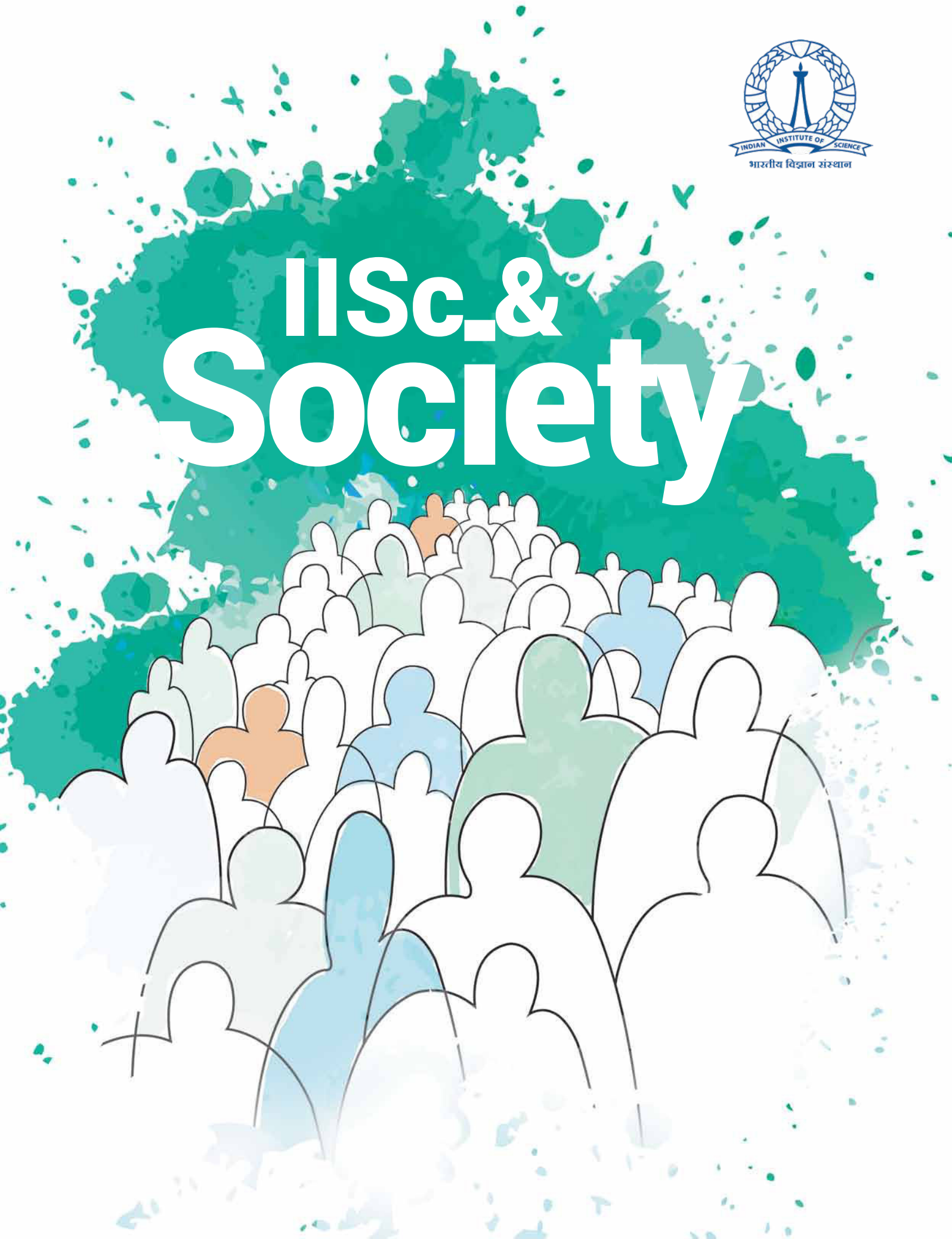
INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

IISc & Society



Preface

Science is not static; it changes over time, reflecting shifts in the larger societies in which it is embedded.

In recent times, globalisation has penetrated the institution of science and technology. The practice and values which are the hallmark of science – advancement of knowledge, sustaining the autonomy of the scientific institution and peer evaluation and social control of scientific knowledge solely by the scientific community – have begun to transform under its impact. The world economy, market flows and creative industries, including science and technology, are much more integrated today. Scientific communities are reorienting themselves towards "creation of wealth": creation of economic value from the application of science. Innovation and commercialisation of academic research have become an integral part of university governance and academic policy along with teaching and research.

Even as globalisation and industrialisation have resulted in increased economic growth, there is evidence of growing inequity and worsening social indicators amongst the lower sections of society. It is imperative that scientific institutions contribute to improving the livelihood of these sections through adequate access to health, housing, sanitation and nutritious food. Questions such as how to create employment and sustainable livelihoods for people living in non-urban regions necessitate adopting an "inclusive innovation" paradigm through which more could be obtained with lesser cost and that which could benefit more number of people. The new perspective blends local knowledge systems with science and technology in agriculture, health, manufacturing and other areas.

The Indian Institute of Science (IISc) has strived to keep pace with the changing social relations between science and society ever since its formation in 1909. The Institute has contributed to India's economic growth by training leaders in science and engineering. It has responded to the demands of globalisation through collaborative research and innovation with multinational and other corporations. In some instances, this has resulted in

the development of cost-effective innovations. There are mechanisms for technology licensing and protecting intellectual property. Though the practical application of science was a priority even during the early years of the Institute, as evidenced by the setting up of the Government Sandalwood Factory in Mysore in 1916 following experiments conducted for the extraction of sandalwood oil at IISc, there now exists a conscious policy to promote wealth creation and employment generation. The Institute provides facilities for entrepreneurs to set up companies through the Society for Innovation and Development and the Entrepreneurship Cell.

Responding to the need to address societal concerns such as availability of adequate clean water, urban development and housing, development of alternative and cheaper forms of energy and a clean and green environment, IISc has initiated trans-disciplinary research in these areas using an inclusive innovation model. This supplements research done employing mainstream science in more traditional domains. The setting up of units such as the Centre for Sustainable Technologies, Centre for Infrastructure, Sustainable Transportation and Urban Planning, Interdisciplinary Centre for Water Research, Interdisciplinary Centre for Energy Research and the Centre for Nano Science and Engineering is reflective of the importance the Institute lays on providing solutions to societal problems. In recent years, the Institute has also explored the possibility of raising money for socially meaningful research from industry and philanthropic foundations.

As part of its outreach programme, the Institute organises public lectures, exhibitions and an annual Open Day, when all the departments are thrown open to the general public. The Institute faculty also delivers science-based lectures at other venues. The Centre for Continuing Education at IISc offers courses for the general public, some of which are online, in select subject areas to supplement its regular Master's and PhD courses. A Talent Development Centre trains high school and college teachers from all over the country at IISc's second campus in Challakere, which is being developed as a science city. The Institute's publication wing- IISc Press- facilitates dissemination of information and knowledge through publication of books on topics of contemporary interest in science and technology for students of science and the general public in both English and Hindi. The state-of-the- art facilities and expertise in the various units of IISc are made available to the wider research community in the country.

A new approach to the role of science in problem solving in the context of the uncertainties of natural systems and the relevance of human values is emerging. There is a need to incorporate several new features in the methodology of science transcending the bounds of normal training and research. Recognising this, IISc introduced an undergraduate program in science with an adequate component in the arts, humanities and social sciences in the year 2011. The course seeks to develop the ability to shift deliberately among alternative perspectives and to bring each to bear upon a complex problem. This would allow the student to make connections between disciplines and theories, between practical problems and accumulated knowledge and between a society's assumptions and those of other cultures. A variety of tools and methodologies such as role plays and decision cases are sought to be employed in the course.

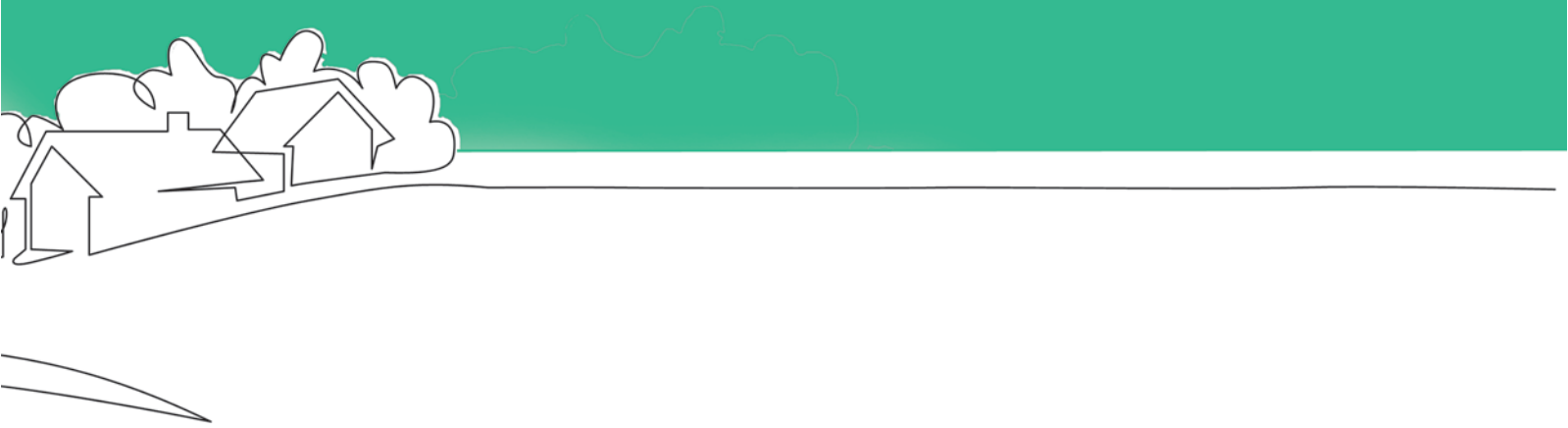
A more specific account of the activities indicated above can be found in the pages that follow in this document. These are categorized under five main headings: Rural and Urban Development, Health and Medicine, Environment and Sustainability, Emerging Technologies and Reaching Out.

Though globalisation has impacted the social institution of science and transformed it radically, we need to ensure that it is not completely taken over by economic and market forces. There is a need to evolve mechanisms for maintaining a balance between public good and market good. IISc is committed to open disclosure of research, building channels for knowledge flow and enabling free circulation of knowledge in the interests of society at large wherever possible: these and related issues would be addressed by the newly set up Centre for Society and Policy in the Institute. Its commitment also lies in moving beyond mere popularization of science to engaging with the public in a much bigger way in order to enable science to effectively respond to people's needs and the general public to effectively contribute to science.

Anurag Kumar
Director

September 2019

Rural and Urban Development



01
Rural Development

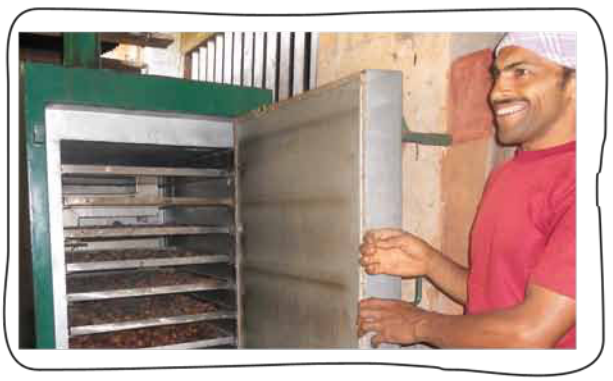
02
Urban Development

Rural Development

For over four decades now, research on rural technology at IISc has been directly impacting communities. These technologies promote low-cost, energy-efficient, sustainable alternatives that are designed to be built using locally available materials and maintained by the communities themselves, thereby empowering them and even enabling livelihoods.

ASTRA OLE stove and ASTRA vegetable and fruit drier

The ASTRA OLE stove, which can be built using locally available materials and uses wood or agro-waste as fuel, is about five times as fuel-efficient as conventional stoves. The stove also reduces cooking time and produces less smoke. The fuel-efficient ASTRA vegetable and fruit drier completely dehydrates a wide variety of foods, which can then be packaged in powdered form and readily used in preparing various dishes. The technology is helping farmers and farm labourers, including women, earn a livelihood through self-help groups.



An ASTRA vegetable and fruit drier in Shakrulil in Sirsi, Karnataka

The ram-pump irrigation system in Taipadar

Micro-hydropower and irrigation in Bastar

A project in Taipadar, an Adivasi village in Bastar district, Chhattisgarh, that uses a ram-pump and an innovative low-head hydro-turbine will soon be generating electricity and pumping water for irrigation and drinking water needs of the villagers. The ram-pump runs without electricity using the kinetic energy of water from a perennial stream nearby.

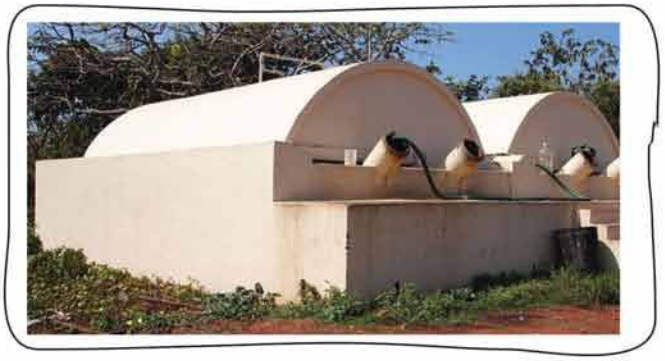
The high throughput ozonator powered by solar energy that is used to disinfect grey water

Tackling wastewater

A pilot project that treats and reuses wastewater has been implemented in a school in Berambadi village, Karnataka, by an interdisciplinary team of experts from India and Scotland. The decentralised treatment system aims to reduce water consumption and the pollution caused by untreated grey water (from kitchen and handwash) and black water (from toilets).

Biomass-based biogas plants

Biomass-based biogas plants developed at IISc have helped in addressing energy shortage in rural areas. More than 35 large and 200 small bioreactors are in operation using diverse biomass sources including agro-residues, which helps in recycling too. Similarly, there are more than 50 gasifiers producing decentralised energy in India and abroad, helping to reduce fossil fuel use.



A biogas plant in the BITS Goa campus

Buildings for rehabilitation of earthquake victims in Bhuj, Gujarat

Sustainable construction

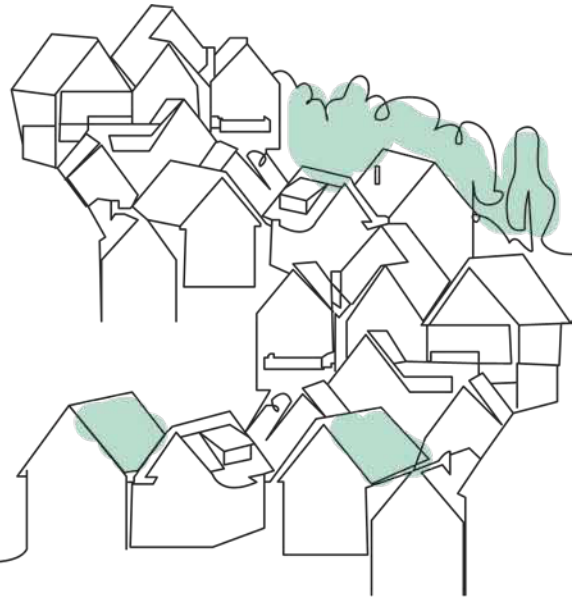
Nearly four decades of R&D at IISc has resulted in development of many low-carbon, alternative building materials and technologies which have been used in constructing more than one lakh buildings. They were also used to build more than 10,000 buildings in earthquake-hit Bhuj in Gujarat and tsunami-affected coastal Tamil Nadu. IISc trains engineers and architects on using these technologies, which have been transferred to several organisations too.

Customized sanitation design

A modified compact septic-tank design was developed, with the participation of the community, and built – along with housing units -- for 140 families in a tsunami-affected island fisher village named Kodiyampalayam, in Nagapattinam district of Tamil Nadu. The design had to accommodate space constraints and ensure that the groundwater in this region does not get contaminated. These structures can be built in using locally available construction material without skilled labour, and can function even in flood-like situations.

Low-cost housing and sanitation units in tsunami-hit Kodiyampalayam, Tamil Nadu, built using fly-ash stabilised blocks

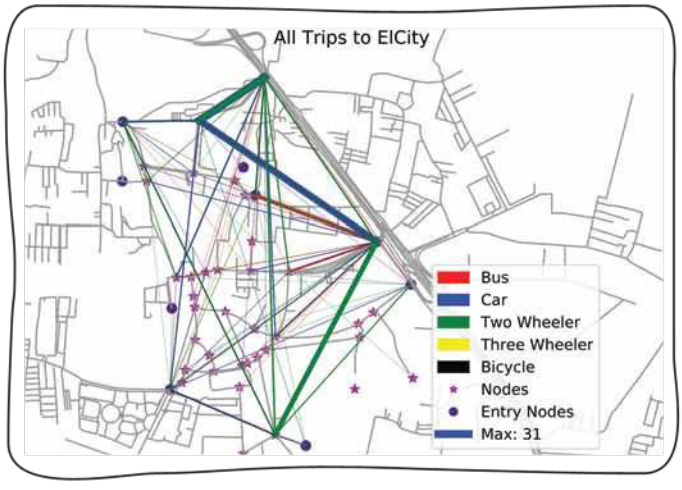
Urban Development

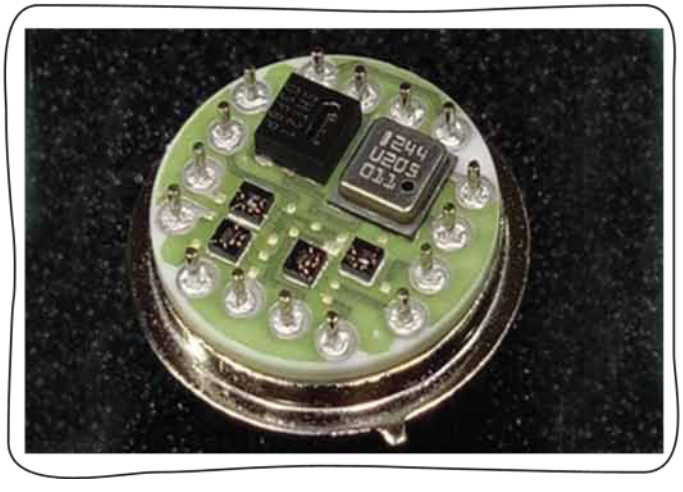


With rapid urbanization, Indian cities are facing unprecedented increase in pollution levels, traffic congestion and water scarcity. IISc researchers are applying cutting-edge engineering advancements to tackle these issues. They are also working closely with government agencies to shape policies, and provide insights for sustainable planning and development.

Solutions for decongesting traffic

IISc researchers are working on solutions to ease traffic congestion in Electronics City, Bengaluru, one of India's largest industrial parks. They are developing a traffic flow modelling framework, with data on volume, delays, and speed collected using sophisticated traffic counting equipment. Working with the Electronics City Industrial Township Authority, they are also studying commuters' travel behaviour and choices (including future travel scenarios such as metro rail completion) and working on options for last-mile connectivity.





Sensor arrays to monitor urban air quality

In collaboration with CSIR-CEERI and the University of Southern California in the United States, IISc is currently working on a project funded by the Indo-U.S. Science and Technology Forum to develop and calibrate low-cost urban air quality sensors. They are working on developing and validating a low-cost sensor array system that will measure all parameters needed to determine air quality index. They are also focusing on calibrating these sensors using low-cost techniques that integrate machine learning with dispersion models.

Open source platform for Smart Cities

The Ministry of Housing and Urban Affairs (MoHUA) has launched an ambitious Smart Cities Mission to develop 100 smart cities across India. With MoHUA's support, IISc researchers are working on setting up an open-source software platform called Indian Urban Data Exchange (IUDX). This will allow easy and efficient exchange of data among various stakeholders of smart cities, by interconnecting disparate urban data platforms, and enabling co-creation and innovation. IISc will work with industry, government agencies, NGOs and citizens to form a consortium to further develop and maintain IUDX.

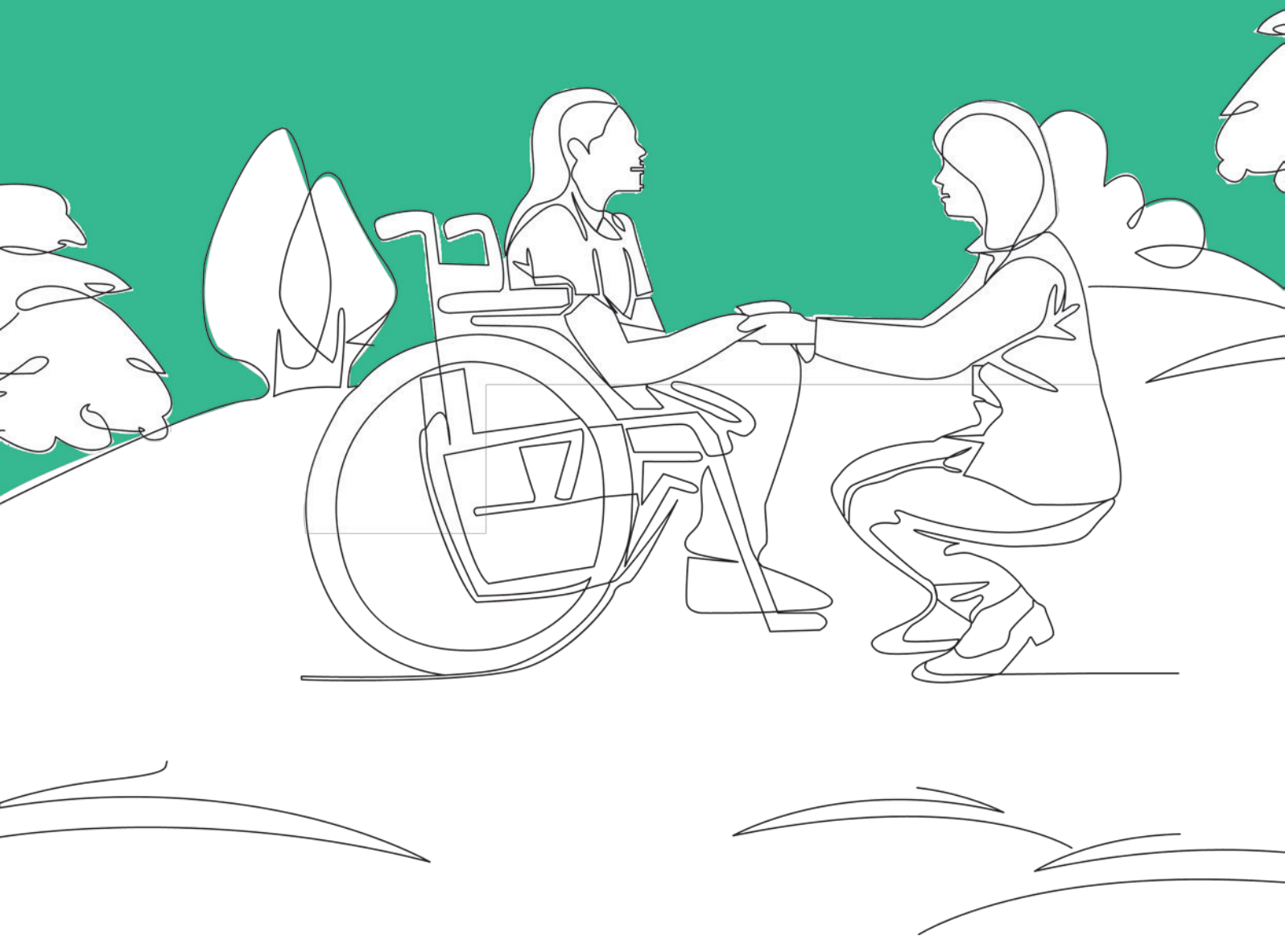
Sustainable transport measures for Bengaluru

Under an Indo-Norway project called CLIMATRANS involving multiple institutes, IISc researchers have been analyzing the impact of climate change on transportation in urban areas. They have analyzed and proposed sustainable transport measures that improve the liveability of Indian cities, especially Bengaluru, New Delhi and Mumbai. As part of this project, a comprehensive report was published in 2018 outlining technology interventions and regulatory measures to reduce traffic congestion and exhaust emissions in Bengaluru.

Towards the future of manufacturing

Industry 4.0 combines manufacturing with smart systems and data analytics to drive greater productivity, quality, flexibility, safety and resource utilisation. Working with industry partners and the Government of India's Department of Heavy Industries (DHI), IISc is developing a Smart Factory platform to explore how to use technologies such as IoT and analytics to empower human labour. The Institute will also conduct conferences, workshops and training programs for small and mid-sized enterprises, and provide policy insights under the DHI's SAMARTH Udyog Bharat 4.0 initiative.

Health and Medicine

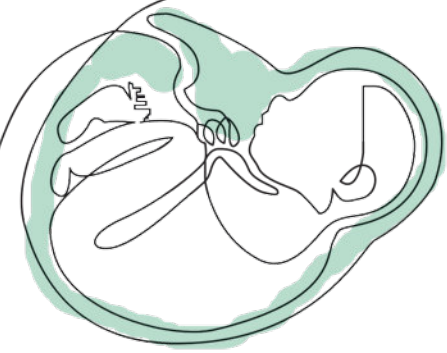


01
Healthcare

02
Cancer

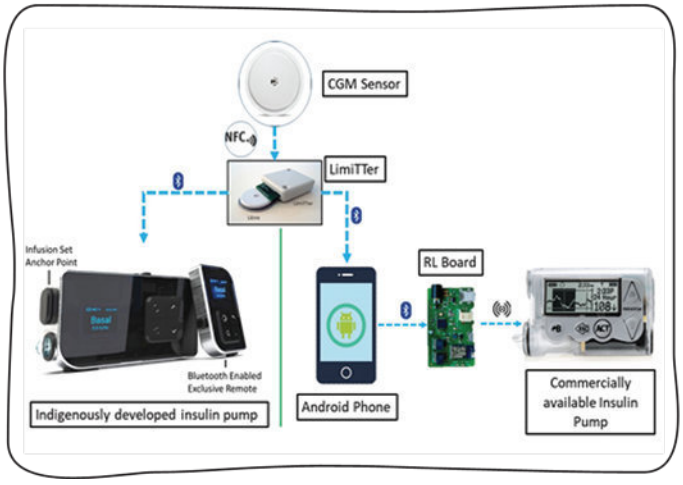
Healthcare

IISc has been focusing on a plethora of areas focusing on healthcare, from developing biomedical devices and vaccinations, to understanding neurodegenerative diseases and the effects of pesticides on health. Here are some of IISc's major contributions in the area.



Wearable sensors for newborns

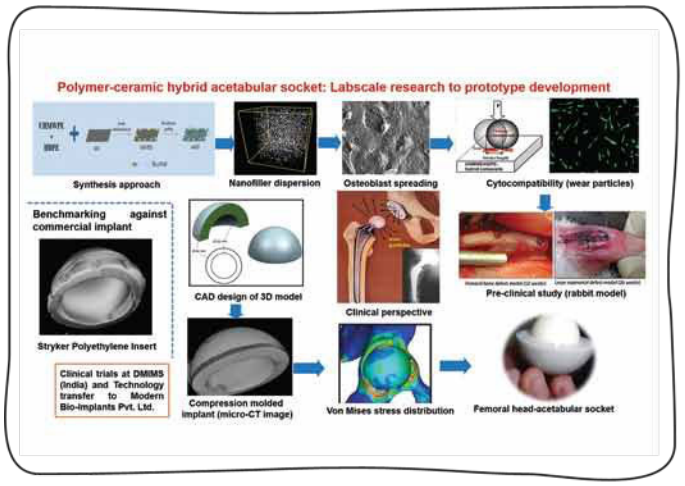
Some newborn babies die before they turn one month old because their body temperature falls below the normal range – a condition called hypothermia. To monitor the real-time body temperatures of mothers and new-borns, scientists from the Robert Bosch Centre for Cyber-Physical Systems have designed a wearable device that raises an alarm upon sensing abnormal body temperatures. This device can be used even in rural areas with minimal infrastructure and has been clinically tested. Recent efforts have been directed towards widening the sensing scope of the device to detect breathing rate, oxygen saturation (SpO2) detection and electrocardiogram (ECG) measurements.



A schematic showing how the artificial pancreas would work

Artificial pancreas

Researchers from IISc and MS Ramaiah College are working on developing artificial pancreas to manage Type1 diabetes through the IMPacting Research INnovation and Technology (IMPRINT), a Ministry of Human Resource Development (MHRD) initiative. Designed to continuously monitor glucose levels in the body, this sensor is connected to a smartphone, which directs the insulin delivery pipe to administer the right dose of insulin. They are also developing low-cost insulin delivery pumps. Clinical trials of this pump are being currently planned.

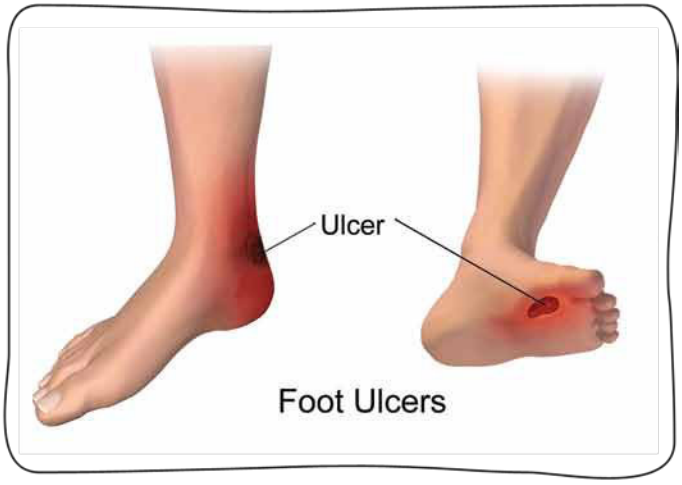


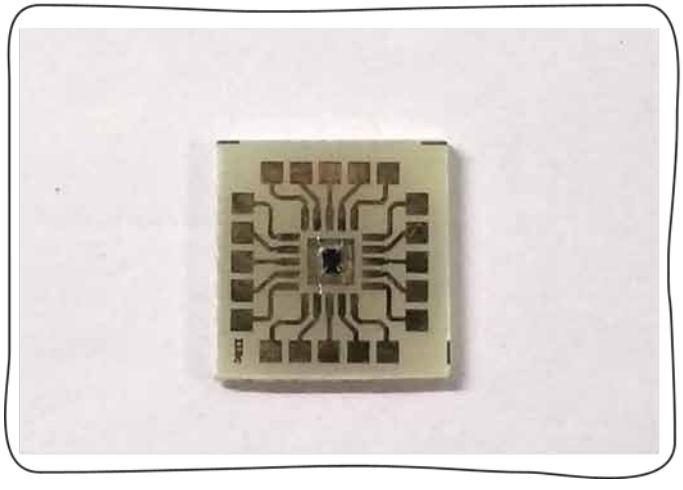
Prosthetics

A major problem with prosthetic implants is that the human body often rejects them. To address this, scientists have developed bone implants that are compatible with the body. Biomaterials for orthopaedic applications such as bone fracture, arthritis and dental applications are currently undergoing technology transfer. To treat hip injuries, they designed biocompatible ceramic fillers acetabular cup for total hip replacement, and also a prototype of patient-specific Zirconia toughened Alumina-based femoral ball head, the cost of which will be around one-third of the imported commercial head.

Support tools for diabetes and arthritis

IISc is also focusing on developing tools to help diabetic patients. One group is developing a new bandage that can sequentially release drugs for diabetic patients with foot ulcers. Another group is working on self-adjusting diabetic shoes equipped with pressure sensors, which are connected to a smartphone. Once the smartphone receives feedback in real-time, it can help patients adjust their gait to avoid aggravation of ulcers. The same group is also building an assistive chair to help the elderly and people suffering from arthritis.





Packaged sensor

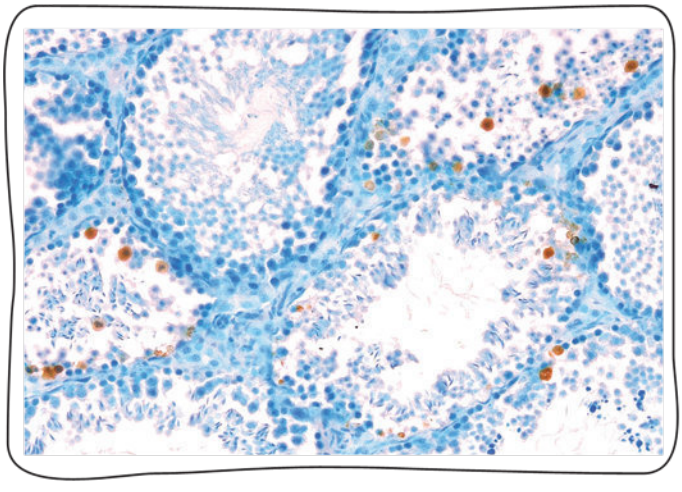
Sensor to diagnose head injuries

An affordable Intracranial Pressure (ICP) sensor to diagnose head-injury (mostly due to two-wheeler accidents) is a grave need in Indian hospitals. To fill this gap, researchers from IISc, National Institute of Mental Health and Neurosciences, Agency for Science, Technology and Research and Defense Research and Development Organisation (DRDO) have developed this sensor to diagnose changes in the intracranial pressure inside the brain: the normal values of ICP in a supine adult are 7-15 mmHg, if it increases beyond 20 mmHg it can cause disability or prove fatal. The sensor is currently being made in large quantities for biocompatibility check and clinical testing.

Neurodegenerative diseases

The Centre for Brain Research (CBR), funded by the Pratiksha Trust, has begun a long-term study on 10,000 people in Karnataka. They will be looking at biomarkers that can provide insights on how Alzheimer's or Parkinson's disease arises. Through this, they aim to identify risks and protective factors for dementia. And through their Genome India Initiative, they will perform whole genome sequencing of several thousand people to better understand the underlying genetic basis of such diseases.

Prime Minister Narendra Modi inaugurating the Centre for Brain Research in 2015



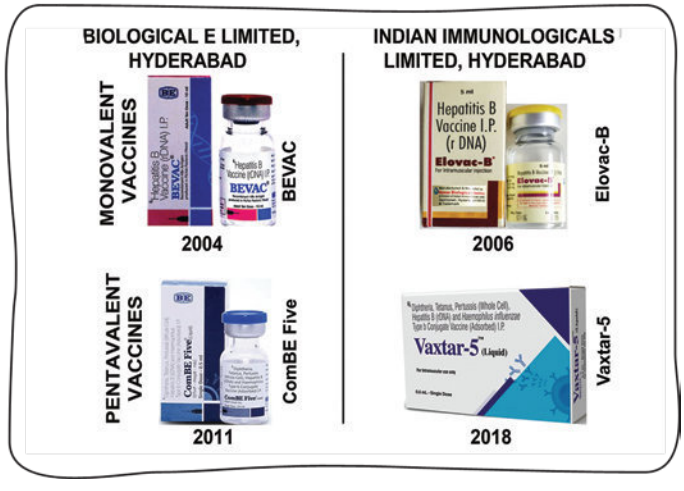
Testicular cell death in Endosulfan-treated testes seen as brown spots

Effects of pesticide overuse

Endosulfan is a commonly used organochlorine pesticide in India and other developing countries. Recently, using a sub-lethal dose of Endosulfan in mice model systems, IISc's researchers have demonstrated how it mediates testicular toxicity and male infertility.

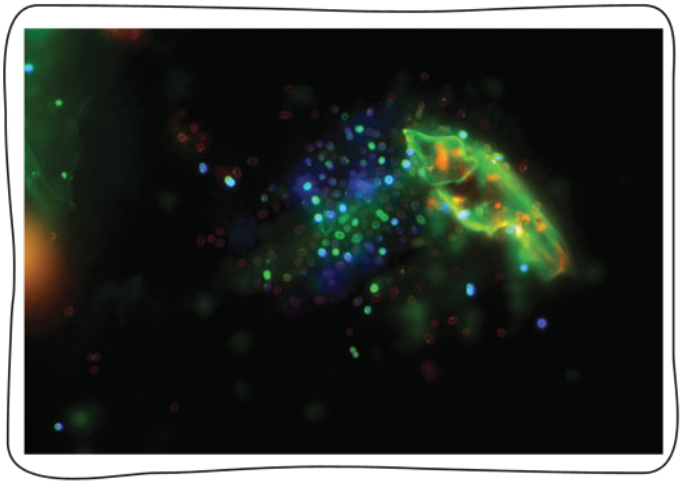
Indigenous vaccines to tackle hepatitis B infection

An indigenous, recombinant Pichia pastoris-based Hepatitis B vaccine was developed at IISc under the MHRD's Technology Development Mission. The technology involved was transferred to two companies in Hyderabad, India. Based on the recombinant yeast strain obtained from IISc, these companies have launched and marketed several monovalent and pentavalent vaccines such as BEVAC, Elovac-B, ComBE Five and Vaxtar-5. Over 100 million doses of these vaccines have been sold so far.



Insights on the inhibition of hepatitis C virus

IISc scientists have developed antivirals that attack various stages of the Hepatitis C virus lifecycle, including ways to prevent the virus from entering cells and, if it has entered, inhibit translation of the virus' RNA. They have shown that extracts from pomegranate and a type of amla have compounds which inhibit virus replication.



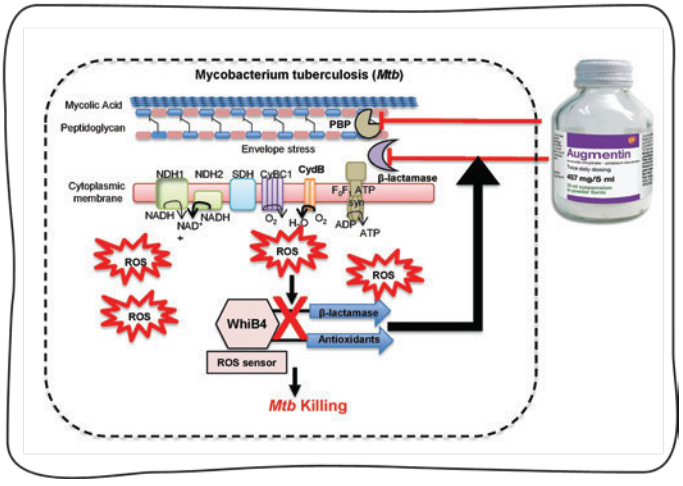
Confocal microscopy image of a cluster of A. baumannii cells. Omega76 is colored green, and is seen interacting with the membrane

Fighting drug-resistant bacteria

The rise of drug resistance in bacteria is a public health crisis, even as scientists struggle to develop new antibiotics. A bacterium called Acinetobacter baumannii tops the World Health Organization's list of threats that urgently need new antibiotics, because it can quickly develop resistance and survive for long periods in hospitals, causing infections. Using a bioinformatics approach, IISc researchers have designed a new short protein (peptide) called Omega76 that can kill it by breaking down its cell membrane. Infected mice treated with Omega76 had much better survival rates. Mice given high doses of Omega76 did not experience any toxic effects. Because it is both safe and effective, it is a promising candidate for developing new antibiotics.

Making TB drugs more powerful

Mycobacterium tuberculosis (Mtb) is resistant to the most commonly used antibiotic: Betalactam (e.g., Augmentin). The bacterium produces Beta-lactamase enzyme that destroys Beta-lactams, and also several antioxidants, which protect Mtb from toxic reactive oxygen species (ROS). Now researchers have identified a protein WhiB4 in Mtb, one that inhibits Beta-lactamase and antioxidant production to reverse drug resistance and promote killing by Augmentin.



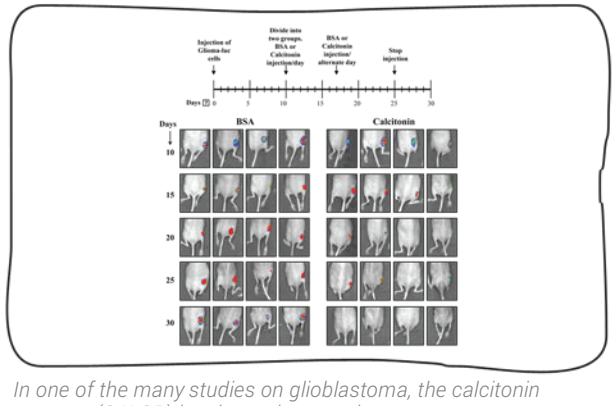
How a novel protein can make a commonly used antibiotic to treat TB more effectively

Cancer

Cancer is a name given to a suite of diseases that can occur in different parts of the body in which some of the body's cells divide without stopping and spread into neighbouring tissues. They are caused by changes to genes that control how our cells grow and divide. These genetic changes can be inherited, but more often than not they arise during an individual's lifetime as a result of errors that occur when cells divide or because of damage to DNA due to certain environmental exposures. Because cancer is a collection of diseases that can occur in different tissues with different triggers, IISc's researchers are carrying out studies to understand and treat these diseases using multiple approaches.

Glioblastoma

Scientists from IISc have, in recent years, attempted to understand the development of tumours of the central nervous system, in particular glioblastoma, the most common malignant primary brain tumour in adults. They are doing this by mapping the molecular mechanisms underlying the progress of glioblastoma, and also developing biomarkers for better grading, prognosis and treatment.

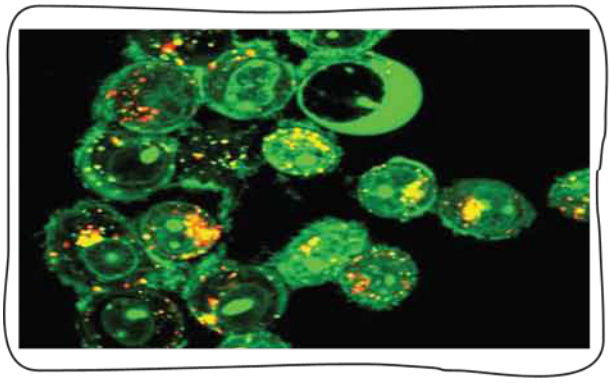


In one of the many studies on glioblastoma, the calcitonin receptor (CALCR) has been shown to be a tumour suppressor

Research has revealed how inhibiting DNA repair mechanisms with the help of a molecule called SCR7 can kill cancer cells

Disrupting DNA repair pathways of cancer cells

Cancer researchers at IISc have identified a molecule called SCR7 which inhibits one of the major DNA repair pathways, leading to accumulation of DNA breaks in cancer cells. In mouse models, SCR7 has been shown to prevent progression of tumour and reduce the dose of radiation required during radiotherapy by 50-75%.



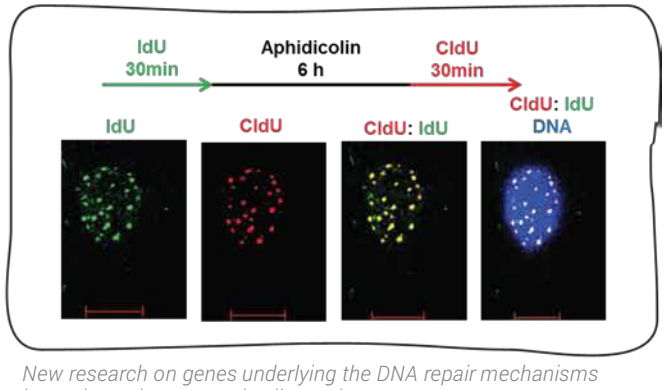
Acridine orange stained acidic vesicles (red/orange puncta) in breast cancer cells showing autophagy

Combating metastasis

Metastasis (spreading of cancer to different parts of the body) is a primary cause of cancer-related death, and yet there are no ways of preventing or treating it because the molecular mechanisms of metastasis are poorly understood. But research from IISc has shown that a double negative feedback between two proteins called AMPK and AKT enables cell survival, a finding with implications for combating the spread of cancer.

Understanding how normal cells become cancerous

DNA in our cells is susceptible to various types of damage from spontaneously-generated free radicals, or by chemicals or radiation. Defects in repair mechanisms are known to cause various genetic diseases as well as cancer. Studies on the genes underlying this process have revealed how normal cells can become cancerous, thus opening the doors for the development of novel strategies to treat cancer.



New research on genes underlying the DNA repair mechanisms have shown how normal cells can become cancerous

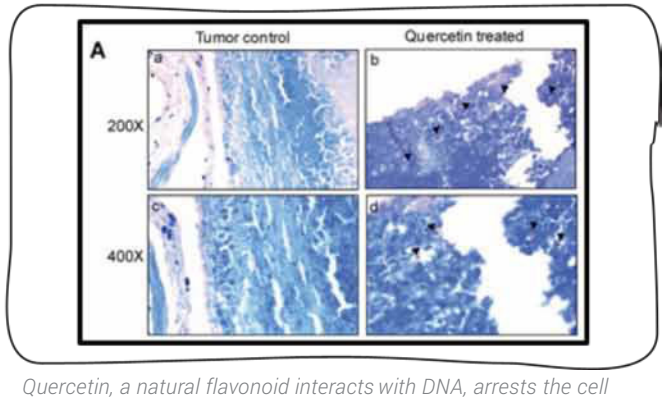
miR-155 inhibition suppresses tumourigenicity in vivo

microRNA as a potential target for oral cancer treatment

In India, oral cancer is the leading cancer in males and the third most common malignancy in females. Recent studies have identified the contribution of microRNAs to the multi-step process of this tumour formation. Researchers at IISc have now demonstrated that microRNA-155 negatively regulates the expression of a tumour suppressor gene called CDC73. They have shown that blocking microRNA-155 helps increase the CDC73 expression levels. This microRNA is therefore a potential therapeutic target for oral cancer.

Screening of chemical compounds for anti-cancer properties

Another area of research at IISc is the screening of various chemically synthesised and naturally derived compounds for anti-cancer properties. The more potent compounds are further tested in vivo in mice models bearing various tumours. Based on results of these studies, scientists aim to design compounds which are target specific proteins that are upregulated in cancers.



Quercetin, a natural flavonoid interacts with DNA, arrests the cell cycle and causes the tumour to regress

Environment and Sustainability

01 Conservation

02 Climate Change

03 Water

04 Energy

Conservation

India is a country rich in biological diversity. But with increasing human population and the push for rapid economic development, our biological wealth is in peril. In order to preserve our remaining wilderness, it is imperative that we as a society find creative ways to prioritise conservation of species, habitats, and ecosystems, and use natural resources sustainably. Towards this end, researchers from IISc have been at the forefront of investigating and addressing challenges related to conservation using foundational principles of ecology and evolution for over three decades now. Their field work extends from the Himalaya to the Western Ghats to the Andaman and Nicobar islands, ranging from terrestrial habitats like high altitude savannas to marine habitats like coral reefs.

Impact of anthropogenic activities

A significant area of research in this field attempts to understand the effects of human-induced disturbances – including climate change, urbanisation, habitat fragmentation, and fire – on the behaviour, physiology and population dynamics of plants and animals. Ecologists are also using mathematical models to predict how resilient ecosystems, like forests and grasslands, are to pressures from anthropogenic activities.

Though wind farms produce relatively clean energy, they have been shown to reduce the number and activity of predatory birds, which in turn has a domino effect on other animals

As a result of habitat loss and fragmentation, elephants and humans are coming into increasing conflict

Human-wildlife conflict

With increasing human population and land-use transformation, conflict between humans and the animals they share space with has also been increasing. Biologists studying endangered animals, such as Asian elephants, sea turtles and blackbuck, are developing strategies to minimise and mitigate human-wildlife conflict.

A device to scan a herbarium sheet. The image will be fed to a digital database of plants

Documenting and digitising knowledge

IISc is developing a Biodiversity Information Database System. The outcome of this project would be a digital database for Indian biota – from microbes to elephants – with information on morphology, behaviour, acoustics, phylogenetic history, biogeography, spatial distribution, breeding biology, identification keys, habitats, and more. As part of this initiative, a digital database of plants of peninsular India has been launched recently.

Policy

Faculty from IISc have contributed to conservation policy and implementation at all levels of governance – both regional (National Green Tribunal Committee for Bengaluru wetlands, Karnataka State Pollution Board, and Karnataka State Wildlife Board) and national (National Board for Wildlife, National Wildlife Action Plan, among other bodies). They are also influencing policy at the international level through their roles in organisations like the Inter-governmental Panel on Climate Change and Global Environment Facility.

A glacier melting in the Himalaya. IISc is influencing environmental policy at multiple levels of governance and also at the international level through its role in the IPCC

SCCS held annually at IISc brings together young conservation scientists from India and other developing countries

Outreach

Conservation science is actively promoted through training, capacity building, and communication. IISc co-organises and hosts the Student Conference on Conservation Science annually, which brings together young researchers from the field. With its considerable collection of flora and fauna, IISc plans to establish a Natural History Museum to inform the general public about India's rich biodiversity. Scientists from IISc have also written several popular science books on a wide variety of topics related to conservation.

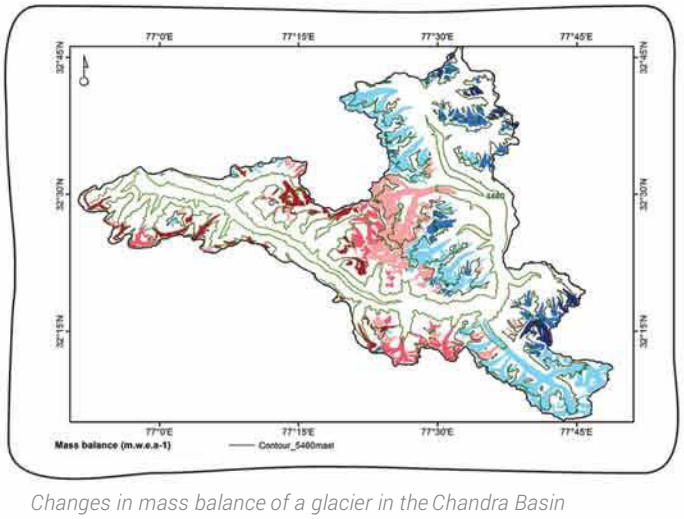
Climate Change

IISc aims to understand climate variability and climate change, and its impact on the environment. It conducts outreach to create awareness among people and policy makers about climate change and its consequences, and identifies technologies to mitigate climate change in collaboration with entrepreneurs and different engineering departments at the Institute.

Monsoon and rainfall

In December 2015, Chennai received a record-breaking amount of rain that caused floods in which over 250 people were killed. A study of the weather phenomenon that caused the extreme rainfall led to a computer simulation of the event to understand the underlying mechanism. As a result, extreme rainfall over the coastal zone can now be predicted and managed with greater confidence. Research at IISc also looks at how factors like irrigation, aerosols and air pollution affect the Indian monsoon. One study found that the reduction of aerosol emissions, not just in India but in the US and Europe as well, would lead to an increase in monsoon rainfall.

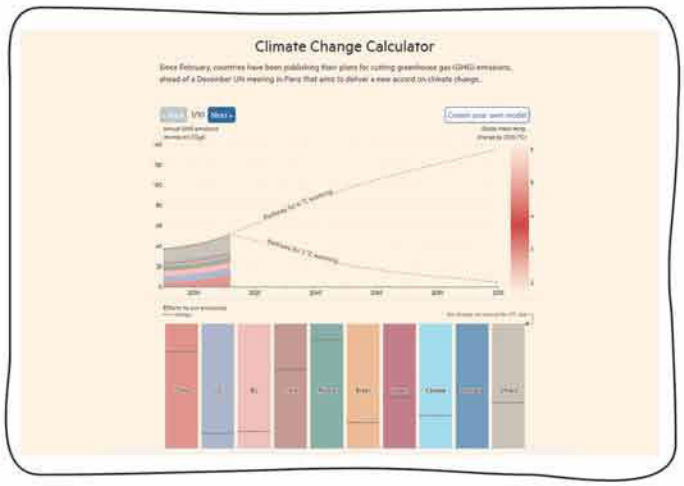
Research shows that irrigation influences rainfall during the monsoon, and increases the greenhouse effect as surface evaporation leads to more water vapour in the atmosphere



Changes in mass balance of a glacier in the Chandra Basin

Glaciers

Glaciers in the Himalaya have been melting because of global warming. Satellite data and local data on temperature and snowfall have been used to accurately measure the decline of ice in glaciers in the Chandra Basin in Himachal Pradesh. This helps to understand how much water is being lost, and to come up with solutions to mitigate water shortage in nearby areas. As the glaciers melt, they form glacial lakes, which can pose a flood threat to people living downstream of the lake. IISc researchers are studying whether they can be a hazard, which would allow for systems to mitigate flooding to be put in place. This has successfully been done at the Lhonak Glacier in Sikkim.



Climate change calculator

An interactive climate change calculator from IISc reveals the path we can take to ensure that global temperatures are kept in check. For instance, it can predict what the global temperature increase is likely to be in 2100 if all countries live up to the sustainability pledges they have made. The award-winning calculator is publicly available and aimed at anyone interested in climate action, especially policy makers and world leaders.

Future earth

IISc is home to the South Asia regional hub of Future Earth, an international programme on global environmental change and sustainability supported by agencies including UNESCO and the United Nations Environment Programme. One of its core activities is the Sustainable Water Future Programme, better known as Water Future, whose mission is to offer solutions to the world's water problems based on interdisciplinary science.

Helping in policymaking, assessing water governance, building capacity to reduce risk, and monitoring water resource challenges are some of Water Future's aims

Water

With an impending water crisis in the country, we need to manage and conserve water more efficiently. Increasing population and the related increase in industrial and agricultural activities have led to dwindling freshwater supply. The problem is further compounded by uncertainties introduced by climate change, increasing contamination of water in the rivers and in the ground, the depleting groundwater table, ill-managed urban water systems, and increased frequency of urban and riverine floods. However, new multidisciplinary approaches adopted by researchers in institutions like IISc to deal with the challenges related to water offer hope. These include recycling of wastewater, desalination of seawater, improvements in water use efficiency, use of new scientific techniques such as remote sensing, the use of stable and radioisotopes, sensor technologies and hydraulic and hydrologic modelling.

Urban flood model

IISc has developed an Urban Flood Model for Bangalore, which is capable of simulating hydrologic and hydraulic behaviour of storm water in existing and natural drainage systems using high resolution terrain data. This project also aims to create a database of terrain data for the city using LiDAR technology and flow data obtained with the help of a high density sensor network.

Soil moisture

A pilot project on development of a cloud-based decision support system utilises a framework of microwave satellite observations (soil moisture and crop variables) and a large mesh of IoT enabled soil sensors (moisture) to provide smart solutions towards irrigation scheduling and irrigation water management. Researchers are also combining active and passive microwave satellite data to estimate soil moisture more accurately in the district of Uttara Kannada.

Water supply

Experts from multiple disciplines in IISc in collaboration with the Bangalore Water Supply and Sewerage Board (BWSSB), and companies that deliver services to BWSSB, are involved in a project to address challenges in providing potable water in sufficient quantity at adequate pressure and acceptable quality, besides studying how water distribution can be made more equitable. The project incorporates IoT technologies of sensing and communications, advanced models of hydraulics and algorithms for controls, optimisation and scheduling. The data gathered is analysed to understand the supply-demand pattern, adequacy of infrastructure, and issues of quality.

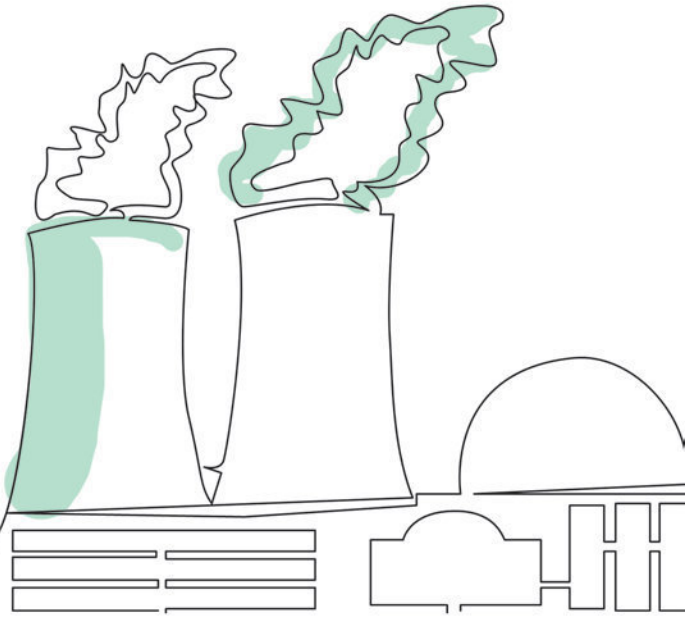
Water management

Several projects at IISc are focused on how to better manage our water resources. Examples include: coupled human and natural systems environment for water management under uncertainty in the Indo-Gangetic Plain, upscaling catchment processes for sustainable water management in peninsular India, and impact assessment of climate and land use/landcover changes on the hydrology and storm water drain network of Bangalore urban area.

Energy

The epic challenge of the 21st century is filling the gap between energy supply and demand with clean, reliable and inexpensive energy. While wind, solar and biofuels appear to be among the most promising, significant breakthroughs are still required to make them viable sources of future energy supply. How do we effectively transport this energy from remote areas to big cities? How can we efficiently store energy generated during the day for use in homes at night? The challenge will be to bridge these supply limitations with a 24-hour demand for electricity. This means making our electricity grid more efficient and streamlined while developing storage systems to allow wind and solar energy to be saved for times of peak use.

In the past few years, IISc has taken up socially-relevant energy-related research in line with several national missions announced by the Government of India. The Institute, through its research, intends to contribute towards advancing technological developments in the energy sector and facilitate framing policies to reduce global energy and carbon footprint.



Clean coal research and development

The Department of Science and Technology (DST), Govt. of India, has set up the National Centre for Clean Coal Research and Development (NCCCR&D) as a national level consortium led by IISc. Consortium partners include IIT Kharagpur, IIT Madras, IIT Guwahati, IIT Bombay and IIT Hyderabad. The primary goal of the consortium project is to address several critical R&D challenges towards the development of clean coal technologies, in tandem with developing supercritical power plant technologies, both at the system level as well as in materials development.

A supercritical CO_2 Brayton test loop

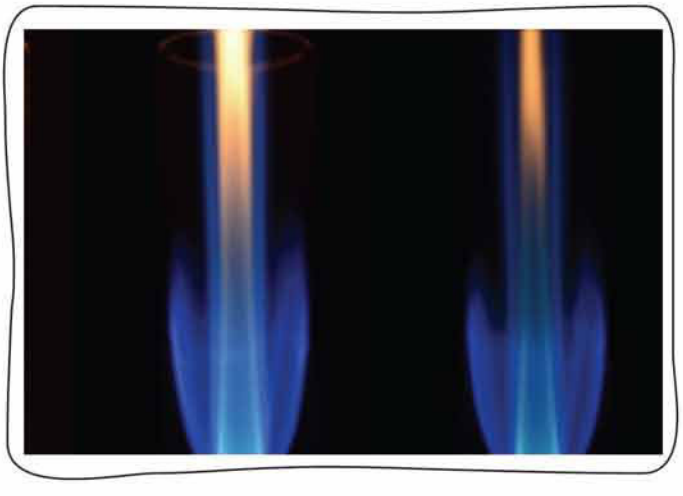
Supercritical CO_2-based Brayton cycle test bed

Supercritical carbon dioxide-based power generation offers a highly efficient alternative to conventional steam-based power plants. IISc has developed India's first supercritical carbon dioxide (S-CO_2) based Brayton cycle test bed. It is designed to generate the necessary data for future development of scaled up S-CO_2 power plants, which would require overcoming several technological challenges: developing critical components such as the turbine, compressor and heat exchangers that can work at the desired pressure and temperature ranges, and using materials that can withstand these conditions.

Solar energy research

Co-led by IISc and the National Renewable Energy Laboratory (NREL), US, a major consortium called Solar Energy Research Institute for India and the United States (SERIIUS) was launched under the US-India Joint Clean Energy Research and Development Center (JCERDC) programme. This initiative focused on accelerating the development of solar electric technologies, especially photovoltaics (PV) and concentrated solar power (CSP). The consortium had 34 partners from India and the US, comprising academic institutions, R&D labs and industries. The first phase of SERIIUS was during 2012-2018, and as a continuation of the India-US collaboration in energy, a new clean energy initiative is under consideration as part of the JCERDC programme.

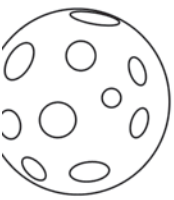
A photovoltaic test bed at Challakere



Combustion research and development

IISc and IIT Madras have been selected to host the National Centre for Combustion Research & Development (NCCRD) funded by the Department of Science and Technology (DST), Government of India. Several advanced and state-of-the-art facilities in combustion research have been established, to address grand challenges in the area of combustion. Several companies and R&D organisations from India and abroad from the automotive, aerospace, thermal power, and fire protection industries are collaborating with NCCRD.

Emerging Technologies



01
Aerospace

02
Nanotechnology

03
Cryptography

Aerospace

IISc's aerospace engineers collaborate with their counterparts in agencies such as Defense Research and Development Organisation (DRDO), Indian Space Research Organisation (ISRO), the Department of Science and Technology (DST), among others, contributing significantly to various projects of national importance. But some of its work in this area also finds applications in the following:

Shockwave technology used for water purification, animal husbandry and healthcare

Shockwave technology, which was developed for military and space applications, is now being used by start-ups created by IISc faculty members to purify water, inseminate cattle, investigate brain injuries, remove brain tumours and enable needle-less drug delivery, among other uses.

The Reddy Tube, a shock tube developed by Super-Wave Technologies

Drones are being used for a number of purposes, including mapping and surveillance

Drones used in agriculture, mapping and healthcare services

Drones or unmanned aerial vehicles (UAVs) are being developed by aerospace researchers at IISc for use in crop assessment, using cameras to identify the amount of crop yield. They are also used for seeding and reforestation. Drones with cameras are used for mapping and surveillance. And to serve the needs of hospitals that require speedy delivery of organs for transplants, the researchers have been working on drones that carry organs directly to the desired location, eliminating the delays usually created by dispatching organs by road through traffic.

Nanotechnology

Nanotechnology at IISc aims to meet national objectives for self-reliance while also doing cutting-edge research. Low-cost, low-power, inexpensive devices are being developed for various uses without compromising on frontier research that could create new industries and propel economic growth.

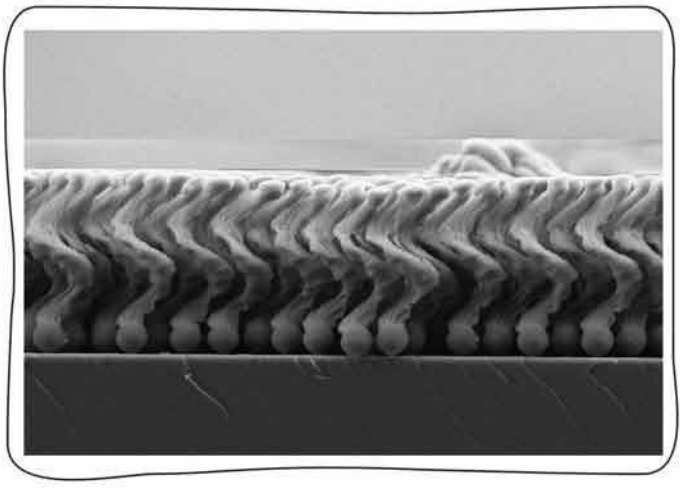
The Envirobat air quality monitoring device being field tested on the IISc campus

Devices to detect pollution levels

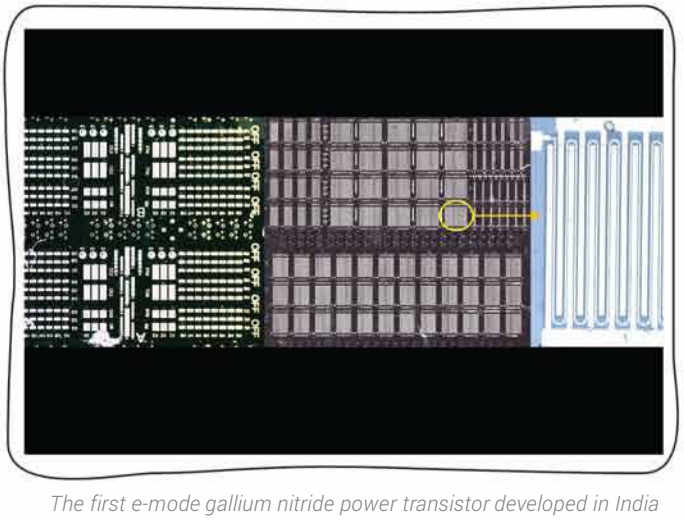
Air quality measured in select locations in a city does not give local data, a problem that can be tackled with low-power, low-cost monitoring devices, such as Envirobat, a device developed at IISc that can measure the CO, CO_2, SO_2, NO_2, O_3 levels, along with temperature and humidity, and wirelessly transmit the data. Many such devices can be connected in a network to map the air quality of an entire city.

Nanoswimmers for drug delivery

Maneuvering nanoscale objects non-invasively in human blood using small rotating magnetic fields, in a way that mimics the shapes and swimming methods of microorganisms, could lead to various biomedical applications such as drug delivery. Such maneuvering has been demonstrated with a ferromagnetic helical nanostructure that is propelled by its corkscrew motion.



Array of helical nanoswimmers of length approximately 2.5 microns



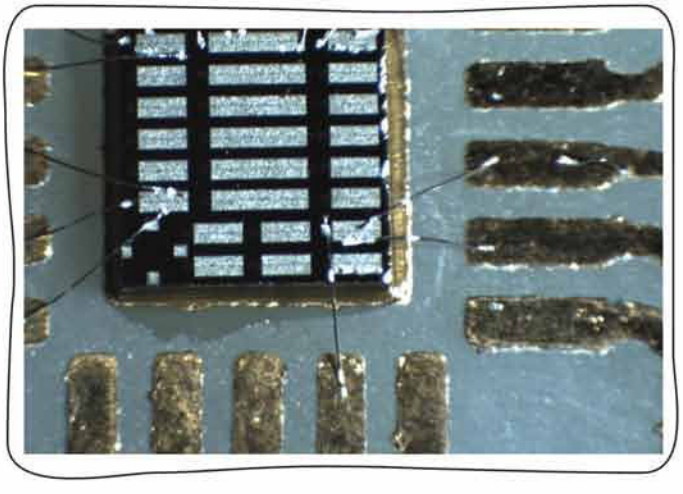
The first e-mode gallium nitride power transistor developed in India

Gallium Nitride for electronics

Gallium Nitride (GaN) is thought to be the future of power and radio-frequency electronics, with applications in the consumer and strategic sectors. IISc has taken an initiative to ensure that India has a headstart in GaN electronics -- it is incubating a company and has submitted a Detailed Project Report to MeitY and NITI Aayog for a commercial GaN foundry.

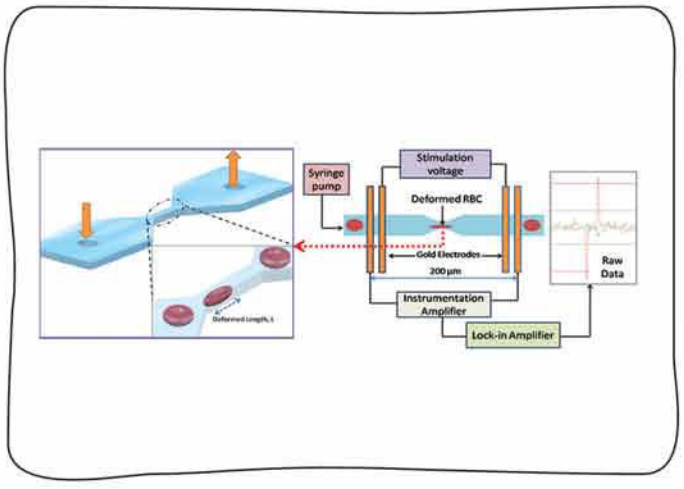
Solar cells beyond silicon

Research on solar cells at IISc looks beyond the current silicon technology -- whose efficiency and fabrications cost have limited room for improvement -- to develop newer technologies such as perovskite-like and silicon/perovskite tandem cells, and GaAs solar panels on a steel substrate.



Biomicrofluidics for research and diagnosis

Cells respond to changes in their environment by changing their physiology. This manifests as a change in their mechanical properties which can be detected with an arcade of advanced characterization techniques combined with cell biology. IISc is developing a high throughput biomicrofluidic device that can act as a research tool for biologists and a diagnostic tool for various diseases.



A schematic showing the working of the biomicrofluidic device

Low-cost moisture sensor

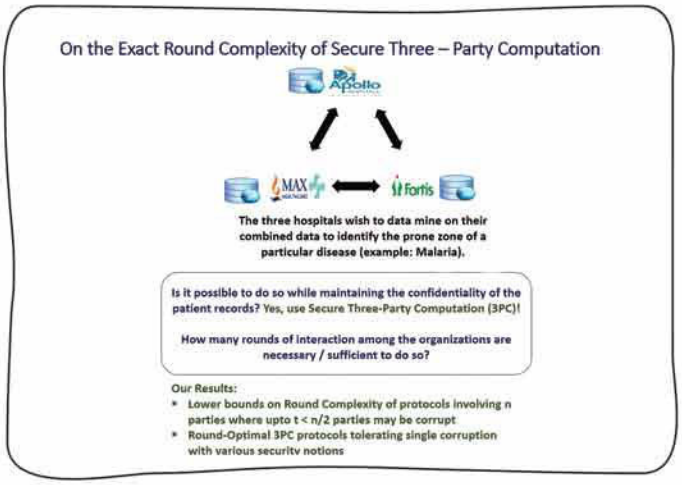
A low-cost, low-power soil moisture sensor powered by a solar cell array has been developed at IISc. The sensor can test different kinds of soil and accurately measure moisture content up to 30%, which is above the saturation limit for most soils. It has been calibrated against white clay and tested on red soil, and is currently undergoing field trials.

Cryptography and CyberSecurity

Cryptography is the science of protecting sensitive digital information and enables secure communications, in this age of increasing data theft. IISc has been chosen as Anchor Institution for Karnataka State Centre of Excellence (CoE) in cyber security. As an academic partner for this centre, about 20 scientists from IISc's Security Research Group will interact with Bangalore startups, help in capacity building and outreach, while also raising awareness on cyber security issues. The group also works on several projects related to strengthening data security.

Security for hardware

Though personal computing devices, such as phones, tablets, glasses, watches, assistive health monitors and other embedded devices have become an integral part of our daily lives, there are issues. They can be misused in enterprise settings or federal institutions. Scientists have come up with a method to control the use of smart devices in such restricted environments, thereby preventing data thefts and misuse.



Security for collaborative work

To support secure collaborations, such as those between different hospitals studying prevalence of a particular disease, researchers from IISc have come up with a protocol that enables hospitals to share patient data securely. The protocol provides solutions -- how prevalent a particular disease is -- while also ensuring that the collaborators will have no access to individual patient records.

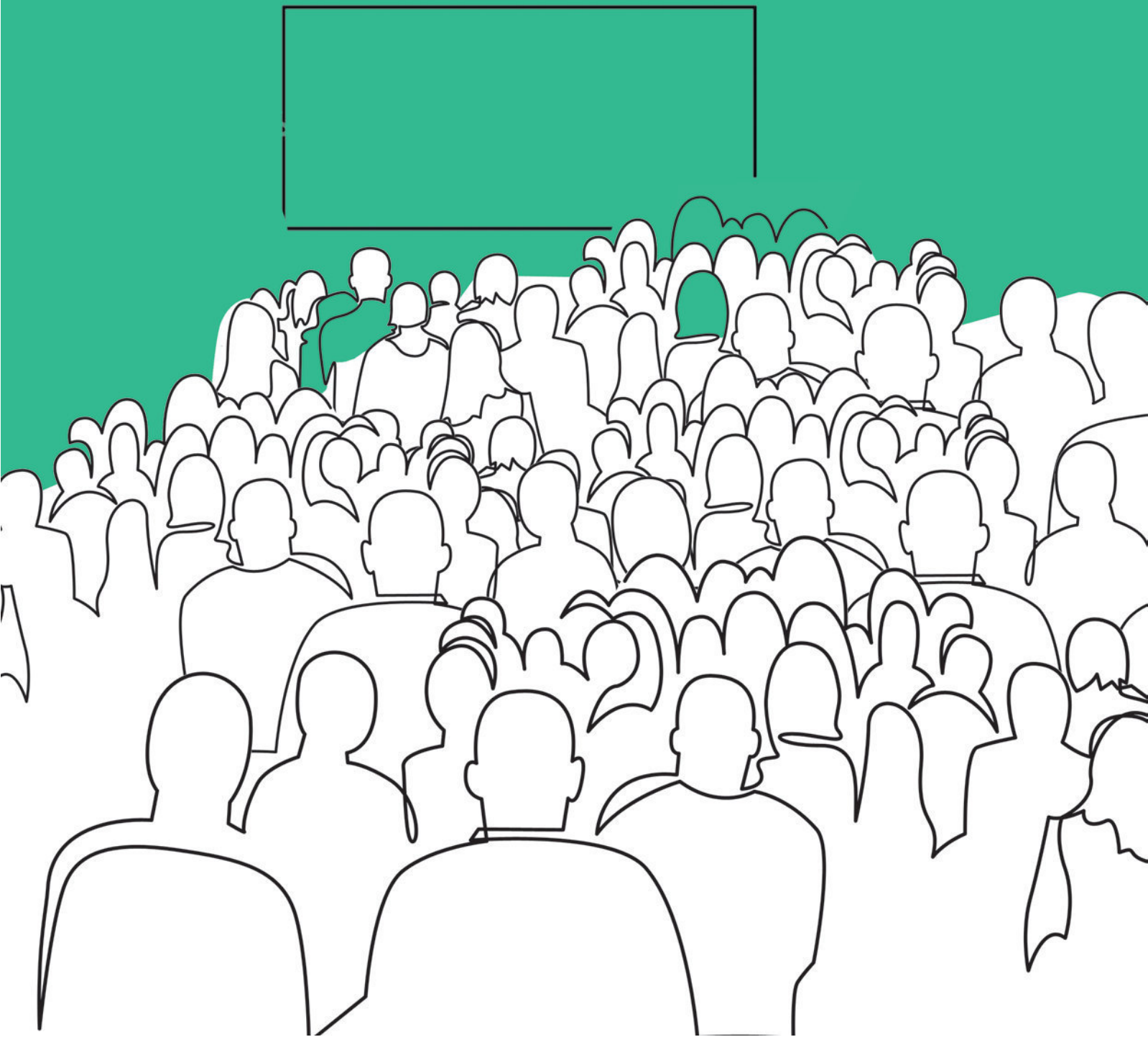
Security for Smart cities

IISc is collaborating with the Ministry of Housing and Urban Affairs to facilitate their Smart City Mission. To harness the full potential of the enormous data generated in smart cities, researchers from IISc are creating a software platform called India Urban Data Exchange (IUDX). Since this process will involve collecting and analysing peoples' private information, the team will study privacy concerns for smart cities and provide space for secure data collection and analysis.

Aadhaar

IISc is also working on privacy concerns associated with Aadhaar. The Unique Identification Authority of India (UIDAI) had recently rolled out a new safety feature – Virtual Identity Number (VID) – through which users can generate a unique 16-digit number each time they deal with a service provider such as a bank or a telecom operator. Though this ensures greater privacy, the onus is on the user to manage and remember each VID. To deal with this problem, IISc scientists have developed a security or privacy model, which while providing an equivalent to VIDs, also automatically generates "VIDs" and require no management from its users.

Reaching Out



01
Public Engagement

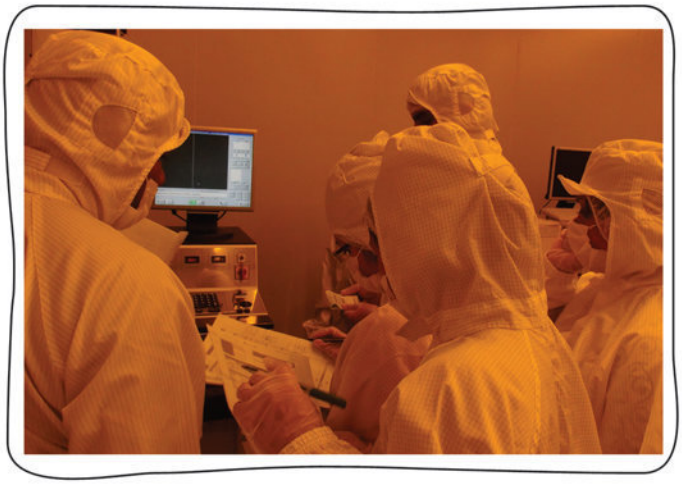
02
Startups

Public Engagement

In addition to its mandate of research and higher education, IISc has been proactive in engaging with the public to disseminate knowledge and raise awareness on fundamental issues. It organizes regular training programs and workshops for local and national communities, as well as activities for school and college students to instill the spark of scientific curiosity.

Training rural teachers in science and mathematics

In 2009, IISc started a unique programme at its Challakere campus to train rural science and mathematics teachers. Built on the idea of teaching scientific concepts through experiments, this residential programme has trained more than 11,000 teachers from schools and colleges across the country. Following the Prime Minister's visit to IISc in 2015, the training centre was declared a Centre of Excellence under the Pandit Madan Mohan Malviya National Mission on Teachers and Teaching. The success of this initiative has also inspired the establishment of a new HAL-IISc Skill Development Centre in the same campus.



National capacity building in Nanoelectronics

Launched in 2008, the Indian Nanoelectronics Users' Program (INUP) is a unique initiative aimed at accelerating research and development in nanoelectronics in India. It not only aims to train researchers in using advanced equipment and facilities, but also help them kick-start new research projects and collaborations. The three-tier programme has trained more than 4,200 researchers from 450 institutions across India. It has also been offered to researchers in India's neighbouring countries such as Sri Lanka, Bangladesh, Myanmar, Maldives, Vietnam and Kazakhstan, through the Ministry of External Affairs.

Showcasing science and technology for the general public

An extremely popular annual event, Open Day is organised by IISc to welcome students and the general public into its campus to catch a glimpse of the various research activities and facilities. Attendees have the opportunity to visit the departments and centres, tour state-of-the-art labs, and interact with faculty members and students. Open Day features popular lectures, experimental demos, poster presentations, quiz contests, scientific competitions and exhibitions. A special "Kids Zone" with demos and experiments is a popular attraction for young school children.

Raising awareness about climate change

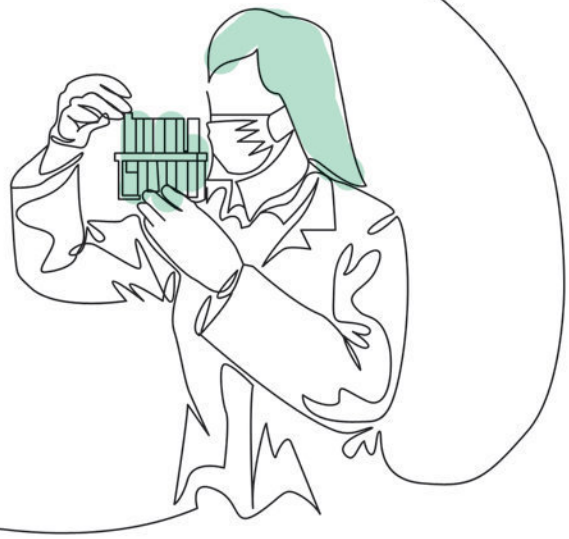
An annual Climate and Environment Science Quiz is organized at IISc for science and engineering college students, in order to raise awareness about climate change and mitigation mechanisms. While the focus of the quiz is climate change, it also includes topics such as weather, atmosphere and oceans, and renewable energy. Hundreds of students from colleges across the city participate each year. The quiz aims to strengthen the students' knowledge and awareness of climate change issues, and inspire them to pursue careers in related areas.

Preserving scientific history

Set up in 2008, IISc's archives houses a valuable collection of letters, photographs, memos, publications and other valuable documents. IISc was set up 110 years ago when scientific research was non-existent in India and has since established itself as a premier institute for science and technology. It has also seeded several other science institutes across the country. The documents in the archives tell several stories about modern science in India and the people behind them. Efforts are currently underway to conserve old documents as well as digitise the collection so that it can be accessed by students, researchers, historians, and the general public.

Startups

In the last few decades, IISc has nurtured several deep science startups that seek to revolutionize the way science and technology is applied for social benefit. Many IISc faculty members and alumni have established companies that develop solutions for healthcare, agriculture, space technology, renewable energy and mobility. Products from several of these startups have already penetrated their markets. Here are a few such start-ups.



PathShodh

PathShodh has developed a first-of-its-kind, multi-analyte point-of-care diagnostic device. This compact, hand-held unit is capable of performing tests for multiple analytes linked to chronic diseases including diabetes and its complications, anemia, malnutrition, and kidney and liver diseases. In partnership with the Tata Trusts, PathShodh's product has already been deployed for rural health screening as part of a rural telemedicine project serving several villages across the country.

Openwater

Openwater has developed a water filtration system that uses no membranes or chemicals and has almost 0% wastage. It applies an electro-physical approach to remove impurities in water, including fluorides, arsenic and nitrates. Small communities and industries can use this unit to treat their water locally, and reduce the strain on government-run centralized systems. Portable units can also be deployed for disaster-hit areas. Several field trials have successfully been conducted with groundwater and industrial wastewater.

Sickle innovations

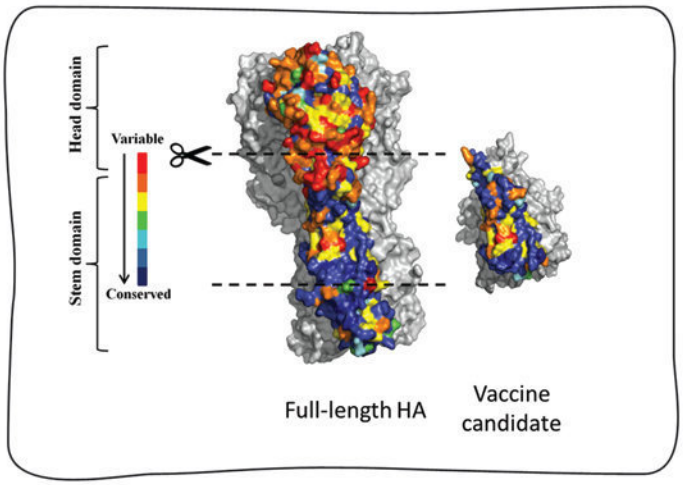
Small and medium-sized farmers need affordable automation to boost productivity and earnings. Sickle Innovations aims to improve conventional farming practices through design intervention. The startup works closely with farming communities to offer unique solutions based on their requirements. It has developed devices for fruit harvesting, smart drying solutions, and grading machines that sort fruits and vegetables using image processing and machine learning.

Astrome

Astrome is a technology startup with the goal of streaming internet to both rural and urban areas using an army of high-capacity satellites. These satellites are fitted with next-generation wireless communication technology that will make space internet infrastructure cost-effective. The company seeks to provide location-free broadband internet connection to consumers and businesses in all developing countries.

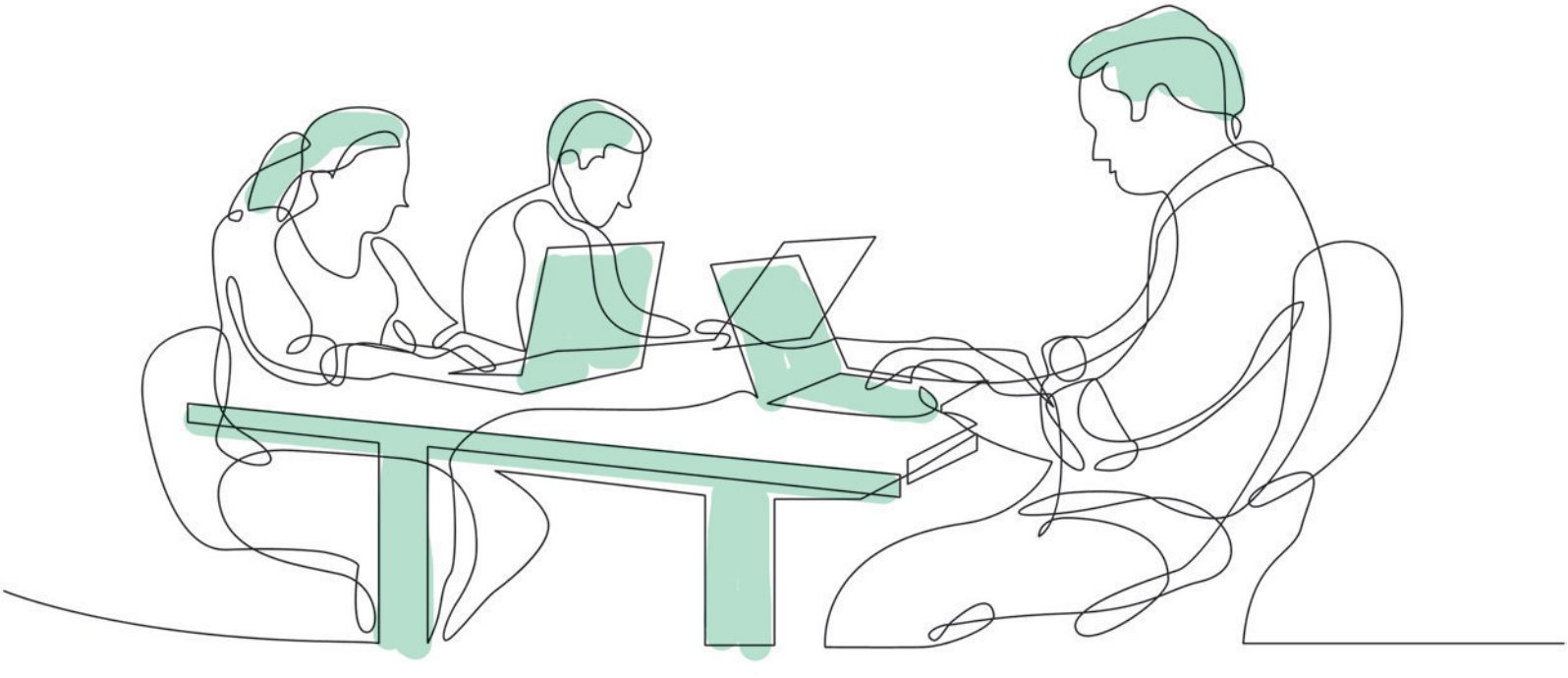
Mimyk

Mimyk aims to design, patent and market medical simulators to train doctors in medical procedures. It has developed an endoscopy simulator in collaboration with gastroenterology surgeons at the Asian Institute of Gastroenterology, Hyderabad. This simulator combines state-of-the-art graphical visualization and real-time computational models with haptics to enable rapid and efficient training of doctors. The technology can also be extended for many other interventional procedures such as colonoscopy, bronchoscopy, and angio-training.



Mynvax

Mynvax focuses on using experimental and computational protein design techniques to develop novel and improved vaccines for infectious diseases such as influenza. Current influenza vaccines have limited efficacy due to several factors. They typically focus on the variable head domain of a protein on the virus surface. Mynvax, on the other hand, focuses on developing antibodies against the conserved stem domain. The company seeks to develop universal human and avian influenza vaccines, as well as rapidly producible seasonal influenza vaccines.



OFFICE OF COMMUNICATIONS
Indian Institute of Science, Bangalore 560 012

Email: office.apc@iisc.ac.in | Phone: 91-080-2293 2066