		**9,07,37,29,742.80**	**8,94,00,33,246.39**
Excess of Income over Expenditure (A-B) (Before PPI & PPE)		**-10,53,92,998.80**	**-1,54,53,35,164.39**
Excess of Expenditure over Income (A-B) (Before PPI & PPE)		**-**	**-**
Prior Period Income	Schedule 24	31,50,39,853.40	30,44,36,648.63
Prior period Expenditure	Schedule 25	33,80,582.68	39,29,35,339.00
Excess of Income over Expenditure (A-B) (After PPI & PPE)		**-**	**-**
Excess of Expenditure over Income (A-B) (After PPI & PPE)		**20,62,66,271.92**	**-1,63,38,33,854.76**
Transfer to Special Reserve (Specity each)		**-**	**-**
Transfer to / from General Reserve		**-**	**-**
Balance Being Surplus (Deficit) carried to Corpus/Capital Fund		**20,62,66,271.92**	**-1,63,38,33,854.76**
Significant Accounting Policies	Schedule 26		
Contingent Liabilities and Notes to Accounts	Schedule 27		

* CY- This amount reflect total grant received by SERB of Rs. 900,00,00,000/- less Fixed Assets purchased of Rs. 4,70,44,501/- (transferred to Corpus Fixed Assets Sch. 1)

* PY- This amount reflect total grant received by SERB of Rs. 7,41,17,92,699/- less Fixed Assets purchased of Rs. 2,56,67,831/- (transferred to Corpus Fixed Assets Sch. 1)

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

CA Pulkit Agrawal
(Partner)
M. No. 431102
Date : 06.05.2022
Place : New Delhi

V.P.C.A AND ASSOCIATES * DELHI * Chartered Accountants

For Science and Engineering Research Board

Secretary
SERB
Date :
Place : New Delhi

Director-Finance
SERB

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 1 - Corpus / Capital Fund

Particulars	Current Year	Previous Year
Corpus Balance at the beginning of the year	28,10,25,883.89	1,93,04,86,957.90
Add: Sale/Exchange of Fixed Assets (Laptop & Printer)	-	-
Less: Interest earned on refunds during FY 2019-20 transferred to GOI, Consolidated Fund	-	-1,56,27,219.25
Less: Interest earned during FY 2017-18 & FY 2018-19 transferred to GOI, Consolidated Fund	-	-
Less: Prior period Refund from various Institution transferred to GOI, Consolidated Fund	-26,08,30,915.00	-
Add/(Deduct) : Balance of net income/(Expenditure) transferred from the Income & Expenditure Account	20,62,66,271.92	-1,63,38,33,854.76
Corpus Balance at the end of the year (A)	**22,64,61,240.81**	**28,10,25,883.89**
Corpus (Fixed Assets) Balance at the beginning of the year	9,38,21,609.00	7,67,26,842.00
Add: Contributions towards Corpus/Capital Fund (Fixed Assets)		
FY 2021-22	4,70,44,501.00	-
FY 2020-21	-	2,56,67,831.00
Sale/Exchange of Fixed Assets (Laptop & Printer)	1,76,190.00	-
Fixed Assets (Interior work) written off /discard**	-66,52,491.00	-
Deferred Revenue Grant for FY 2021-22*	-1,53,81,235.00	-
Deferred Revenue Grant for FY 2020-21*	-	-85,73,064.00
Corpus (Fixed Assets) Balance at the end of the year (B)	**11,90,08,574.00**	**9,38,21,609.00**
Total of Corpus & Corpus (Fixed Assets) (A) + (B)	**34,54,69,814.81**	**37,48,47,492.89**
***Refer Point No. 12 In Schedule 26 Significant Accounting Policies**		
****Refer Point No. 9 In Schedule 27 Significant Accounting Policies**		

Schedule 2 - Reserve and Surplus

Particulars	Current Year		Previous Year	
1. Capital Reserves :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
2. Revaluation Reserves :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
3. Special Reserve :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
4. General Reserve :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
Total		**-**		**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 3A - Earmarked/Endowment Funds MOFPI

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	**1,39,86,179.00**	**1,50,88,947.00**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (MFPI)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest from SERB on Saving Balance	4,05,599.00	6,98,812.00
Interest on MFPI Refund	-	-
Refund from previous year Grant FY 2013-14 (Ann. 1 & 1A)	-	-
Refund from previous year Grant FY 2014-15 (Ann. 2 & 2A)	-	-
Refund from previous year Grant FY 2015-16 (Ann. 3 & 3A)	-	-
Refund from previous year Grant FY 2016-17 (Ann. 4 & 4A)	-	89,783.00
Refund from previous year Grant FY 2017-18 (Ann. 5 & 5A)	-	-
Refund from previous year Grant FY 2018-19 (Ann. 6 & 6A)	-	-
Total (a+b)	**1,43,91,778.00**	**1,58,77,542.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (MFPI- Capital) (Ann. 7 & 7A)	-	3,58,775.00
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (MFPI- General) (Ann. 8 & 8A)	-	15,32,588.00
Total c)	**-**	**18,91,363.00**
d) Less: Amount given back to Ministry of Food Processing	**-**	**-**
Net Balance as at the year end (a+b-c-d)	**1,43,91,778.00**	**1,39,86,179.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 3B - Earmarked/Endowment Funds S & T Programme

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	**1,99,57,631.59**	**1,81,32,642.00**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (S & T Programme - Schedule Castes)	-	-
Grant in Aid (S & T Programme - Schedule Tribe)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
S & T SC-Interest from SERB on Saving Balance	5,75,298.00	8,31,001.00
S & T ST-Interest from SERB on Saving Balance	3,473.00	5,124.00
S & T SC- Refund from previous year Grant FY 2013-14 (Ann. 9 & 9A)	10,59,083.50	2,29,546.00
S & T SC- Refund from previous year Grant FY 2015-16 (Ann. 10 & 10A)	86,574.00	3,22,633.00
S & T SC- Refund from previous year Grant FY 2016-17 (Ann. 11 & 11A)	1,03,282.00	-
S & T SC- Refund from previous year Grant FY 2018-19 (Ann. 12 & 12A)	8,92,177.97	4,36,685.59
S & T - Interest on Refund -ST	2,44,331.00	
S & T - Interest on Refund -SC	10,48,448.73	-
Total (a+b)	**2,39,70,299.79**	**1,99,57,631.59**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (S & T- Schedule Castes - Capital)	-	-
Grant-in-aid (S & T- Schedule Tribe - Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (S & T- Schedule Castes - General)	-	-
Grant-in-aid (S & T- Schedule Tribe - General)	-	-
Total c)	**-**	**-**
Net Balance as at the year end (a+b-c)	**2,39,70,299.79**	**1,99,57,631.59**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 3C - Earmarked/Endowment Funds ICPS

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	**79,19,175.00**	**1,04,09,284.00**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid- ICPS	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (ICPS: 349902010049636)	2,36,204.00	2,87,611.00
Total (a+b)	**81,55,379.00**	**1,06,96,895.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	27,77,720.00
Other Additions	-	-
Grant-in-aid (ICPS- Capital) (Ann. 13 & 13A)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure- Bank Charges	-	-
Grant-in-aid (ICPS- General) (Ann. 14 & 14A)	-	-
Total c)	**-**	**27,77,720.00**
Net Balance as at the year end (a+b-c)	**81,55,379.00**	**79,19,175.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 3D - Earmarked/Endowment Funds DOT

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	**77,80,121.00**	**76,95,864.00**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (DOT- General)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest from SERB on Saving Balance	2,25,623.00	84,257.00
Total (a+b)	**80,05,744.00**	**77,80,121.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (DOT- Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (DOT- General) (Ann. 15 & 15A)	-	-
Total c)	**-**	**-**
Net Balance as at the year end (a+b-c)	**80,05,744.00**	**77,80,121.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 3E - Earmarked/Endowment Funds IMPRINT-II -MHRD

Particulars	Current Year	Previous Year
a) Opening Balance of the Funds	**11,10,55,497.00**	**11,96,87,564.00**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (IMPRINT-II)	92,00,000.00	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (IMPRINT-II: 349902010049001)	17,04,366.00	33,22,988.00
Interest earned on Saving Balance General	-	
Refund from previous year Grant FY 2018-19 (Ann. 16 & 16A)	12,57,124.00	58,976.00
Refund from previous year Grant FY 2019-20 (Ann. 17 & 17A)	2,232.00	-
Refund from previous year Grant FY 2021-22 (Ann. 18 & 18A)	11,87,535.00	-
Interest on IMPRINT-II Refund	3,89,139.00	85,969.00
Total (a+b)	**12,47,95,893.00**	**12,31,55,497.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (IMPRINT-II- Capital) (Ann. 19 & 19A)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (IMPRINT-II- General) (Ann. 20 & 20A)	11,06,80,000.00	1,21,00,000.00
Total c)	**11,06,80,000.00**	**1,21,00,000.00**
Net Balance as at the year end (a+b-c)	**1,41,15,893.00**	**11,10,55,497.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 3F - Earmarked/Endowment Funds Industrial Research Engagement (FIRE)

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**-**	
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (FIRE)	63,00,000.00	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance	-	-
Total (a+b)	**63,00,000.00**	**-**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (Fire- Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Other Administrative Expenditure		
Grant-in-aid (Fire- General)	-	-
Total c)	**-**	**-**
Net Balance as at the year end (a+b-c)	**63,00,000.00**	**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 4 - Secured Loans and Borrowings

Particulars	Current Year		Previous Year	
1. Central Government		-		-
2. State Government		-		-
3. Financial Institutions				
a) Term Loans	-		-	
b) Interest accrued and dues	-	-	-	-
4. Banks :				
a) Term Loans	-		-	
Interest accrued and due	-		-	
b) Other Loans	-		-	
Interest accrued and due	-	-	-	-
5. Other Institutions and Agencies		-		-
6. Debentures and Bonds		-		-
7. Others		-		-
Total		**-**		**-**

Schedule 5 - Unsecured Loans and Borrowings

Particulars	Current Year		Previous Year	
1. Central Government		-		-
2. State Government		-		-
3. Financial Institutions				
4. Banks :				
a) Term Loans	-		-	
b) Other Loans	-	-	-	-
5. Other Institutions and Agencies		-		-
6. Debentures and Bonds		-		-
7. Fixed Deposites		-		-
8. Others		-		-
Total		**-**		**-**

Schedule 6 - Deferred Credit Liabilites

Particulars	Current Year	Previous Year
a) Acceptances secured by Hypothecation of Capital Equipment & other assets	-	-
b) Others	-	-
Total	**-**	**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 7 - Current Liabilities And Provisions

Particulars	Current Year		Previous Year	
A) Current Liabilities				
1. Acceptances		-		-
2. Sundry Creditors				
a) For Goods		-		-
b) Others:				
Shree Bhagatrams, New Delhi	-		-	
Uneecode Inc., Delhi (RSM Enterprises, New Delhi)	-		-	
VPCA and Associates	13,41,660.00		12,85,020.00	
National Mission on Bamboo Application	-		-	
FDS Management Services Private Limited			3,53,686.00	
Mansarover Industrial Corporation, New Delhi			-	
S. N Solutions, Delhi	1,65,615.00		1,66,853.00	
Suncity Projects Private Limited, New Delhi			1,58,579.00	
Balmer Lawrie & Co. Ltd., New Delhi			-	
Dinesh Singh Tomer, New Delhi			1,966.00	
Darsheel Enterprises, New Delhi	44,832.00		-	
Shalu Tour And Travels, New Delhi	1,78,178.00		3,04,950.00	
R S Travels Solution Private Limited			-	
Sonpal	20,570.00		18,300.00	
Sr. Post Master Sarojini Nagar, H.P.O.	9,534.00		3,009.00	
Deldsl-Digital NTC			74,100.00	
Digital NTC-New Delhi			30,680.00	
Airtel	33,941.52		33,941.52	
K B Enterprises, New Delhi			22,442.00	
MV Infotech India, New Delhi			-	
Nandini Flower Decoration, New Delhi			7,800.00	
Uneecops Technologies Limited, New Delhi			-	
Gung HO Marketing Services Private Limited, New Delhi			1,78,200.00	
J W Marriott, New Delhi			9,180.00	
A P Enerprises New Delhi	21,240.00			
NIT Ram Choudhary Tempo Services	10,780.00			
Adeptech Solutions Private Limited, New Delhi			-	
NSDL E Governanace Infrastructure Limited	799.00		766.00	
Net Creative Mind Solutions Private Limited		18,27,149.52	-	26,49,472.52
3. Advances Received		-		-
4. Interest accrued but not due on :				
a) Secured Loans / Borrowings		-		-
b) UnSecured Loans / Borrowings		-		-
5. Statutory Liabilities				
a) Over Due		-		-
b) Others : TDS - Section 194C	7,008.00		17,038.00	
TDS - Section 194J	-		19,500.00	
TDS - Section 194I	-		900.00	
TDS - Section 192	10,10,610.00		8,97,393.00	
GST -TDS	3,29,288.00	13,46,906.00	2,98,724.00	12,33,555.00
Total (1)		**31,74,055.52**		**38,83,027.52**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 7 - Current Liabilities And Provisions

Particulars	Current Year		Previous Year	
6. Other Current Liabilities				
Expenses Payable				
Salary Payable	83,75,061.00		68,82,429.00	
Wages Payable	10,000.00		7,500.00	
EPF Payable Employee Contribution	9,000.00		1,69,200.00	
EPF Payable Employer Contribution	10,213.00		1,88,435.00	
NPS Contribution Payable	7,72,828.00		6,59,007.00	
Audit Fee Payable	9,04,500.00		7,79,500.00	
Telephone Expenses Payable (Reimbursement)			11,145.00	
Children Education Allowance Payable (Reimbursement)			2,43,000.00	
Medical Expenses Payable (Reimbursement)			-	
Newspaper Expenses Payable (Reimbursement)			-	
Travelling Expenses Payable (Domestic)			10,004.00	
Accomodation Expenses Payable			-	
AMC Payable	1,34,263.00			
Housekeeping and Other Office Expenses Payable	6,22,340.00			
Honorarium Expenses Payable (Non-Official)	4,000.00	1,08,42,205.00	43,000.00	89,93,220.00
Deductions Payable				
Secretary Deduction Payable (IIT Kanpur)	28,036.00		78,036.00	
Secretary Leave Salary & Pension Contribution Payable	6,28,119.00		8,10,514.00	
Other Employees Deduction Payable	1,03,165.00			
Other Employees Contribution Payable	5,23,128.00	12,82,448.00	1,03,165.00	9,91,715.00
Expenses (Current Liabilities Staff)				
Satish Marar	-		325.00	
Raja Ravi Verman	-		866.00	
Pradeep Kumar (IT Technician)	-		9,434.00	
Deepak Krishna	5,291.00		-	
Manisha Sethi	1,215.00	6,506.00		10,625.00
	-		-	
MINISTRY OF FOOD PROCESSING (PY's Meeting Refund)		5,54,552.00		5,54,552.00
GOVERNMENT OF INDIA, CONSOLIDATED FUND		3,35,49,642.44		6,46,99,786.66
Total (2)		**4,62,35,353.44**		**7,52,49,898.66**
Total (A) =(1) + (2)		**4,94,09,408.96**		**7,91,32,926.18**
B. Provision		-		-
1. For Taxation		-		-
2. Gratuity		88,57,000.00		88,57,000.00
3. Superannuation / Pension		-		-
4. Accumulated Leave Encashment		1,26,11,211.00		77,00,738.00
5. Trade Warranties / Claims		-		-
6. Others		-		-
Total (B)		**2,14,68,211.00**		**1,65,57,738.00**
Total (A+B)		**7,08,77,619.96**		**9,56,90,664.18**

Amount in Rs.

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2022

Schdeule 8

SCHEDULE 8-FIXED ASSETS		GROSS BLOCK				DEPRECIATION					NET BLOCK	
(PURCHASED OUT OF GRANT-IN-AID RECEIVED FROM DST) DESCRIPTION	Rate of Depre-ciation	Cost / valution as at beginning of the year	Additions during the year	Deductions during the year	Cost / valuation at the year end	As at the beginning of the year	On Opening balance	On Additions during the year	On Deductions during the year	Total up to the year end	As at the current year end	As at the previous year end
A. FIXED ASSETS												
1. LAND												
a) Freehold		-	-	-	-	-	-	-	-	-	-	-
b) Leasehold		-	-	-	-	-	-	-	-	-	-	-
2. BUILDING												
a) On Freehold Land		-	-	-	-	-	-	-	-	-	-	-
b) On Leasehold Land		-	-	-	-	-	-	-	-	-	-	-
c) Ownership Flats/Premises		-	-	-	-	-	-	-	-	-	-	-
d) Interior work	10%	2,33,42,784.00	13,75,186.00	1,79,92,942.00	67,25,028.00	1,30,58,642.00	3,63,165.00	68,760.00	1,13,40,451.00	21,50,116.00	**45,74,912.00**	**1,02,84,142.00**
3. PLANT & MACHINERY	15%	15,72,908.00	30,208.00	-	16,03,116.00	8,11,976.00	1,14,140.00	2,266.00	-	9,28,382.00	**6,74,734.00**	**7,60,932.00**
4. VEHICLES		-	-	-	-	-	-	-	-	-	-	-
5. FURNITURE & FIXTURES	10%	1,52,19,023.00	8,05,059.00	-	1,60,24,082.00	69,73,820.00	8,24,520.00	40,253.00	-	78,38,593.00	**81,85,489.00**	**82,45,203.00**
6. OFFICE EQUIPMENT	15%	40,80,621.00	11,23,590.00	-	52,04,211.00	26,52,905.00	2,14,159.00	84,268.00	-	29,51,332.00	**22,52,879.00**	**14,27,716.00**
7. COMPUTER/PERIPERALS					-		-	-		-	-	
A) COMPUTER SOFTWARES	40%	5,88,55,802.00	3,90,000.00	-	5,92,45,802.00	5,39,83,619.00	19,48,873.00	91,800.00	-	5,60,24,292.00	**32,21,510.00**	**48,72,183.00**
B) PERIPHERALS	40%	15,82,584.00	18,77,469.00	-	34,60,053.00	12,38,975.00	1,37,443.00	5,03,272.00	-	18,79,690.00	**15,80,363.00**	**3,43,609.00**
C) PRINTERS/SCANNERS	40%	44,69,567.00	6,20,444.00	62,100.00	50,27,911.00	38,13,818.00	2,62,217.00	1,24,088.00	61,894.00	41,38,229.00	**8,89,682.00**	**6,55,749.00**
D) COMPUTERS	40%	1,18,50,913.00	79,47,860.00	26,02,305.00	1,71,96,468.00	1,00,95,655.00	6,70,054.00	21,96,564.00	25,22,181.00	1,04,40,092.00	**67,56,376.00**	**17,55,258.00**
8. ELECTRIC INSTALLATIONS	10%	25,50,385.00	-	-	25,50,385.00	14,81,440.00	1,06,895.00	-	-	15,88,335.00	**9,62,050.00**	**10,68,945.00**
9. LIBRARY BOOKS	40%	1,24,120.00	6,274.00	-	1,30,394.00	96,221.00	11,160.00	2,510.00	-	1,09,891.00	**20,503.00**	**27,899.00**
10. TUBEWELL & W. SUPPLY		-	-	-	-	-	-	-	-	-	-	-
11. INTANGIBLE ASSETS	25%	66,85,030.00	2,63,76,673.00	-	3,30,61,703.00	22,48,393.00	11,09,160.00	65,05,668.00	-	98,63,221.00	**2,31,98,482.00**	44,36,637.00
TOTAL OF CURRENT YEAR (A)		**13,03,33,737.00**	**4,05,52,763.00**	**2,06,57,347.00**	**15,02,29,153.00**	**9,64,55,464.00**	**57,61,786.00**	**96,19,449.00**	**1,39,24,526.00**	**9,79,12,173.00**	**5,23,16,980.00**	**3,38,78,273.00**
PREVIOUS YEAR		**12,38,96,734.00**	**64,37,003.00**	**-**	**13,03,33,737.00**	**8,78,82,400.00**	**71,84,343.00**	**13,88,721.00**	**-**	**9,64,55,464.00**	**3,38,78,273.00**	**3,60,14,334.00**
B. CAPITAL WORK IN PROGRESS		5,99,43,336.00	3,24,16,931.00	2,56,68,673.00	6,66,91,594.00	-	-	-	-	-	**6,66,91,594.00**	**5,99,43,336.00**
TOTAL (A+B)		**19,02,77,073.00**	**7,29,69,694.00**	**4,63,26,020.00**	**21,69,20,747.00**	**9,64,55,464.00**	**57,61,786.00**	**96,19,449.00**	**1,39,24,526.00**	**9,79,12,173.00**	**11,90,08,574.00**	**9,38,21,609.00**
PREVIOUS YEAR		**16,46,09,242.00**	**2,56,67,831.00**	**-**	**19,02,77,073.00**	**8,78,82,400.00**	**71,84,343.00**	**13,88,721.00**	**-**	**9,64,55,464.00**	**9,38,21,609.00**	**7,67,26,842.00**

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 9 - Investments from Earmarked/Endowment Funds

Particulars	Current Year	Previous Year
1. In Government Securities	-	-
2. Other approved Securities	-	-
3. Shares	-	-
4. Debentures and Bonds	-	-
5. Subsidiaries and Joint Ventures	-	-
6. Others (to be Specified)	-	-
Total	**-**	**-**

Schedule 10 - Investments - Others

Particulars	Current Year	Previous Year
1. In Government Securities	-	-
2. Other approved Securities	-	-
3. Shares	-	-
4. Debentures and Bonds	-	-
5. Subsidiaries and Joint Ventures	-	-
6. Others	-	-
Total	**-**	**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 11 - Current Assets, Loans, Advances Etc

Particulars	Current Year		Previous Year	
A) Current Assets				
1.Inventories :				
a) Stores and Spares (Stationery Stock)		11,26,084.00		12,07,561.00
b) Loose Tools		-		-
c) Stock-in-Trade				
Finished Goods		-		-
Work-in-Progress		-		-
Raw Material		-		-
2. Sundry Debtors :				
a) Debts outstanding for a period exceeding six months		-		-
b) others:		-		-
3. Cash Balances in Hand (including Cheques / Drafts and Imprest)				
Petty Cash Account		20,000.00		20,000.00
Cash in Hand		75,000.00		-
4. Bank Balances :				
a) With Scheduled Banks :				
On Current Accounts	-		-	
On Deposit Accounts	-		-	
On Savings Accounts - SERB (Union Bank of India)	28,96,60,216.10		40,03,80,278.40	
SERB EPFO Account (UBI)	3,27,072.02		1,688.26	
SERB RTI Account (UBI)	890.00		855.00	
SERB NM ICPS (UBI)	80,97,481.00		78,61,004.00	
SERB FSER II (UBI)	3,93,27,848.44			
SERB Intel FIRE (UBI)	63,00,000.00			
IMPRINT-II Account (UBI)	1,30,69,000.00	35,67,82,507.56	11,00,71,396.00	51,83,15,221.66
b) With non-Scheduled Banks :				
On Current Accounts	-		-	
On Deposite Accounts	-		-	
On Savings Accounts	-	-	-	-
5. Post Office - Savings Accounts		-		-
Total (A)		**35,80,03,591.56**		**51,95,42,782.66**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2022

Schedule 11 - Current Assets, Loans, Advances Etc

Particulars	Current Year		Previous Year	
B) Loans, Advancees and Other Assets :-				
1. Loans:				
a) Staff Loan		-		-
b) Other entities engaged in activities/objectives similar to that		-		-
c) Others		-		-
2. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) On Capital Account	-		-	
b) Prepayments				
Computer software expenses	3,08,525.00		3,72,525.00	
Video Conferencing License	8,07,896.00		8,07,896.00	
Vajra Website-Updation Expenses	-		1,20,263.00	
Membership Fee - India International Centre, New Delhi	1,06,200.00		91,450.00	
AMC Covid-19 Portal	-		98,206.00	
Prepaid Internet Charges	45,50,080.00			
Lifesize Device Software Subscription-ICON 400	-		-	
Cyberoam Firewall - Licence Fee	-	57,72,701.00	-	14,90,340.00
c) Security Deposit				
Deldsl-Digital NTC (Security Deposit)	-		20,000.00	
Digital NTC (Security Deposit)	-	-	10,000.00	30,000.00
d) Others-				
Centre for Development of Advanced Computing, Noida	-		24,61,008.00	
Mahanagar Telephone Nigam Limited, New Delhi	33,32,945.00		45,61,880.00	
Red fox Hotel Aerocity, New Delhi	-		-	
Bureau of Outreach & Communication, New Delhi (DAVP)	2,111.00		1,80,082.00	
Deepak Krishna	-		-	
Magesh Kumar - LTC Advance			14,000.00	
Pankja Kumar Rawat - LTC Advance			27,000.00	
Shiv Mohan Singh - LTC Advance			50,000.00	
Department of Science & Technology (IMPRINT-II Expenditure by SERB)	-		-	
Ministry of Human Resource Development	5,13,668.00	38,48,724.00	5,13,668.00	78,07,638.00
3. Income Accrued:				
a) On Investments from Earmarked/ Endowment Funds	-		-	
b) On Investment – Others	-		-	
c) On Loans and Advances	-		-	
d) Others (includes income due unrealized)	-		-	
Interest accrued on Saving A/c Balance - SERB UBI	45,46,972.00		76,72,061.00	
ICPS (UBI)	57,898.00		58,171.00	
IMPRINT-II (UBI)	48,068.00	46,52,938.00	8,14,159.00	85,44,391.00
4. Claim Receivable		**-**		**-**
Total = (B)		**1,42,74,363.00**		**1,78,72,369.00**
Total (A) + (B)		**37,22,77,954.56**		**53,74,15,151.66**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2022

Schedule 12 - Income From Sales / Services

Particulars	Current Year	Previous Year
1. Income from Sales		
a) Sale of finished Goods	-	-
b) Sale of Raw Material	-	-
c) Sale of Scraps	-	-
2. Income from Services		
a) Labour and Processing Charges	-	-
b) Professional / Consultancy Services	-	-
c) Agency Commissions and Brokerages	-	-
d) Maintenance Services (Equipment/Property)	-	-
e) Others	-	-
Total	**-**	**-**

Schedule 13 - Grants / Subsidies

Particulars	Current Year		Previous Year	
1. From Central Government				
a) Grant in Aid (General)	5,50,00,00,000.00		4,07,14,91,498.00	
Transferred to Corpus/Fixed Assets (Schedule 1)	-4,70,44,501.00	5,45,29,55,499.00	-2,56,67,831.00	4,04,58,23,667.00
b) Grant in Aid (Capital)		2,66,00,00,000.00		2,81,99,52,390.00
c) Grant in Aid (Scheduled Castes - General)		35,00,00,000.00		30,72,67,379.00
d) Grant in Aid (Scheduled Castes - Capital)		25,00,00,000.00		6,98,85,194.00
e) Grant in Aid (Scheduled Tribe - General)		10,00,00,000.00		6,16,90,867.00
f) Grant in Aid (Scheduled Tribe - Capital)		8,00,00,000.00		3,44,36,107.00
g) Grant in Aid (Salaries)		6,00,00,000.00		4,70,69,264.00
2. State Government(s)		-		-
3. Government Agencies		-		-
4. Institutions Organisations		-		-
5. International Organisations		-		-
6. Other		-		-
Total		**8,95,29,55,499.00**		**7,38,61,24,868.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2022

Schedule 14 - Fees / Subscriptions

Particulars	Current Year	Previous Year
1. Entrance Fees	-	-
2. Annual Fees / Subscriptions	-	-
3. Seminar / Program Fees	-	-
4. Consultancy Fee	-	-
5. Others	-	-
Total	-	-

Schedule 15 - Income From Investments (Income on Invest. From Earmarked/Endowment Funds transferred to Funds)

Particulars	Investment from Earmarked Funds		Investment -Others	
	Current Year	Previous Year	Current Year	Previous Year
1. Interest				
a) On Govt. Securities	-	-	-	-
b) Other Bonds/Debentures	-	-	-	-
2. Dividends				
a) On shares	-	-	-	-
b) On Mutual Fund Securities	-	-	-	-
3. Rents	-	-	-	-
4. Others : Interest on MFPI Balance in Saving Account	4,05,599.00	6,98,812.00	-	-
Interest on S & T SC Balance in Saving Account	5,75,298.00	8,31,001.00	-	-
Interest on S & T ST Balance in Saving Account	3,473.00	5,124.00	-	-
Interest on DOT Balance in Saving Account	2,25,623.00	84,257.00		
Total	12,09,993.00	16,19,194.00	-	-
Transferred to Earmarked/Endowment Funds	12,09,993.00	16,19,194.00		

Schedule 16 - Income from Royalty, Publication Etc.

Particulars	Current Year	Previous Year
1) Income from Royalty	-	-
2) Income from Publications	-	-
3) Other	-	-
Total	-	-

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2022

Schedule 17 - Interest Earned

Particulars	Current Year		Previous Year	
1. On Term Deposits				
a) With Scheduled Banks	-		-	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	-	-	-	-
b)With Non-Scheduled Banks		-		-
c) With Institutions		-		-
d) Others		-		-
2. On Savings Accounts				
a) With Scheduled Banks	1,48,54,056.00		4,02,33,985.00	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	-1,48,54,056.00	-	-4,02,33,985.00	-
b) With Non-Scheduled Banks		-		-
c) Post Office Savings Accounts		-		-
d) Others		-		-
3. On Loans :				
a) Employees / Staff		-		-
b) Others		-		-
4. Interest on Debtors and Other Receivables		-		-
5. Interest on Refund *	1,86,95,586.44		88,38,582.41	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	-1,86,95,586.44	-	-88,38,582.41	-
Total		**-**		**-**

*** Note: Interest on Refund earned during the FY 2021-22 has also been transferred to GOI, Consolidated Fund in Current FY (refer Schedule 1).**

Schedule 18 - Other Income

Particulars	Current Year	Previous Year
1. Profit on sale/disposal/exchange of Assets		
a) Owned assets	-	-
b) Assets acquired out of grants, or received free of cost	-	-
2. Export Incentives realized	-	-
3. Fees for Miscellaneous Services	-	-
4. Deferred Revenue Grant (AS-12)	1,53,81,235.00	85,73,064.00
5. Miscellaneous Income- Other Income RTI Receipts	10.00	150.00
Total	**1,53,81,245.00**	**85,73,214.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2022

Schedule 19 - Increase / (Decrease) in stock of Finished Goods & Work in Progress

Particulars	Current Year	Previous Year
a) Closing Stock		
Finished Goods	-	-
Work-in-Progress	-	-
b) Less : Opening Stock		
Finished Goods	-	-
Work-in-Progress	-	-
Total	**-**	**-**

Schedule 20 - Establishment Expenses

Particulars	Current Year	Previous Year
a) Salaries and Wages	11,51,73,183.00	9,82,20,429.00
b) Allowances and Bonus	-	-
c) Contribution to Provident Fund- Employer		22,39,196.00
d) Contribution to Other Fund : NPS Employer Contribution	51,54,822.00	43,09,920.00
e) Staff Welfare Expenses	-	-
f) Expenses on Employee's Retirement & Terminal Benefits		
Leave Encashment Provision	49,10,473.00	20,31,880.00
Gratuity Expense	-	71,59,680.00
Secretary Leave Salary Contribution	2,97,000.00	2,97,000.00
Others Leave Salary Contribution	4,09,115.00	-
Secretary Pension Contribution	6,20,802.00	6,48,172.00
Secretary Pension Contribution	4,21,071.00	
g) Others		
Telephone Expenses Reimbursement	2,98,293.00	2,76,935.00
School Fee Reimbursement	54,000.00	2,43,000.00
Newspaper Reimbursement	80,700.00	64,963.00
Medical Reimbursement	6,21,440.00	3,30,323.00
Transfer Expenses Reimbursement	-	39,900.00
Leave Encashment	-	-
Leave Travel Concession	6,69,652.00	3,50,504.00
Total	**12,87,10,551.00**	**11,62,11,902.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2022

Schedule 21 - Other Administrative Expenses

Particulars	Current Year	Previous Year
a) Bank Charges	13,682.80	71,382.13
b) Car Hire Charges	49,62,515.00	45,14,017.00
c) Professional Fees	37,75,799.00	63,71,410.00
d) Electricity Charges	10,34,045.00	17,76,692.00
e) Membership Fee	91,450.00	1,73,160.00
f) Meeting Expenses	77,69,629.00	30,05,359.00
g) Honorarium Expenses (Non- Official)	1,17,88,000.00	1,32,16,812.00
h) Hospitality Expenses	12,24,153.00	7,32,214.00
i) Printing & Stationery	64,61,164.00	40,02,122.00
j) Rent- Building	4,33,29,346.00	5,34,99,192.00
k) Advertisement/Publication	4,63,013.00	24,33,765.00
l) Courier Expenses		2,165.00
m) Conveyance Expenses		14,647.00
n) Housekeeping/Security Expenses	54,91,696.00	38,51,639.00
o) International Conference		-
p) Repair & Maintenance	9,89,198.00	7,45,242.00
q) Travelling Expenses (Domestic)	38,44,498.00	12,54,890.00
r) Travelling Expenses (International)		-
s) Audit Fee	4,49,500.00	4,49,500.00
t) Accommodation Expenses (Domestic)		33,388.00
u) Accommodation Expenses (International)		-
v) Computer Hardware & Software	15,53,426.00	14,32,252.00
w) Internet Charges	9,74,198.24	13,27,699.74
x) Newspaper & Periodicals	25,934.00	16,773.00
y) Postage Expenses	24,372.00	27,117.00
z) Telephone Expenses	5,94,301.00	3,68,160.00
aa) Festival Expenses	26,088.00	-
ab) NSDL E Governance Charges	3,134.00	3,154.00
ac) Training Exenses		10,000.00
ad) Conference/Event Expenses	14,23,600.00	9,273.00
ae) AMC	57,82,557.32	55,88,151.00
af) Digitisation Cost		35,400.00
ag) Miscellaneous Expenses	54,18,810.26	24,72,758.52
Total	**10,75,14,109.62**	**10,74,38,334.39**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2022

Schedule 22 - Expenditure on Grants, Subsidies Etc

Particulars	Current Year	Previous Year
Grants given to Institutions/Organisations		
a) Grants in Aid (Capital Assets) (Ann. 21 & 21A)	2,66,76,56,214.00	2,90,05,66,479.00
b) Grant in Aid (General) (Ann. 22 & 22A)	5,34,40,82,745.18	5,28,97,62,959.00
c) Grant in Aid (Scheduled Castes - Capital) (Ann. 23 & 23A)	26,06,43,220.00	10,37,62,970.00
d) Grant in Aid (Scheduled Castes - General) (Ann. 24 & 24A)	36,34,28,494.00	30,28,29,465.00
e) Grant in Aid (Scheduled Tribe - Capital) (Ann. 25 & 25A)	8,19,85,394.00	3,21,36,782.00
f) Grant in Aid (Scheduled Tribe - General) (Ann. 26 & 26A)	10,43,27,780.00	7,87,51,291.00
Total	**8,82,21,23,847.18**	**8,70,78,09,946.00**

Schedule 23 - Interest

Particulars	Current Year	Previous Year
a) On Fixed Loans (Including Bank Charges)	-	-
b) On Other Loans (Including Bank Charges)	-	-
c) Others	-	-
Total	**-**	**-**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2022

Schedule 24 - Prior Period Income

Particulars	Current Year (H)	Previous Year (F)
A) Refund received against previous year grants		
a) Refund from Projects (Capital) FY 2011-12 (Ann. 27 & 27A)	1,323.00	-
b) Refund from Projects (General) FY 2011-12 (Ann. 28 & 28A)	65,059.00	1,24,470.00
c) Refund from Projects (Capital) FY 2012-13 (Ann. 29 & 29A)	14,18,761.00	15,92,470.44
d) Refund from Projects (General) FY 2012-13 (Ann. 30 & 30A)	4,37,874.00	2,03,933.00
e) Refund from Projects (Capital) FY 2013-14 (Ann. 31 & 31A)	5,04,375.00	4,74,306.00
f) Refund from Projects (General) FY 2013-14 (Ann. 32 & 32A)	5,76,260.00	3,30,573.00
g) Refund from Projects (SC-Capital) FY 2013-14 (Ann. 33 & 33A)	-	2,78,629.00
h) Refund from Projects (ST-Capital) FY 2013-14 (Ann. 34 & 34A)	-	-
i) Refund from Projects (Capital) FY 2014-15 (Ann. 35 & 35A)	28,16,406.66	24,35,740.00
j) Refund from Projects (General) FY 2014-15 (Ann. 36 & 36A)	8,46,885.00	28,41,712.60
k) Refund from Projects (SC-Capital) FY 2014-15 (Ann. 37 & 37A)	13,893.00	3,00,757.41
l) Refund from Projects (ST-Capital) FY 2014-15 (Ann. 38 & 38A)	-	-
m) Refund from Projects (ST-General) FY 2014-15 (Ann. 39 & 39A)	-	-
n) Refund from Projects (Capital) FY 2015-16 (Ann. 40 & 40A)	1,22,49,848.25	1,17,84,065.99
o) Refund from Projects (General) FY 2015-16 (Ann. 41 & 41A)	9,56,818.00	30,47,768.74
p) Refund from Projects (SC-Capital) FY 2015-16 (Ann. 42 & 42A)	47,146.00	11,98,097.00
q) Refund from Projects (SC-General) FY 2015-16 (Ann. 43 & 43A)	5,00,000.00	13,46,980.00
r) Refund from Projects (Capital) FY 2016-17 (Ann. 44 & 44A)	2,58,00,127.67	4,95,63,044.95
s) Refund from Projects (General) FY 2016-17 (Ann. 45 & 45A)	93,75,619.14	85,21,242.28
t) Refund from Projects (SC-Capital) FY 2016-17 (Ann. 46 & 46A)	23,56,465.00	16,16,413.00
u) Refund from Projects (SC-General) FY 2016-17 (Ann. 47 & 47A)	2,01,030.00	1,06,083.00
v) Refund from Projects (ST-Capital) FY 2016-17 (Ann. 48 & 48A)	12,91,787.00	8,07,971.00
w) Refund from Projects (Capital) FY 2017-18 (Ann. 49 & 49A)	2,47,36,819.63	1,88,87,742.81
x) Refund from Projects (General) FY 2017-18 (Ann. 50 & 50A)	1,24,78,671.03	1,24,00,508.22
y) Refund from Projects (SC-Capital) FY 2017-18 (Ann. 51 & 51A)	61,29,586.00	19,49,546.50
z) Refund from Projects (SC-General) FY 2017-18 (Ann. 52 & 52A)	11,00,081.00	9,34,819.00
aa) Refund from Projects (ST-Capital) FY 2017-18 (Ann. 53 & 53A)	3,27,824.00	33,028.00
ab) Refund from Projects (ST-General) FY 2017-18 (Ann. 54 & 54A)	-	-
ac) Refund from Projects (Capital) FY 2018-19 (Ann. 55 & 55A)	2,40,12,546.71	77,91,422.70
ad) Refund from Projects (General) FY 2018-19 (Ann. 56 & 56A)	1,91,18,759.61	4,65,45,353.03
ae) Refund from Projects (SC-Capital) FY 2018-19 (Ann. 57 & 57A)	3,49,312.00	4,20,047.00
af) Refund from Projects (SC-General) FY 2018-19 (Ann. 58 & 58A)	21,30,150.00	9,85,480.00
ag) Refund from Projects (ST-Capital) FY 2018-19 (Ann. 59 & 59A)	3,06,684.00	2,15,978.00
ah) Refund from Projects (ST-General) FY 2018-19 (Ann. 60 & 60A)	59,614.38	45,257.00
ai) Refund from Projects (Capital) FY 2019-20 (Ann. 61 & 61A)	91,84,556.72	26,09,509.00
aj) Refund from Projects (General) FY 2019-20 (Ann. 62 & 62A)	5,07,63,735.16	8,31,29,524.36

ak) Refund from Projects (SC-Capital) FY 2019-20 (Ann. 63 & 63A)	3,05,750.00	
ak) Refund from Projects (SC-General) FY 2019-20 (Ann. 64 & 64A)	26,71,640.80	62,73,074.96
al) Refund from Projects (ST-Capital) FY 2019-20 (Ann. 65 & 65A)	-	1,07,200.00
am) Refund from Projects (ST-General) FY 2019-20 (Ann. 66 & 66A)	6,67,519.85	5,10,759.00
ai) Refund from Projects (Capital) FY 2020-21 (Ann. 67 & 67A)	1,45,433.00	
aj) Refund from Projects (General) FY 2020-21 (Ann. 68 & 68A)	6,44,78,124.33	
ak) Refund from Projects (SC-Capital) FY 2020-21 (Ann. 69 & 69A)	11,27,130.00	
ak) Refund from Projects (SC-General) FY 2020-21 (Ann. 70 & 70A)	69,05,537.95	
al) Refund from Projects (ST-Capital) FY 2020-21 (Ann. 71 & 71A)	-	
am) Refund from Projects (ST-General) FY 2020-21 (Ann. 72 & 72A)	11,02,753.50	
an) Refund from Projects SERC (Ann. 73 & 73A)	-	2,76,037.00
ao) Refund from Projects PY (Ann. 74 & 74A)	2,74,77,946.01	59,92,945.64
B) Other income liabilities written back		
M/s Mansarover Industrial Corporation, New Delhi	-	2,350.00
Grants Pending for Clearance (FY 2011-12 to FY 2014-15)	-	2,87,51,809.00
Total A) + B)	**31,50,39,853.40**	**30,44,36,648.63**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2022

Schedule 25 - Prior Period Expenditure

Particulars	Current Year	Previous Year
a) Professional Fees		18,585.00
b) Accomodation Expenses		68,433.00
c) International Conference		-
d) Travelling Expenses (Domestic)	10,500.00	10,81,791.00
e) Advertisement Expenses		9,99,562.00
f) Grant-in-Aid (Capital)		-
g) Newspaper Reimbursement	32,900.00	-8,700.00
h) Medical Expenses Reimbursement	85,460.00	50,705.00
i) Telephone Expenses Reimbursement	41,791.00	10,803.00
j) School Fee Reimbursement	27,000.00	-
k) Salary Arrear (Regular Employees)		-8,424.00
l) Salary Arrear (Contract Employees)		-
m) AMC Computers & Printers		-29,972.00
n) AMC Photocopier	4,734.68	4,735.00
o) AMC Biometric Attendance System		192.00
p) AMC MIS System (PRISM)		57,46,668.00
q) Newspaper & Periodicals		-
r) Bank Charges		-
s) Digitisation Cost		-
t) EPF Employer Contribution		-
u) Honorarium Expenses (Non-Official)	2,44,000.00	1,52,000.00
v) Leave Encashment		-
w) Depreciation A/c		9,81,170.00
x) Meeting Expenses		2,39,813.00
y) IMPRINT_II Expenses		38,36,27,978.00
z) AMC SERB Website	17,80,227.00	-
aa) Electricity Charges	2,13,977.00	-
ab) Leave Salary Contribution	2,99,727.00	-
ac) Pension Contribution	3,69,512.00	-
ad) Water Charges	2,68,054.00	-
ae) Printing and Stationary	2,700.00	-
Total	**33,80,582.68**	**39,29,35,339.00**

FINANCE

Amount in Rs.

Receipts & Payments for the Year Ended 31.03.2022

	Receipts	Current Year	Previous Year		Payments	Current Year	Previous Year
1	**Opening Balances**			1	**Expenses**		
a)	Cash in hand	20,000.00	19,918.00	a)	**Establishment Expenses (corresponding to Schedule 20)**	12,24,97,078.00	10,66,18,966.00
b)	Bank balances			b)	**Administrative Expenses (corresponding to Schedule 21)**	10,64,32,955.30	11,61,24,963.87
	i) In Current Accounts	-	-	2	**Payments made against funds for various projects**		
	ii) In Deposit Accounts	-	-		**Grants given to Institutions/Organisations**		
	iii) Savings Accounts : SERB UBI	40,03,80,278.40	1,71,41,67,284.90	a)	Grants in Aid (Capital Assets)	2,66,76,56,214.00	2,90,05,66,479.00
	: SERB RTI	855.00	685.00	b)	Grant in Aid (General)	5,34,40,82,745.18	5,28,97,62,959.00
	: SERB EPFO	1,688.26	531.00	c)	Grant in Aid (Scheduled Castes - Capital)	26,06,43,220.00	10,37,62,970.00
	: IMPRINT-II UBI	11,00,71,396.00	11,85,11,462.00	d)	Grant in Aid (Scheduled Castes - General)	36,34,28,494.00	30,28,29,465.00
	: SERB NM ICPS (UBI)	78,61,004.00		e)	Grant in Aid (Scheduled Tribe - Capital)	8,19,85,394.00	3,21,36,782.00
				f)	Grant in Aid (Scheduled Tribe - General)	10,43,27,780.00	7,87,51,291.00
2	**Grants Received**			3	**Investments & Deposits made**		
a)	From Government of India			a)	Out of Earmarked/Endowment Funds	-	-
	Grant in Aid (General)	5,50,00,00,000.00	4,07,14,91,498.00	b)	Out of Own Funds (Investments-Others)	-	-
	Grant in Aid (Capital)	2,66,00,00,000.00	2,81,99,52,390.00	4	**Expenditure on Fixed Assets & Capital Work-in**		
	Grant in Aid (Scheduled Castes - General)	35,00,00,000.00	30,72,67,379.00	a)	Purchase of Fixed Assets	1,48,84,090.00	34,93,493.00
	Grant in Aid (Scheduled Castes - Capital)	25,00,00,000.00	6,98,85,194.00	b)	Expenditure on Capital Work-in Progress	3,24,16,931.00	1,92,30,828.00
	Grant in Aid (Scheduled Tribe - General)	10,00,00,000.00	6,16,90,867.00	5	**Refund of surplus money/loans**		
	Grant in Aid (Scheduled Tribe - Capital)	8,00,00,000.00	3,44,36,107.00	a)	To the Government of India	-	-
	Grant in Aid (Salaries)	6,00,00,000.00	4,70,69,264.00	b)	To the State Government	-	-
	Grant in Aid (IMPRINT II)	92,00,000.00		c)	To other providers of Funds	-	-
	Grant in Aid (FIRE)	63,00,000.00		6	**Finance Charges (Interest)**	-	-
b)	From State Government	-	-	7	**Other Payments (Specify)**		
c)	From Other Sources (details)	-	-	a)	MFPI Earmarked Payment	-	18,91,363.00
3	**Income on Investments from**			b)	Refund to Ministry of Food Processing	-	-
a)	Earmarked/Endowment Funds	-	-	c)	ICPS Earmarked Payment	-	27,77,720.00
b)	Own Funds			d)	IMPRINT-II Earmarked Payment	11,06,80,000.00	1,21,00,000.00
4	**Interest Received**			e)	DOT Earmarked Payment	-	-
a)	On Bank Deposits	2,18,96,072.00	5,14,95,297.00	f)	IMPRINT-II Expenditure by SERB	-	-
b)	Loans Advances	-	-	g)	Bureau of Outreach & Communication, New Delhi	-	1,80,082.00
c)	Interest on Refund	2,03,77,505.17	88,38,582.41	h)	Mahanagar Telephone Nigam Limited, Delhi	-	45,61,880.00
5	**Other Income**	10.00	150.00	i)	Centre for Development of Advanced Computing, Noida	-	24,61,008.00
6	**Amount Borrowed**	-	-	j)	Government of India, Consolidated Fund	32,55,30,701.66	9,95,59,578.00
7	**Any Other Receipts**			k)	National Mission on Bamboo Application	-	10,80,145.00
				l)	MHRD Expenditure by SERB		
a)	Refunds Received Against Previous Year Grant (SERB)	31,50,39,853.40	27,58,76,334.63	m)	PrePaid Internet Charges	45,50,080.00	
b)	MFPI Earmarked Receipt	-	89,783.00				
c)	S & T Earmarked Receipt	21,41,117.47	9,88,864.59	8	**Closing Balances**		
d)	ICPS Earmarked Receipt	-	1,06,38,724.00	a)	Cash in hand	95,000.00	20,000.00
e)	IMPRINT-II Earmarked Receipt	24,46,891.00	38,04,879.00	b)	Bank balances		
f)	DOT Earmarked Receipts	-			i) In Current Accounts	-	-
g)	Proceed from Sale of Assets	2,56,520.00	-		ii) In Deposit Accounts	-	-
					iii) Savings Accounts : SERB UBI	28,96,60,216.10	40,03,80,278.40
					: IMPRINT-II UBI	1,30,69,000.00	11,00,71,396.00
					: SERB RTI	890.00	855.00
					: SERB EPFO	3,27,072.02	1,688.26
					: SERB NM ICPS (UBI)	80,97,481.00	78,61,004.00
					: SERB FSER II UBI	3,93,27,848.44	
					: SERN Intel FIRE(UBI)	63,00,000.00	
	Total	**9,89,59,93,190.70**	**9,59,62,25,194.53**		**Total**	**9,89,59,93,190.70**	**9,59,62,25,194.53**

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES

Chartered Accountants

CA Pulkit Agrawal

(Partner)

M. No. 431102

Date : 06.05.2022

Place : New Delhi

For Science and Engineering Research Board

Secretary

SERB

Date :

Place : New Delhi

Director-Finance

SERB

SCHEDULE 26

SIGNIFICANT ACCOUNTING POLICIES

1. Basis of Preparation of Financial Statements

These financial statements have been prepared on the accrual basis of accounting, under historical cost convention, in accordance with the accounting principles generally accepted in India.

2. Fixed Assets

Fixed assets are stated at cost of acquisition less accumulated depreciation and impairment losses, if any. Cost of fixed assets comprises purchase price, duties, levies and other directly attributable costs of bringing the assets to its working conditions for the intended use.

3. Capital Work in Progress

Expenditure incurred on construction of assets which are not ready for their intended use are carried at cost less impairment (if any), under Capital work-in-progress.

4. Depreciation

Depreciation on fixed assets is computed on the written down value (WDV) method at the rates and in the manner prescribed under the Provisions of Income Tax Act.

In respect of additions to/deductions from fixed assets during the year, depreciation is considered on pro-rata basis, as per the provision of Income Tax Act. Assets costing Rs.5,000/- each or less are fully provided.

5. Grant/ Subsidies Received

Grants, subsidies or similar assistance received for the general purposes and objectives of the Entity, on an irrevocable basis, be treated as income on receipt basis.

6. Expenditure on Grants, Subsidies etc.

Grants, subsidies or other similar assistance given to the Institutions/Organisations for general purposes and objectives of the Entity, on an irrevocable basis, be treated as expenditure when they are released.

7. Interest Income of SERB

Besides the grants-in-aid received from Central Government, SERB also generates income from: -

a. Interest on Short term FDs on the Grant-in Aid
b. Interest on the Saving A/c Balance; and
c. Interest on Refunds

As on 31st March, 2022, total interest of Rs. 33549642/- (for details Refer Schedule no 17) earned during the current FY 2021-22 has been transferred to Consolidated Fund of Government of India and shown as payable in Schedule 7 - Current Liabilities and Provisions.

8. Prior period Income/Expenditure

Income/expenditure relating to previous Financial Years has been booked as Prior Period Income/Expenditure in the Income and Expenditure Account.

9. Refund from beneficiaries:

a) Refund/repayment of grant/assistance received by SERB from the beneficiaries as per the conditions stipulated in the sanction document is accounted for on receipt basis.
b) Refund/repayment of grant/assistance given and received back in the same financial year has been netted off with Grant-in-Aid (expenditure) in the Income and Expenditure Account.
c) Refund/repayment of grant/assistance given in previous years and received back in later years (i.e. not in same financial year) has been shown as "Refund received against Previous Year Grant" in the Income and Expenditure Account under "Prior Period Income".
d) Refund/repayment of grant/assistance given in previous years and received back during the year through NEFT without any supporting documents or any communication from the grantee institutions and the details of which are not traceable till the finalization of Annual Accounts has been shown as "Refund from projects Previous Year" in the Income and Expenditure Account under "Prior Period Income".

10. Unspent balances of Grants received from DST:

The unspent balances of Grants received from DST are not to be refunded to DST as grants released by the Government are credited to Science and Engineering Research Board in terms of Section 10(1) of SERB Act, 2008. However, under the directions of administrative ministry (DST), the unspent balance of grants, if any, now to be refunded to administrative ministry by transferring the same to Consolidated fund of India.

11. Time barred cheques

All cheques issued by SERB during the FY 2021-22 have been cashed within its validity period of 3 months from the date of the issue of Cheque, if any.

12. Government Grant for Fixed assets of SERB

In order to comply with AS-12 Accounting for Government Grants under direction of C&AG, amount equivalent to cost of acquisition of fixed assets out of Grants in Aid (General) has been shown as Corpus Fixed Assets. Depreciation for the year amounting Rs. 1,53,81,235/- is being credited to Income & Expenditure A/c as Deferred Revenue Grant as per para 8 of AS 12. The depreciated value of assets impaired, discarded due to end of useful life, is being charged to Corpus for fixed assets, amounting to Rs.66,52,491/-

13. Retirement Benefits

SERB makes provision for liability towards encashment of leave lying to the credit of employees as on the last day of current financial year subject to the maximum period of leave allowable as per extant rules and retirement benefits shall be governed by the National Pension System (NPS) as applicable to the officers of equivalent rank of the Central Government as amended from time to time.

SERB makes provision for Gratuity as on the last day of the financial year subject to the maximum limit as per extant orders of retirement benefits as applicable to the officers of equivalent rank of the Central Government as amended from time to time.

14. Surplus/Deficit in Income & Expenditure A/c

Surplus/Deficit in Income & Expenditure Account at the year-end has been transferred to Corpus/Capital Account.

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

CA Pulkit Agrawal
(Partner)
M. No. 431102
Date : 06.05.2022
Place : New Delhi

For Science and Engineering Research Board

Secretary
SERB
Date :
Place : New Delhi

Director-Finance
SERB

SCHEDULE FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31.03.2022

SHCEDULE- 27 CONTINGENT LIABILITIES AND NOTES TO ACCOUNTS

1. CONTINGENT LIABILITIES

1.1 Claims against the Entity not acknowledge as debts **Rs. NIL** (Previous year **Rs. NIL**)

1.2 In respect of

- Bank Guarantees given by/on behalf of the Entity **Rs. NIL** (Previous year **Rs. NIL**)
- Letters of Credit opened by Bank on behalf of the Entity **Rs. NIL** (Previous year **Rs. NIL**)
- Bills discounted with banks **Rs. NIL** (Previous year **Rs. NIL**)

1.3 Disputed demands in respect of:

- Income tax **Rs. NIL** (Previous year **Rs. NIL**)
- Sales Tax **Rs. NIL** (Previous year **Rs. NIL**)
- Municipal Taxes **Rs. NIL** (Previous year **Rs. NIL**)
- In respect of claims from parties for non-execution of orders but contested by the Entity **R NIL** (Previous year **Rs. NIL**)

1.4 For Income Tax ***(Refer Para 6 below)***
- Current Year – Rs 12,12,88,862/- Previous year – Rs 12,12,88,862/-

	Current Year	Previous Year
FY 2011-12	Rs. 9,43,38,079/-	Rs. 9,43,38,079/-
FY 2012-13	Rs. 2,69,50,783/-	Rs. 2,69,50,783/-
FY 2013-14	Nil	Nil
FY 2014-15	Nil	Nil
FY 2015-16	Nil	Nil
FY 2016-17	Nil	Nil
FY 2017-18	Nil	Nil
FY 2018-19	Nil	Nil
FY 2019-20	Nil	Nil
FY 2020-21	Nil	Nil
FY 2021-22	Nil	Nil
Total	**Rs. 12,12,88,862/-**	**Rs. 12,12,88,862/-**

2. CAPITAL COMMITMENTS

- Estimated value of contracts remaining to be executed on capital account and not provide for (net of advances) **Rs. NIL** (Previous year **Rs. NIL**)

3. LEASE OBLIGATIONS

- Future obligations for rentals under finance lease arrangements for plant and machinery amount to **Rs. NIL** (Previous year **Rs. NIL**)

4. CURRENT ASSETS, LOANS AND ADVANCES

- In the opinion of the Management, the current assets, loans and advances have a value on realization in the ordinary course of business, at least equal to the amount at which they are stated in the Balance Sheet.

5. Net Profit/Loss in Current FY 2021-22

Total Income of Current FY 2021-22 is Rs. 8,96,83,36,744/- whereas Total Expenditure of Current FY is Rs. 9,07,37,29,742.80.

In Income & Expenditure A/c excess of Expenditure over Income shows a difference of Rs. 10,53,92,998.80 as Gross Loss.

SERB is having Net Profit of Rs. 20,62,66,271.92 in FY 2021-22 after considering Prior Period Income of Rs. 31,50,39,853.40 and Prior Period Expenditure of Rs. 33,80,582.68/-.

6. TAXATION

SERB has got exemption u/s 10(46) of the Income Tax Act, 1961 for 5 financial years from FY 2013-14 to FY 2017-18 vide gazette notification no. 24/2017/F.No.196/15/2013-ITA-I published on 31st March, 2017.

Since our original application for exemption u/s 10(46) was from inception of SERB, the matter has been taken up again with CBDT to grant us exemption for FY 2011-12 and FY 2012-13 also.

Further we have applied for exemption u/s 10(46) of the Income Tax Act, 1961 to CBDT and Income Tax Department for FY 2018-19 and onwards.

In such a situation we have shown Contingent Liability for Income Tax at point 1.4.

SERB is registered as charitable organization u/s 12A of the Income Tax Act, 1961 from AY 2017-18 and eligible for exemption from Income Tax u/s 11 of the Income Tax Act, 1961. Registration u/s 12A is renewed for next 5 years from AY 2022-23 to AY 2026-27.

FOREIGN CURRENCY TRANSACTIONS

(Amount Rs.)

7.1 Value of Imports Calculated on C.I.F. Basis:	**Current Year**	**Previous Year**
Purchase of finished Goods	Nil	Nil
Raw Materials & Components (Including in transit)	Nil	Nil
Capital Goods	Nil	Nil
Stores, Spares & Consumables		

7.2 Expenditure in foreign currency:

a) Travel	Nil	Nil
b) Remittances and Interest Payment to Financial Institutions/ Banks in Foreign Currency	Nil	Nil
c) Other expenditure:		
- Commission on Sale	Nil	Nil
- Legal and Professional Expenses	Nil	Nil
- Miscellaneous Expenses	Nil	Nil
- Grant-in-Aid (General)	Rs.6,79,01,370/-	Rs.7,97,20,044/-

7.3 Earning:

Value of Exports on FOB basis	Nil	Nil

7.4 Remuneration to Auditors:

- Auditors Fee (CAG)	Rs. 1,25,000/-	Rs. 1,25,000/-
- Auditors Fee (CA)	Rs. 3,24,500/-	Rs. 3,24,500/-
- Taxation matters	……..	……
- For management services	…….	……
- For certificate	…….	…….
- Others	……	……

Absorption of expenses incurred on IMPRIMT-II scheme from SERB Fund

SERB has been funding various schemes since November 2011 as per the objectives stated in SERB Act, 2008. As a part of various scheme SERB has funded IMPRINT-I Scheme and IMPRINT-II. Now as per the directions of Secretary, DST , The IMPRINT-II Scheme has been transferred to SERB and it is conveyed that SERB shall manage IMPRINT-II out of its budget allocation of Funds and no separate grants would be released for IMPRINT-II.

9. During the Current Financial Year, SERB has shifted its office from rent premises to space allocated in administrative ministry (DST). On vacating rented premises, furnishing and interior works such as flooring and ceiling could not be removed and were left as it is. These flooring and ceiling like interior are not removable for productive use, on the contrary it requires extra spending for removal before handing over the premises to owner on as is where is basis. The amount of such interior works which were capitalized and carried over as fixed assets, are impaired /discarded at the depreciated value of Rs.66,52,491/-. The shifting expenses of Rs.23,07,679/- are charged to revenue account under the head Other Administrative expense.

10. During the year under review, as per the prescribed norms of Government, the old laptops (used for more than 5 years) which were given to regular Officer were allowed to be retained on payment of 10% of the original cost price. Further, SERB has purchased new desktop computers under buy-back scheme in replacement of old computers, at the rate Rs.5000/-each. The resultant profit of Rs. 1,76,190/-, due to above transactions, being difference in exchange price/transfer price and depreciated value of fixed assets, is being transfer to Corpus for fixed asset.

11. The SERB MIS Software and Accelerated Vigyan Web portal on completion and successful implementation are being transfer from work in progress to Intellectual intangible property worth Rs.2,56,68,673/-during the year with effect from 1st April, 2021.

12. Previous Year figures have been regrouped /recast wherever found necessary.

13. Schedules 1 to 27 are annexed to and form an integral part of the Balance Sheet as at 31.03.2022 and the Income and Expenditure Account for the year ended on that date.

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

CA Pulkit Agrawal
(Partner)
M. No. 431102
Date : 06.05.2022
Place : New Delhi

For Science and Engineering Research Board

Secretary
SERB
Date :
Place : New Delhi

Director-Finance
SERB

Spud Post

कार्यालय महानिदेशक लेखापरीक्षा,
पर्यावरण एवं वैज्ञानिक विभाग
नई दिल्ली-110 002
OFFICE OF THE DIRECTOR GENERAL OF AUDIT,
ENVIRONMENT & SCIENTIFIC DEPARTMENTS,
A.G.C.R. BUILDING, I.P. ESTATE
NEW DELHI-110 002

स.म.नि.ले.प.(पर्या.एवं वै.वि)/नि./2(9)/Annual Accounts-SERB/2022-23/721-722 दिनांकः 28/9/2022

सेवा में,

The Secretary,
Science and Engineering Research Board (SERB),
5 & 5A, Lower Ground Floor Vasant Square Mall,
Sector-B, Pocket-5, Vasant Kunj
New Delhi-110070

विषयः विज्ञान और इंजनियरी अनुसंधान बोर्ड (SERB) के वर्ष 2021-22 के लेखों पर पृथक ऑडिट रिपोर्ट।

महोदय,

मुझे विज्ञान और इंजनियरी अनुसंधान बोर्ड के वर्ष 2021-22 के लेखों पर ऑडिट रिपोर्ट अग्रेषित करने का निर्देश हुआ है।

संसद के दोनों सदनों में प्रस्तुत करने से पहले वर्ष 2021-22 के वार्षिक लेखों को विज्ञान और इंजनियरी अनुसंधान बोर्ड, नई दिल्ली द्वारा अपनाया जाए। प्रत्येक दस्तावेज जो संसद में प्रस्तुत किया जाए उसकी तीन प्रतियां इस कार्यालय तथा दो प्रतियां भारत के नियंत्रक एवम महालेखापरीक्षक को अग्रेषित की जाए। संसद के दोनों सदनों में प्रस्तुत करने की तिथि (या) भी इस कार्यालय को सूचित की जाए।

आपसे अनुरोध है कि पृथक ऑडिट रिपोर्ट का हिन्दी अनुवाद अपने कार्यालय में कराने के पश्चात सॉफ्ट कॉपी तथा हार्ड कापी दोनों में हमें भेज दें ताकि हिन्दी प्रति को शीघ्र अग्रेषित किया जा सके।

यह महानिदेशक द्वारा अनुमोदित है।

भवदीय,

संलग्कः यथोपरि।

उप-निदेशक (निरीक्षण)

SEPARATE AUDIT REPORT ON ACCOUNTS OF SCIENCE AND ENGINEERING RESEARCH BOARD, NEW DELHI FOR THE YEAR 2021-22

We have audited the attached Balance Sheet of the Science & Engineering Research Board (SERB), New Delhi as at 31st March 2022 and the Income & Expenditure Account/Receipt & Payment Account for the year ended on that date under Section 19(2) of the Comptroller and Auditor General's (Duties, Power and Condition of Service) Act, 1971 read with Section 13(3) of SERB Act, 2008. These financial statements are the responsibility of the Board's management. Our responsibility is to express opinion on these financial statements based on our report.

2. This Separate Audit Report contains the comments of the Comptroller and Auditor General of India on the accounting treatment only with regard to classification, conformity with the best accounting practices, accounting standard and disclosure norms etc. Audit observations (Propriety and Regularity) and efficiency–cum–performance aspects, etc., if any are reported through Inspection Reports/Comptroller and Auditor General's Audit Report separately.

3. We have conducted our audit in accordance with auditing standards generally accepted in India. These standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatements. An audit includes examining, on a test basis, evidences supporting the amounting and disclosure in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of financial statements. We believe that our audit provides a reasonable basis for our opinion.

4. Based on our audit, we report that –

(i) We have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit,

(ii) The Balance Sheet, Income and Expenditure Account and Receipts and Payments account dealt with by this report have been drawn up in the format approved by the Government of India,

(iii) In our opinion, proper books of accounts and other relevant records have been maintained by the Board, as required, in so far as it appears from our examination of such books.

(iv) We further report that:

A. Balance Sheet

A.1 Liabilities

A.1.1 Current Liabilities and provisions - Rs. 7.09 crore (Schedule 7)

Refund received against previous years unspent grants amounting to Rs. 3150.40 lakh was shown as Prior Period Income instead of Unspent Grant under Schedule 7 "Current Liabilities". This resulted in overstatement of Income and Understatement of Current Liabilities to the extent of Rs. 3150.40 lakh.

A. 2 Assets

A.2.1 Current Assets, Loan, Advances etc. - Rs. 37.23 Crore (Schedule 11)

Schedule 11-Current Assets, Loans, Advances etc. depicted an amount of Rs.0.95 lakh as Cash Balances in Hand. However, closing balance of cash book was Rs.0.20 lakh for the year 2021-22. SERB replied that the payment of Rs.0.75 lakh is yet to be adjusted on the receipts of the bills.

B. Income & Expenditure Account

B.1Expenditure

B.1.1 Establishment Expenditure - Rs.12.87 lakh (Schedule 20)

An amount of Rs. 10.63 lakh was paid to EPFO but the same was accounted under the head 'salaries and wages' instead of "Contribution to Provident Fund-Employer" under Schedule 20-Establishment Expenses. Further, an amount of Rs 19213 was shown as Current Liabilities under provident fund but the expenses were not shown in Schedule 20-Establishment expenses "Contribution to Provident Fund-Employer". This resulted in understatement of Expenses by Rs.19213.

C. General

C.1 **No Actuarial valuation of Gratuity and Leave Encashment**

SERB made provisions of Rs 88.57 lakh and Rs 126.11 lakh under Gratuity and Accumulated Leave Encashment respectively during 2021-22. However, no actuarial valuation has been carried out for Gratuity and Leave Encashment till date. In the absence of actuarial valuation report, audit cannot quantify the liability to be provided for Gratuity and Accumulated Leave Encashment as on 31 March 2022.

D. Grants-in-aid

Besides opening balance of ₹ 51.83 crore, SERB had received a grant of ₹ 900 crore from the DST during 2021-22, ₹ 0.46 crore as Earmarked Fund Receipts, ₹ 31.50 crore as 'Refund received against previous year grants', ₹ 2.04 crore as 'interest on refund', ₹2.19 crore towards 'Interest on bank deposits and other receipts. After disbursement from the fund and other expenditure of ₹ 953.92 crore, the board was left with the balance of ₹ 35.68 crore.

(v) Subject to our observations in the preceding paragraphs, we report that the Balance Sheet, Income & Expenditure Account and Receipts & payments Account dealt with by this report are in agreement with the books of accounts.

(vi) In our opinion and to the best of our information and according to the explanations given to us, the financial statements read together with the Accounting Policies and Notes on Accounts and subject to the significant matters stated above and other matters mentioned in Annexure to the

Audit Report give a true and fair view in conformity with accounting principles generally accepted in India.

In so far as it relates to the Balance Sheet of the State-of-affairs of the SERB as of 31st March 2022.
In so far as it relates to the Income and Expenditure Account of the surplus for the year ended on that date.

For and on behalf of C&AG of India

Date:
Place: New Delhi

Director General of Audit
Environment and Scientific Departments

Annexure – I to Separate Audit Report

1. Adequacy of Internal Audit System

Internal audit of SERB for the period from 2019-20 to 2021-22 was carried out in August 2022.

2. Adequacy of Internal Control Systems –

During the audit of SERB, the following deficiencies in relation to internal control system were observed:

2.1 Non maintenance of records of assets created out of Grants for Creation of Capital Assets

As per Schedule 22 of the Annual Accounts for the financial year 2021-22, the Board released ₹ 301.03 crores to 570 institutes as Grants for Creation of Capital Assets, Grant in Aid (Scheduled Caste-Capital) and Grants in Aid (Scheduled Tribe- Capital). The Board, however, has not included any of the physical or intellectual assets procured by these 570 Institutes under the fixed assets cluster of the balance sheet.

2.2 Non maintenance of Register of Grants released by the board
Register of Grants in Form GFR-21 needs to be maintained by the Board as per Rule 234, GFRs 2017, the same was not being done.

2.3. Monitoring of Utilisation Certificates (UCs)

26329 number of UCs amounting to a total of ₹ 2177.65 crore for the years 2011-12 to 2020-21 were outstanding as of 31 March 2022.

2.4 Non-utilization of Gem Portal for goods and services procurement

Rule 149 of the General Financial Rules, 2017 made it mandatory for the Government buyers to procure Goods and Services from Government e-marketplace. It was however observed that the Board is yet to begin using the GeM portal.

3. System of Physical Verification of Fixed Assets

No discrepancy was reported in the physical verification of fixed assets carried out for the financial year 2021-22. However, assets not included in Schedule 8 of have already been reported in SAR.

4. **System of Physical Verification of Inventory**

No discrepancy was reported in the physical verification of fixed assets carried out for the financial year 2021-22.

5. Regularity in payment of statutory dues

Though the Board had no undisputed statutory dues outstanding for more than six months from the date of becoming due during 2021-22, an amount of ₹ 12.13 crore was disclosed as contingent liability towards Income Tax Department for the period 2011-12 & 2012-13 against which the Board had applied for exemption u/s 10(46) of the Income Tax Act 1961.

Dy. Director (Inspection)

Annexure A

(In Rupees)

Sl. No.	Name of Asset	Addition in 2021-22	Rate of Depreciation to be charged (%)	Depreciation to be charged for 2021-22	Net Asset as on 31.03.2022
01	Hard Disk 500 GB	115541	20	23108.20	92432.8
02	TFT display	23010	20	4602	18408
03	MS Office 365 Personal/ Business Premium	39530	40	15812	23718
04	MS Office 365 Personal/ Business Premium	23718	20	4743.6	18974.4
05	MS Office Home & Business	34220	20	6844	27376
06	Firewall and Multicore processor	421260	40	168504	252756
07	Adobe	33512	20	6702.4	26809.6
08	PBX System	525511	7.5	39413.32	486097.68
	Total	**1216302**		**269729.52**	**946572.48**

Sr. Audit Officer (Inspection)

Notes

Notes

About SERB

Set up through an Act of Parliament, viz. the Science and Engineering Research Board Act, 2008, SERB serves as the national premier funding agency for planning, promoting and steering internationally competitive research in science and engineering. The mandate is to promote basic research in frontier areas of Science and Engineering and provide financial assistance to persons engaged in such research, academic institutions, research and development laboratories, and other agencies. This is achieved through various schemes like extramural research funding fellowships, grants, awards, scholarships and joint industrial relevant collaborations.

Science and Engineering Research Board

Submit R&D proposals online at: www.serbonline.in

3rd and 4th Floor, Block-II, Technology Bhawan, New Mehrauli Road,
New Delhi - 110016 Telefax : 011-26511094

For General & Programme related Enquiries: 011 – 26511173
E-mail: info@serbonline.in Website : www.serb.gov.in