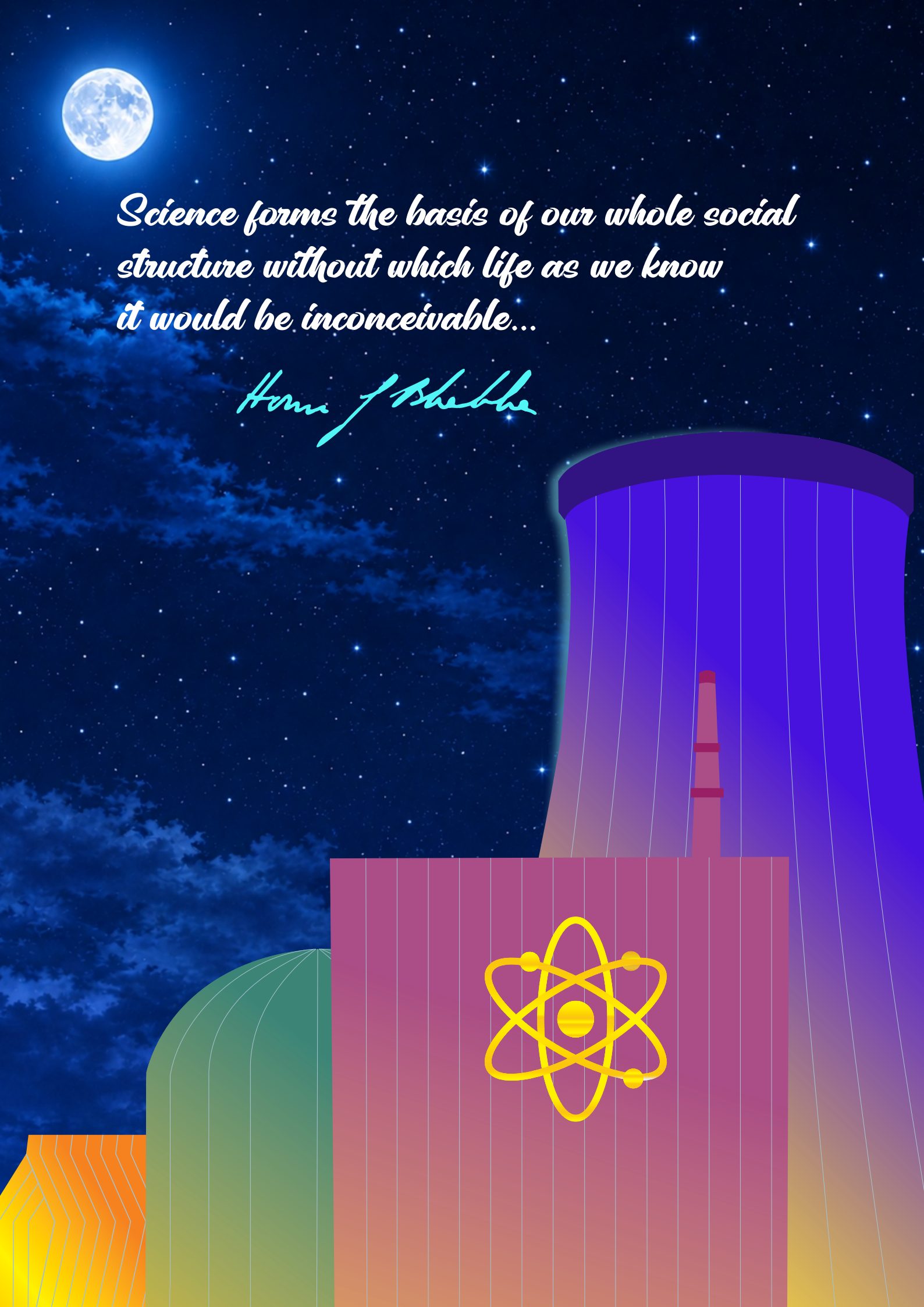

Science forms the basis of our whole social structure without which life as we know it would be inconceivable...

BASIC Sciences

Expanding Frontiers in Fundamental Research

आधारभूत विज्ञान: मौलिक अनुसंधान के विस्तृत क्षितिज

Radiation-Induced Mutation Breeding: In line with the national objective of 'Atmanirbharta' in oilseeds, pulses and cereals, sustained research efforts in mutation breeding has led to the development of seven new crop varieties, which have been released and Gazette notified in 2026, for commercial cultivation in different states. These include wheat varieties, Chhattisgarh Trombay Kumud (CG 1047) for Maharashtra, Karnataka, Andhra Pradesh, Goa, Tamil Nadu, Keralam and Trombay Him Palam Gehun 4 (THPW 4) for Himachal Pradesh; mungbean varieties, PDKV Phalguni (TAKSM 140) and PDKV Varsha (TAKM-141); rice variety, Trombay Konkan Mahan (TKR-35); sorghum variety, PDKV Shashwat (TAKS 461 R) and sesame variety, Trombay Latur Til-7 (TLT-7). The mungbean, rice, sorghum and sesame varieties have been released for cultivation in Maharashtra. Among these, TAKS 461 R and TLT-7 are gamma ray-induced direct mutants, while the others are mutant-derived varieties. Both the wheat varieties are bold seeded, with higher grain yield, good chapati-making quality and also have higher content of iron & zinc. Both the mungbean varieties are high yielding with characters such as earliness, synchronous maturity and resistance to yellow mosaic

▲ *Dispatch of breeder seed of Trombay (TG) variety groundnut.*

▶ *A farmer from interior Maharshtra region proudly holds a bunch of freshly harvested Trombay (TG-88) variety groundnut pods.*

disease. TAKM-140 is the first variety released for summer cultivation in Maharashtra, whereas TAKM-141 is to be grown in rainy season. TKR 35 is a disease resistant, longer duration, non-lodging, semi-dwarf rice variety with long slender superior-quality grains. The sorghum (jowar) TAKS 461 R is a bold seeded variety with enhanced content of essential micronutrients (iron & zinc) and better roti making quality. This variety is also resistant to charcoal rot and blight diseases. Sesame variety, TLT 7 shows superior seed as well as oil yield, early maturity, lodging tolerance and bold seeds, making it suitable for export. With the Gazette notification of these 7 varieties, the total number of varieties released by BARC now stands at 79.

In order to transfer the benefits of Trombay varieties to the farming community, BARC has undertaken farmer-participatory breeder seed production in Maharashtra and at BARC, Vizag. Consequently, 330 quintals breeder seed of six Trombay groundnut varieties were produced and supplied to 37 organizations/agencies in various states for further foundation and certified seed production. For popularizing the mustard variety TAM108-1 among farmers, 150 Front Line Demonstrations (FLDs) were conducted in 50 acres in Maharashtra. Further, 38.9 quintals breeder and 300 quintals certified seeds of TAM108-1 were produced and distributed among farmers. Cluster FLDs of mustard variety BBM1 were carried out in 3000 ha and 3 quintals breeder seed were also produced in Jharkhand. TBM143 and TJM1 & 2 mustard varieties were also demonstrated in West Bengal and Rajasthan, respectively.

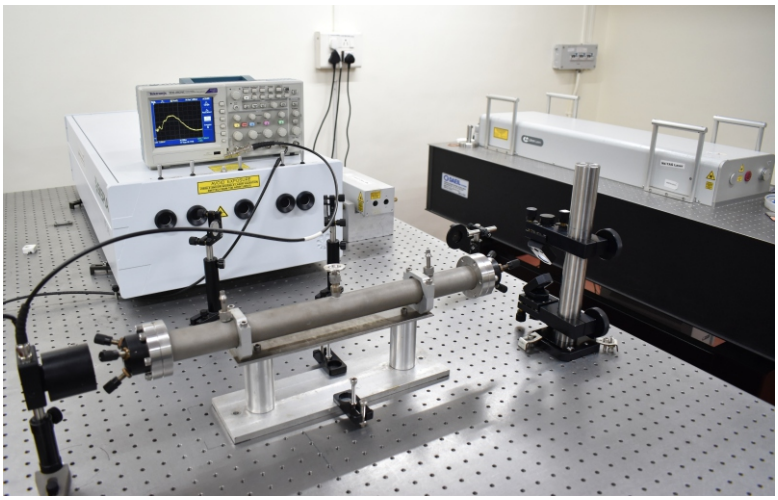
Transcription factor 'MusaNAC46' regulates stress-induced senescence in Banana: In banana, the transcription factor, MusaNAC46 was demonstrated to function as a novel regulator of stress-induced senescence (SIS). The MusaNAC46-overexpressing plants not only aged earlier than the control plants, but also displayed a distinct inhibition in growth. The overexpression line showed the ample presence of autophagic bodies, which correlated very well with the elevated expression of prominent autophagy-associated genes (ATGs) in this line. The MusaNAC46 promoter was also activated by drought or salt stress, furthermore implicating its role in SIS.

Fumigation-free preservation protocol developed in BARC implemented at a makhana (fox nuts) processing facility near Patna, Bihar.

Trade of Chemical-Free Makhana Using Radiation Technology: A radiation-based protocol for fumigation-free preservation of makhana (fox nuts) was developed in BARC. The technology was implemented at the recently commissioned food irradiation facility near Patna in Bihar, established by the Government of Bihar and operated under an operations and maintenance (O&M) arrangement. On 8 August 2026, an 18-tonne consignment of irradiated makhana was exported from Bihar to Australia by sea in seven containers. This achievement demonstrates the potential of radiation technology as an alternative to conventional chemical fumigation, supporting phytosanitary compliance, international market access, value addition, and agricultural trade.

Mushroom Preservation Technology: The technology of shelf-life extension of mushroom by combining gamma irradiation with complementary treatment was developed in BARC. The technology know-how was transferred to the industry partner M/s. Jitban Supply Chain Pvt. Ltd. A commercial-scale trial involving approximately 1.5 tonnes of mushrooms resulted in successful export to Thimphu, Bhutan. The mushrooms retained good quality for up to 21 days under chilled storage and received positive consumer responses. Interest in larger-volume procurement highlights the technology's commercial potential for reducing post-harvest losses, extending distribution networks, and facilitating the international marketing of fresh mushrooms.

Enriched Lutetium-176 & Nickel-62 using an in-house Electromagnetic Isotope Separator: BARC has developed an Electromagnetic Isotope Separator through in-house efforts and successfully produced Lutetium-176 and Nickel-62 with enrichment exceeding 99.5%. Lutetium-176 is an important precursor for producing Lutetium-177, widely used in targeted radionuclide therapy. Highly enriched Nickel-62 is required to produce Nickel-63, a long-lived beta emitter used in nuclear batteries, gas chromatography electron-capture detectors, and ion



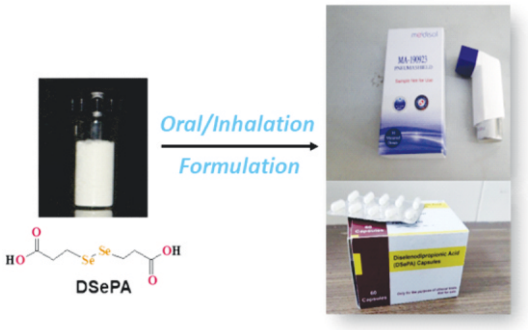
Laser Cavity Ring-Down set-up for measurement of reflectivity of high reflection mirrors.

mobility spectrometers. The EMIS comprises a high-current metal-vapour/sputter ion source, beam extraction and transport optics, a 90° sector electromagnet, and dedicated collectors. The system can produce approximately 1 mg of enriched Nickel-62 every two days, strengthening domestic capabilities in isotope production.

Proton Beamline at the Medical Cyclotron Facility in Kolkata: A new 30 MeV proton beamline has been installed at the Medical Cyclotron Facility, Kolkata, to support Accelerator Driven System research, target-window development, and fast-neutron spectrometry. The beamline includes horizontal transport optics, diagnostic and control systems, and a 90° bending magnet directing the beam to a shielded target cave eight metres underground. Its EPICS-based control system enables remote operation and monitoring. The facility is designed for proton currents up to 350 μA to irradiate target materials, generate fast neutrons and gamma rays, and produce radioisotopes for physics studies and computational-code validation. A semi-automated irradiation module supports beam qualification, neutron-yield measurements, and safe handling of irradiated targets. A key milestone has been achieved by transporting a 30 MeV, 10 μA proton beam to the beam dump, with a beam spot size of 35-55 mm at the target location.

Laser Cavity Ring-Down Facility for High-Reflectivity Mirrors: A Cavity Ring-Down (CRD) facility was setup in BARC to measure the reflectivity of high-reflectivity optical mirrors at 1064 nm, including mirrors relevant to Laser Interferometer Gravitational-Wave Observatory (LIGO) applications. The technique measures the exponential decay of laser light trapped between two mirrors to determine reflectivity with high precision. The facility was validated using a commercial reference mirror. An indigenously developed 33-layer Ta_2O_5/SiO_2 multilayer mirror demonstrated a reflectivity of 99.930 ± 0.002% at 1064 nm. This capability supports the development of advanced optical thin-film coatings for high-performance mirrors.

Horizontal section of the ADS beamline at Medical Cyclotron Facility, Kolkata.



Prototype formulations of DsePA.

Indigenous Technology for Large Single-Crystal Growth: The technology for growing Germanium and Silicon single crystals up to 50 mm in diameter and 150 mm in length using the Czochralski technique was developed in BARC. The development includes hot-zone and system design, along with optimization of material-specific crystal-growth parameters. These semiconductors are essential for microelectronics and radiation detectors. To facilitate technology transfer and commercialization, an incubation agreement was signed in March 2025 between Rana Semiconductor Pvt. Ltd. and the Atal Incubation Centre, Anushakti Nagar, under the Atal Innovation Mission. This initiative advances indigenous semiconductor technology under the Atmanirbhar Bharat vision.

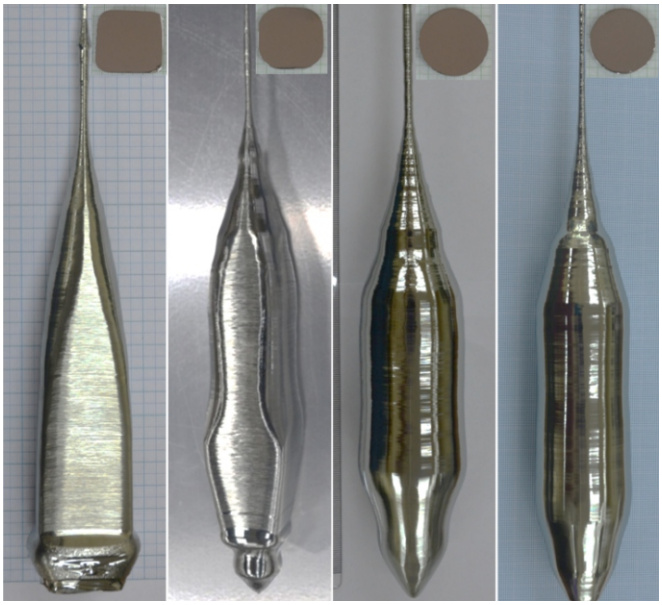
Condensed Matter Research Using Neutrons and Synchrotron Radiation: Advanced materials were extensively investigated in BARC using neutrons at Dhruva and synchrotron radiation at Indus-2. Research covers quantum materials, including topological insulators and low-dimensional magnets; functional materials, such as battery materials, molecular magnets, and thermoelectrics; and soft matter, including polymer membranes, hydrogels, and biomaterials. These studies establish structure–function relationships and support materials development. Both national facilities also serve researchers from universities, IITs, national laboratories, and industry across India, strengthening collaborative research and scientific capacity.

Clinical Translation of DSePA (Organo-selenium) as a Radiotherapy Adjuvant: Radiation pneumonitis (RP), a serious complication of thoracic radiotherapy, compromises treatment intensity and the therapeutic ratio, resulting in poorer clinical outcomes. Steroids are the current standard of care for RP; however, prolonged administration can cause associated complications, necessitating the development of specific therapeutic agents.

Systematic chemico-biological evaluation of organoselenium compounds at Chemistry Group (CG), BARC, has identified 3,3'-diselenodipropionic acid (DSePA) as a potent candidate, with efficacy against RP validated in cellular and murine models. For clinical translation, prototype oral and inhalation formulations have been indigenously developed using FDA-approved excipients. Bioequivalence studies in murine models confirmed DSePA absorption in lung tissue within the desired concentration range.

An intellectual property rights proposal covering DSePA formulations, methods of use, and associated devices was filed in India (TEMP/E-1/123701/2025-MUM, dated 14-Nov-2025). Detailed toxicity studies were completed in rodent models at a GLP-compliant laboratory in accordance with CDSCO guidelines. Licences for manufacturing GMP-grade DSePA and its formulation were subsequently secured from CDSCO (SW/IND/CT-15/2025/000002072, dated 31-Dec-2025; FDA/MFG/SR-2072/2025-2026, dated 04-Apr-2026).

The Institutional Human Ethics Committee of Tata Memorial Centre and CDSCO reviewed the investigational new drug (IND) dossier for DSePA as a radiotherapy adjuvant and granted in-principle approval for a Phase I single-ascending-dose (SAD) trial, subject to minor protocol amendments and completion of GMP manufacturing (OIEC/4346/2026/00001, dated 10-Feb-2026). GMP manufacturing of DSePA and its tablet formulation is currently underway. The GMP batches will be used for the Phase I safety study in humans at TMC.



Germanium single crystal growth.

Curcumin loaded Pickering emulsion

Prototype formulation

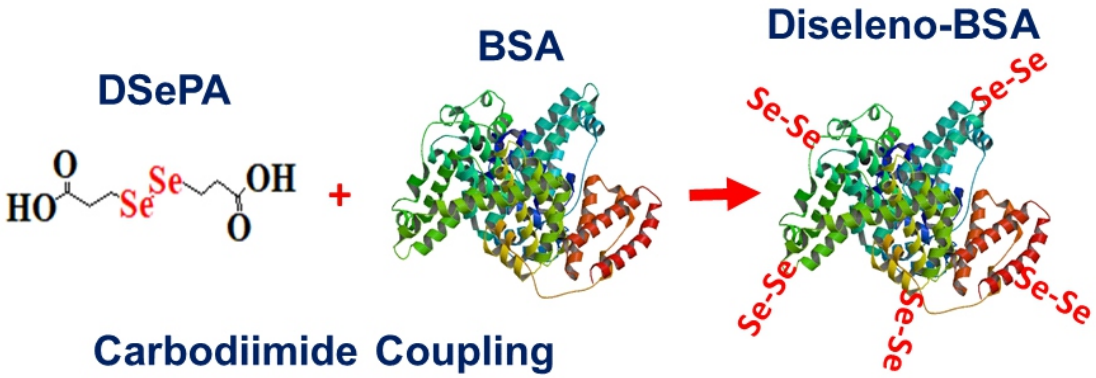
Development of curcumin formulation for higher cellular uptake.

Protein-Based Oral Curcumin Formulations for Improved Cellular Uptake: Curcumin, the active ingredient of turmeric (_Curcuma longa_), has recognized health benefits, but its therapeutic use is limited by poor aqueous solubility, chemical stability, and cellular uptake. An in-house methodology to prepare curcumin-loaded gels/Pickering emulsions was developed in BARC using FDA-approved proteins and lipids for oral and/or buccal delivery. The formulations significantly improved curcumin solubility and stability and enhanced cellular uptake by approximately threefold.

The methodology know-how has been transferred to an industry partner, where successful scale-up and prototype manufacturing have been completed. Administrative procedures for obtaining regulatory and commercialization licences from the competent authority, FSSAI, are currently underway.

Synthetic Selenoproteins for Healthcare Applications: Protein-based bioconjugates offer potential pharmacokinetic advantages over small molecules for therapeutic applications. Building on research at in BARC, for establishing organoselenium compounds as promising chemo-radiotherapeutic agents, an in-house method was developed to synthesize diselenide-functionalized gelatin and albumin for anti-cancer applications.

The bioconjugates demonstrated potent anticancer activity in the A549 lung cancer cellular model, retaining selenium's therapeutic potential. Mechanistic studies established that their anticancer activity involves targeting Ero1α-driven protein folding, leading to lethal endoplasmic reticulum (ER) stress and mitochondrial oxidation. Pharmacokinetic studies in mice demonstrated an approximately fourfold longer circulation half-life of selenium compared with the free diselenide. In vivo efficacy studies using xenograft tumour models are currently underway.



Design of selenium-functionalized bovine serum albumin (BSA).