“The fight against the coronavirus pandemic is an example of India's self-reliance. India's strive to achieve self-reliance cannot be possible without the appropriate use of science and technology for economic development and societal benefit.”

Dr Harsh Vardhan  
Union Minister of Science & Technology
“When WHO declared COVID-19 a pandemic in January, it was clear to DBT that as a science agency, which is deeply engaged in the biotechnology sector, we have to come forward with all stakeholders to device a collective strategy with the Government of India on how is science and technology going to respond to this huge challenge. The fight against pandemic is being fought by the scientists and the health workers.”

Dr Renu Swarup
Secretary DBT
72nd Republic Day
Parade Tableau

DBT’s tableau showcased the strength and efforts of biotechnology sector in responding rapidly through the development of vaccine and diagnostics for COVID-19.

“भारत को कोरोना-मुक्त बनाएंगे आविष्कार हम करते हैं चुनौतियों से लड़ते हैं देश की है आन हम देश की हैं शान”
COVID-19
The Virus

Testing, Treatment, Prevention
COVID-19 RESEARCH CONSORTIUM

Develop biomedical tools for prevention, identification and treatment to combat the epidemic of COVID-19 through considering a holistic approach addressing critical roadblocks.

**TESTING**
- Development of molecular and serological tests
- Development of novel diagnostics
- Testing Hubs
- Mobile I-Lab

**TREATMENT**
- Plasma therapy
- Monoclonal antibodies
- Drug re-purposing efforts
- DBT-AYUSH Phyto-pharmaceuticals

**GENOMICS**
- PAN-India 1000 SARS-CoV-2 RNA genome sequencing successfully completed by DBT AI consortium
- Nasal microbiome study - Useful for epidemiological studies

**PREVENTION**
- BCG Trial
- Multiple vaccine platforms
- Assays and animal models
- Clinical Trial sites
- Immunoassay lab

**FACILITATING THE ECOSYSTEM**
- 5 COVID-19 Bio-repositories
- Indigenization of Resources
- Validation Centres
- Rapid Regulatory Framework

**OTHER INTERVENTIONS**
- Scaling up of manufacturing-ventilators, PPE, Screening and monitoring devices, disinfection and sterilization platforms
**SUPPORT UNDER COVID-19 RESEARCH CONSORTIUM**

<table>
<thead>
<tr>
<th>Area</th>
<th>Industry/Industry-Academia Collaborations</th>
<th>Scientists in Academia/Research institutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostics and Facilities for Scale-up</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>Therapeutics, Repurposing &amp; Supporting Ecosystem</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Vaccines &amp; Supporting Ecosystem</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Other Biomedical Interventions</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>76</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>
Mission COVID Suraksha - for research and development of Indian COVID-19 vaccines, was announced by the Hon'ble Finance Minister, on 12th November, 2020.

The Mission is being implemented at a total cost of Rs. 900 Cr. for 12 months by BIRAC, a PSU of DBT.

- Process and cell line development
- GMP manufacturing (Toxicology and clinical trials)
- Regulatory guidance
- Animal challenge facilities
- Immunoassay labs
- Clinical trial sites

Mission COVID Suraksha

GRANTS FOR CANDIDATE VACCINE PLATFORMS

FACILITIES

CAPABILITIES
MISSION COVID SURAKSHA

THE INDIAN COVID 19 VACCINE DEVELOPMENT MISSION

3 Requests for Expression of Interest (REOI) announced for accelerating Indian COVID-19 vaccine development

**REOI-1**

Accelerated development of 5-6 vaccine candidates that are closer to licensure and introduction in the market within the next 12 months.

**REOI-2**

Strengthening service facilities for conducting animal studies and immunological assays and make them available for COVID-19 vaccine developers.

**REOI-3**

Strengthening Capacities to conduct Clinical Trials for COVID-19 Vaccine Candidates.
<table>
<thead>
<tr>
<th>Candidate</th>
<th>Scale-up feasibility</th>
<th>Delivery feasibility</th>
<th>Company Experience</th>
<th>Existing Dose Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIIPL (ChAdOx1/ AZD 1222)</td>
<td>No non-replicating viral vector vaccine licensed in India</td>
<td>2 doses, IM, 2-8</td>
<td>WHO PQ, supplying vaccines globally – NRA by ANVISA, INVIMA, SAHPRA, PICS</td>
<td>100 million doses committed to GAVI</td>
</tr>
<tr>
<td>Biological E (protein subunit)</td>
<td>Established platform</td>
<td>2 doses, IM, 2-8</td>
<td>WHO PQ facilities, FDA, EMA approved DP facilities</td>
<td>Min. 21% of annual production to GAVI eligible countries and 49% to India</td>
</tr>
<tr>
<td>Bharat Biotech-ICMR/NIV</td>
<td>Need for BSL-3 facilities</td>
<td>2 doses, IM and ID</td>
<td>WHO PQ facilities; Have BSL-3 facilities</td>
<td>MoU with ICMR states priority is to provide vaccines to GoI</td>
</tr>
<tr>
<td>Zydus Cadila (DNA)</td>
<td>Time to manufacture a risk as facility under development; regulatory clearance needs clarity</td>
<td>Potential barriers to uptake due to ID admin. and/or need for delivery device</td>
<td>WHO PQ facilities</td>
<td>No</td>
</tr>
<tr>
<td>Gennova (Sa mRNA)</td>
<td>2 doses, IM, 2-8 degree C</td>
<td></td>
<td>First vaccine to be commercialised. Strong in biotherapeutics</td>
<td>No</td>
</tr>
<tr>
<td>Non-replicating viral vector</td>
<td>Preclinical</td>
<td>Phase 1</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>BHARAT BIOTECH/THOMAS JEFFERSON</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIIPL (CHADOX1/AZD 1222)*</td>
<td></td>
<td></td>
<td></td>
<td>Rolling review of CHMP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protein subunit</th>
<th>Preclinical</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOLOGICAL E/COLLABORATION</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inactivated virus</th>
<th>Preclinical</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHARAT BIOTECH-ICMR/NIV*</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Granted permission for restricted use in emergency situation
## R&D PIPELINE: OVERVIEW

<table>
<thead>
<tr>
<th>Replicating viral vector</th>
<th>AUROBINDO PHARMA</th>
<th>ZYDUS CADILA</th>
<th>BHARAT BIOTECH/FLUGEN</th>
<th>SIIPL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live attenuated</td>
<td>INDIAN IMMUNOLOGICALS</td>
<td>SIIPL/CODAGENIX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DNA Vaccine</td>
<td>ZYDUS CADILA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RNA Vaccine</td>
<td>GENNOVA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repurposing</td>
<td>SIIPL (RBCG)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Preclinical**
- **Phase 1**
- **Phase 2**
- **Phase 3**
Phase III Clinical Trials of Indian COVID vaccines in Neighbouring and Friendly Countries

- Advisory support to LMICs for executing Phase III clinical trials
- Immunogenicity assay testing of potential vaccine candidates

Trainings for Strengthening Clinical Research Capacity in Neighboring Countries

- E-course series of 4 Programs held from October-December 2020 completed
- Second edition of the E-course launched on 21st January 2021
- Well-received by participants from Nepal, Maldives, Bangladesh, Mauritius, Sri Lanka, Bhutan and Afghanistan
DEVELOPMENT OF HUMAN T-CELL ASSAYS AT DBT-NII

- Cutting-edge T-cell assays for measuring the vaccine efficacy.
- Assays for studying the T-cell correlates-of-protection in COVID-19 and defining the traits of immunological memory.

Indian population has very high levels of T cells developed during exposure to ‘Common Cold’ viruses, prior to the COVID-19 pandemic. These pre-existing T cells strongly respond to the COVID-19 virus.
(A.Ansari et.al., 2020. doi.org/10.1101/2020.11.16.20232967)

Indian patients recovered from mild COVID-19 disease have durable immunological memory in most important protective arms of protective immunity - T cells, B cells and antibodies. Such memory response should give protection against re-infection at least for few years.
(A.Ansari et.al., 2020. doi.org/10.1101/2020.11.16.20232967)
India’s engagement in ACT Accelerator

- Partnership with Ministry of External Affairs (MEA) and Indian Missions abroad for strengthening of clinical trial capacity in neighbouring countries.
- THSTI’s Bioassay laboratory supported under the Ind-CEPI Mission selected by as one of the 06 global network of laboratories for centralized assessment of COVID-19 Vaccines.
- DBT as the focal point for the R&D and manufacturing as part of the ACT accelerator
PARTNERSHIPS FOR GLOBAL IMPACT

COVID-19 VACCINE DEVELOPMENT

DIAGNOSTICS AND VALIDATION

ASSAY ESTABLISHMENT AND SUPPORT SYSTEM FOR VACCINE DEVELOPMENT AND SERO-EPIDEMILOGY

VACCINE DEVELOPMENT AND DELIVERY SYSTEMS
PHASE III CLINICAL TRIALS OF INDIAN COVID VACCINES IN NEIGHBOURING AND FRIENDLY COUNTRIES

Building science diplomacy for technological advancement and acceleration of indigenous vaccine development efforts

1. For Indian companies and researchers, conducting Clinical trials of vaccines developed by them in neighbouring and friendly countries

2. For LMICs, access to advisory support for planning and executing Phase III trials

3. For partnering countries, access to the Indian Vaccine development Ecosystem e.g. immunogenicity assay testing of potential vaccine candidates
TRAININGS FOR STRENGTHENING CLINICAL RESEARCH CAPACITY IN NEIGHBOURING COUNTRIES

**SCOPE**
- Strengthen clinical trial capabilities of researchers in neighboring countries for conduct of trials is in compliance with ICH-GCP guidelines
- Trainings on GCP, ethics, GCLP and large vaccine trials

**LEAD BY**
- Ind-CEPI + BIRAC +CDSA, THSTI
- Sessions delivered by field experts

**TRAINEES**
- PI, Co-PIs, health workers, technicians, nurses and support staff from hospitals, CHCs, field sites
- 1st series had 771 participants from Nepal, Maldives, Bangladesh, Mauritius, Sri Lanka, Bhutan and Afghanistan

**DELIVERY MODE**
- Each series has 3-4 modules organized weekly
- Online mode with exit exam and certifications
TRAINING PROGRAM TO STRENGTHEN THE CLINICAL TRIAL RESEARCH CAPACITY IN NEIGHBORING COUNTRIES

Series initiated on 22nd September; Successfully completed 4 E-Courses Organised by DBT India and BIRAC, through their Ind-CEPI Mission along with MEA and Missions abroad

2nd series commenced on 21st January 2021

- Good Clinical Practice: 4 Session E-Course
- Ethical Considerations in Clinical Research: 2 Session E-Course
- Good Clinical Laboratory Practice: 2 Session E-Course
- Large Vaccine Field Trials: 2 Session E-Course
FIELD SITES FOR CLINICAL TRIALS

DBT's Resource of Indian Vaccine Epidemiology Network (DRIVEN)

05 DHS Sites

- INCLEN Trust International, Patwai, Haryana
- KEM, Vadu, Pune
- Society for Health Allied Research Education (SHARE), Hyderabad
- Maulana Azad Medical College, New Delhi
- ICMR-National Institute of Epidemiology, Tirunelveli, Tamil Nadu
- ICMR-Regional Medical Research Centre, Bhubaneswar, Orissa
- Andhra Medical College, Vishakhapatnam, Andhra Pradesh
- Pondicherry Institute of Medical Sciences, Pondicherry, Tamil Nadu

06 New DHS Sites

- Maulana Azad Medical College, New Delhi
- INCLEN Trust International, Shillong, Meghalaya
- ICMR-Regional Medical Research Centre, Bhubaneswar, Orissa
- Andhra Medical College, Vishakhapatnam, Andhra Pradesh
- Pondicherry Institute of Medical Sciences, Pondicherry, Tamil Nadu
- INCLEN Trust International, Patwai, Haryana

T tribal
Urban/Rural

New DHS Sites

18
Aim is to address the need of Indian Vaccine companies for Immunogenicity assays.

Two Immunogenicity GCLP compliant labs established (Total IgG, Neutralisation, CMI).

Plan to establish 4 more labs under Ind-CEPI for supporting vaccine trials.

THSTI, Faridabad, as one of the CEPI global network labs.

IRSHA, Pune

Antibody response

CMI response
COVID-19 CONSORTIUM DIAGNOSTICS
PROJECT PORTFOLIO

COMMON/SHARED FACILITIES - DBT AMTZ COMMAND CONSORTIA

- Ventilator assembly line (3500 units manufactured)
- RT-PCR assembly line (94 lakh test manufactured)
- VTM (6 lakhs units)

PORTFOLIO OF VARIED DIAGNOSTIC FORMATS

- 10 Nucleic Acid Detection
- 10 Antibody Detection Test
- 04 Antigen Detection Test
- 01 AI based Detection System

COMPONENTS/ REAGENTS (TOTAL 5)

- Primers and Probes (1)
- Material transport medium (3)
- Antigen (1)
- Diagnostics Antibody (1)
- Swabs (1)
- DNA & RNA extraction kits (3)
ACHIEVEMENTS

First Indigenous kit for diagnosis of COVID-19 developed by a BIRAC supported start up (MyLab) in Pune, is producing nearly one lakh kits per week.

The first I-Lab is operational and is attached to the THSTI, Faridabad hub. It visited in and around villages and colonies of Faridabad, Ballabgarh, and Palwal and has tested 13,000+ samples in total.

Andhra Pradesh MedTech Zone (AMTZ): Shared facility to manufacture diagnostic kits, ventilators and imaging equipment. Manufacturing capacity of 3 lakh RT-PCR kits/month, 1 lakh RNA extraction kits/month and 1 lakh Viral Transport Medium (VTM)/month.

Dhiti Life Sciences - Fully indigenous Antibody detection kit in market

Molecular Transport Medium (MTM) and Nucleic acid extraction kits developed by Huwel Lifesciences are available in market

Ubio – Antibody detection kit is developed and is in market

Levram - Swabs and VTM are in market
ENSURING SELF-RELIANCE
FOR BIOMANUFACTURING

NBRIC is a nation-wide effort for convergence of indigenous resources, products and services towards developing diagnostics, vaccines and therapeutics for COVID-19 and beyond for self-reliance in India’s biomedical capabilities.
DEVELOPMENT OF SEROSURVEILLANCE TOOLS AND ANIMAL MODEL AT DBT-NII

- Development of low-cost point-of-care serology testing.
- SARS-CoV-2 Pseudovirus for vaccine evaluation in BSL-2 settings.
- Animal model for pre-clinical evaluation of vaccines.

A low-cost point-of-care serology testing of IgG, IgM and IgA in single prick-blood for serosurveillance.

Animal model for evaluation of vaccines and therapeutics.

CITY/REGIONAL CLUSTERS OF TESTING

Set up in a Hub & Spoke Model; In the institutes of eminence under Central and State Governments; To utilize existing capacities for molecular biology / biosafety in the country

Key Outcomes so far:

21 clusters established, with over ~40 testing labs

So far over 29,43,000 samples have been tested as of February 24, 2021
**DBT-AYUSH partnership**
Joint network programme, involving DBT AIs and National Medicinal Plants Board (NMPB) to harness the potential of indigenous medicinal plants for development of plant-based therapeutics to treat COVID-19; 50 plants to be screened

**Immunoglobulin based therapeutics**
- Immunotherapy of COVID infected patients using therapeutic antibodies from Human or Equine sources
- Start trial of pooled convalescent plasma therapy by 20th October 2020.
- Permission for clinical trial expected by next month equine immunoglobulin therapy

**Resources for drug screening**
Organoid technology in vitro platform for drug screening and identification of new drug targets

**DCGI approved First Phytopharma drug**
Phase II clinical trials of AQCH, a phytopharmaceutical drug, developed by DBT-ICGEB along with Sun Pharma initiated. Results expected by October, 2020
BIOSAFETY REGULATION FOR COVID 19

- Rapid Regulatory Response Mechanism
- Interim Guidance Document on Laboratory Biosafety to Handle COVID-19 Specimens
- Rapid regulatory framework for fast track processing of applications relating to recombinant vaccines for COVID-19 has been developed
**STARTUP SOLUTIONS**

1. **Identification**
   - 100+ Covid solutions supported through BIRAC’s Incubator network

2. **Funding initiatives**
   - 50+ Webinars
     - Fund raising
     - Business mentoring
     - Regulatory Guidance
     - Re-Strategize business

3. **Supported**
   - 10,000+ Startups, entrepreneurs, stakeholders reached

**BIRAC’s Incubators/ Stakeholders network**

192

**BIRAC’s supported In-Market Startups**

150

**Prioritized In-Market Products from BIRAC supported Startups**

20

+ 20
Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL) developed a sanitizer. 3200 Liters of sanitizer has been produced. Re. 1 on commercial sale of each sanitizer to reach PM CARES Fund.

BIBCOL is also gearing up for introduction of Zinc+Vit (D&C) tablets for improvement of immunity in general for fighting corona and other infectious diseases.
ANTIBODIES AGAINST SARS-COV-2 AND PLATFORM FOR VACCINE DEVELOPMENT

DBT-NCCS is exploring possibilities for generating IgA antibodies against SARS-CoV-2 to protect lungs and mucosal surfaces (proof of concept for vaccine candidate).

Production of pseudotyped SARS-CoV-2 using a VSV platform for candidate vaccine development and biomedical research use (BIRAC-funded project by IIT-Indore, in collaboration with DBT-NCCS)

SARS-CoV-2 pseudovirus was generated using a VSV platform. Preliminary experiments indicate that the pseudovirus could elicit an antibody response in an animal model.
COVID-19
The Virus

Diagnostics
COVID-19 DIAGNOSTIC KITS
DEVELOPED BY DBT AIs

- THSTI
  - Aptamer
  - Visual PCR
  - ELISA

- RGCB
  - ELISA

- NIAB
  - Biosensor
ELECTROCHEMICAL DEVICE FOR ULTRASENSITIVE AND RAPID DIAGNOSIS OF SARS-COV-2

Technology transferred to Biogenex Pvt. Ltd.
MoU signed for the transfer of technology to M/s Biogenex Life Sciences Private Limited.
EFFORTS ON DIAGNOSTICS
BY DBT-THSTI

Developed the first aptamer-based SARS-COV2 detection assay
Technology transferred to Molbio Diagnostics Pvt Ltd.

DNAzyme-based visual detection method for SARS-COV-2 developed that is compatible with conventional PCR
Technology transferred to Genei Labs, Bengaluru
New testing protocols

- Pooling strategies are both cost effective and reduce time to reporting.
- Simple pooling is ineffective if the rates of infection are >5%.

**Smart Pooling**
(applying a compressed sensing algorithm)

- Uses matrices for pooling
- Identifies positives in one round of PCR
- Can be automated
- Works in conditions when infectivity is high in populations
- Reduces time to reporting
- Broad applications

**DIAGNOSTICS**

**Algorithm**
Manoj Gopalkrishnan (IIT Mumbai)
Sandeep Krishna (NCBS-TIFR)

**Validation**
Dasaradhi Palakodeti (inStem)
COVID-19 diagnostic product developed by Sperogenx Biosciences, Bangalore and POCT Service, New Delhi, in Collaboration with DBT-RGCB

Q-line COVID-19 antigen rapid Test detects within 30 minutes at resource limited settings

Q-line® Molecular

Introducing a Comprehensive COVID-19 Product Range

Q-Line Molecular (nCoV-19) RT-PCR Detection Kit (E, RdRP & IPC)
- Kit consists with Human housekeeping gene as Internal Positive Control (IPC) to ensure human sample availability & quality of nucleic acid for the reference of gene expression.
- Sensitivity: 98.7%
- Specificity: 100%
- Store at -20°C

Q-line Viral RNA Extraction Kit (Spin Column)
- Silica-based column are used for purification to get high quality viral RNA free from protein & other organic compound impurities.
- Kit consists with RNA carrier molecule to enhance yield and purity level.
- Yield of the Viral RNA Recovery: ≥90%
- Storage at 15-30°C. (Room Temperature)

Q-line Viral Transport Medium (VTM) Kit
- Self-standing 10 ml tube with 3 ml filled medium
- Contains antibiotics and anti-fungal to inhibit bacterial as well as fungal growth.
- Individually packed sterile polyester/Nylon swabs with suitable tip & shape with breakpoint as per collection tube.
- Storage at 15-30°C. (Room Temperature)

R & D:
Sperogenx Biosciences Pvt Ltd
Co-developed with:
A joint project of COVID-19 product development with DBT-RGCB & POCT Services

Manufactured & Marketed By:
POCT SERVICES PVT. LTD.
20A(Basement), Najafgarh Road, Shivaji Marg, New Delhi -110015. INDIA
P: 011 4557 7407
E: sales@poctservices.com
W: www.poctservices.com
Toll Free: 1800 123 0079
**COVID-19 Anosmia Checker Strips**

- COVID-Anosmia Checker, a quantitative, rapid and low-cost alternative tool for mass screening of COVID-19
- Detects both symptomatic and asymptomatic Covid-19 carriers.
- 100% specificity and 65-70% sensitivity.
- Technology Transferred to Instigator E-Supporting Services Pvt. Ltd.

**ADVANTAGE**
- No trained manpower required
- Significant reduction in confirmatory test numbers
- Significant reduction in cost
- Significant reduction in testing time

**TESTING STRATEGIES**

- **Self Testing**
  - Testing time: ~ 2 Min
  - Cost: ~ Rs. 10.00 (US$ 0.14)

- **Community / Entry point Screening**
  - Cut along dotted line and smell

**Enter the details of smell perceived into Mobile Application**

**COVID-19 PREDICTION (YES/ NO)**

- **IF YES**
  - Self isolation
  - Undergo Confirmatory Test

**Developed by Neologix**

**www.neologix.ae**
IN OUR FIGHT AGAINST COVID-19
Institute of Life Sciences, Bhubaneswar
2 February, 2021

Achieved the Milestone of Conducting

ยาย 1,50,000

tests with RT PCR

July  | September  | October | November | December | February
50,000 | 75,000 | 1,00,000 | 1,25,000 | 1,50,000
Clustering and supporting North East India COVID-19 testing facilities

- DBT-IBSD-JNIMS COVID-19 testing laboratory at Imphal, Manipur was established on July 11, 2020.

- DBT-IBSD, as the NER Cluster Coordinator for Covid-19 testing facilities has completed the first round of consultation for the 32 DBT-supported laboratories in all 8 NER States, served as spokes with DBT-IBSD as the Hub.

MANIPUR

**DBT-IBSD-JNIMS COVID - 19 Testing Centre, Imphal**

IBSD’s own testing lab, in collaboration with JNIMS established at Imphal with the approval of ICMR, doing independent testing.

- **JNIMS, Govt. of Manipur, Imphal**
  - RT-PCR Machine, Equipment and Consumables support, Manpower assistance and Capacity building

- **Regional Institute of Medical Sciences, Govt. of India, Imphal**
  - RT-PCR, RNA Extraction machine & Manpower support

MEGHALAYA

**Govt. Civil Hospital, Tura**

Equipment and Consumables support

- **Pasteur Institute, Shillong**
  - Facilitating development of BSL2 facility, Equipment support and Capacity building

- **NEIGRIMS, Govt. of India, Shillong**
  - RT-PCR Machine

MIZORAM

**Zoram Medical College, Aizawl**

RT-PCR Machine, Consumables and Manpower support

SIKKIM

**SNTM Hospital, Gangtok**

 Consumables support
ANIMAL MODELS FOR SARS – COV-2

- Syrian golden hamsters (Mesocricetus auratus)
  - Established model for SARS-CoV-2 (Chan FJ et al; Clinical Infectious Diseases, 2020)

- K18-hACE2 transgenic mice
  - Transgenic mice express human ACE2, the receptor used by the severe acute respiratory syndrome coronavirus (SARS-CoV) to gain entry to cells.

- DBT-ILS established Syrian golden hamsters (Mesocricetus auratus) and K18-hACE2 transgenic mice for SARS-COV-2

- THSTI developed a hamster challenge model for SARS-CoV-2. It is being offered as a service to various vaccine developers to evaluate the efficacy in this model. (Rizvi ZA et al, 2021)
PRECLINICAL MODELS OF DISEASE

Engineering Mouse Models for COVID-19 Research

Initiated in May 2020

National Mouse Research Resource

K18-hACE2 transgenic mouse
K18-hACE2 transgene plasmid kindly donated by Paul B. McCray et al. who designed the Tg (K18-hACE2) 2Prlmnn/J [PMID: 17079315]

Humanized hACE2 knock-in mouse using Crispr-Cas9 genome editing
Advantages
- more accurately represents Ace2 expression (existing mouse does not drive expression in heart, ileum, nasal epithelium)
- Can be used to model post-infection inflammation more accurately
- Available November 2020

ACE2 knockout mouse
Available November 2020

Humanised hACE2 Knock-In Mouse using CRISPR/Cas9 genome editing
DRUG REPURPOSING AT ILS AGAINST SARS-COV2

Screening of FDA approved libraries for compounds targeting multiple viral proteins and *in-vitro* validation of identified hits.

Establishing multipotent synergistic therapeutic combinations.

High throughput screening of FDA approved libraries for activity against SARS-CoV2 Proteases (PL_Pro & 3CL_Pro) and RDRP using real-time fluorogenic kinetic assays.
Generation of virus-neutralizing human monoclonal antibodies against SARS-CoV-2 as potential therapeutics

DBT-NCCS has generated clones secreting human monoclonal antibodies (mAbs) against SARS-COV-2. These were transferred to an industry partner for further testing and development, which is being done in association with IIT Indore and PredOmix Technologies Pvt. Ltd.

Peptide-based therapeutics using machine learning

Using machine learning DBT-NCCS has identified peptides with therapeutic potential to target the Mpro protein of the COVID-causing virus (published in BBA Molecular Basis of Disease), which are being tested by an industrial partner.
COVID-19 THERAPEUTICS CALL

IDBT and BIRAC jointly announced a request for proposals in the area of Covid-19 Therapeutics in Oct 2020 for:

- Development of therapeutics to address a rapid response towards the current COVID-19 outbreak.
- Development of therapeutics to address the current and/or future coronavirus outbreaks.

7 proposals were recommended for funding subject to legal, IP and financial clearance. One project aims at Repurposing Anakinra for Treatment of Moderate to Severe Cases of COVID-19. This drug may also be useful for management of autoimmune disease like rheumatoid arthritis.
IBSD has shared RT-PCR machine to Zoram Medical College, Aizawl, which was airlifted by Govt. of Mizoram from Imphal. This has doubled the testing capacity of Mizoram.
A triterpene glycoside compound of *Yashtimadhu or Mulethi (Glycyrrhiza glabra)* is recognized for potential immunomodulating, anti-inflammatory, hepatoprotective, and antineoplastic activities.

This triterpene inhibited cytokine storm as well as SARS-Cov2 replication significantly.
ECONOMICAL DEVICE TO HELP DETECT ASYMPTOMATIC COVID-19 CASES

DBT/Wellcome Trust India Alliance fellow, Dr Nixon Abraham, at Ministry of Education’s IISER Pune designed a custom-built olfactory-action meter that can be used to detect asymptomatic COVID-19 cases.

This new method identified olfactory dysfunction in 82% of asymptomatic COVID-19 carriers. In comparison, only 15% of the same set of patients reported a loss of olfaction in self-reporting paradigms.
ECONOMICAL DEVICE TO HELP DETECT ASYMPTOMATIC COVID-19 CASES

DBT/Wellcome Trust India Alliance fellow Dr Mohan C Joshi at Jamia Millia Islamia (JMI), New Delhi, designed RNA extraction free saliva-based detection technology for COVID-19, MI-SEHAT (Mobile Integrated Sensitive Estimation and High-specificity Application for Testing)

To be used as point of care (POC) device for COVID-19 detection in the field with a provision for at home testing.
EFFORTS ON DIAGNOSTICS

BY “DBT-NABI”

DNA Aptamer- Gold nanoparticles Based Lateral Flow Assay Biosensor For SARS-CoV2 Virus Detection Using Nucleocapsid Peptide As Biomarker

Aptamer as an efficient detection tool

Gold Nanoparticles used for visual signal

Lateral flow Strip for SARS-CoV2 detection
Developed a bead-based assays that utilizes recombinant protein immobilization on beads with affinity tag or nanobody.

Nanobody mediated capture of orange fluorescent protein tagged Spike (S1) protein of SARS-CoV-2 on agarose beads.

This bead served as the trap for soluble recombinant EGFP ACE-2 that is inhibited by neutralizing antibody.

A more simplified system utilized recombinant RBD bead to trap soluble ACE2 EGFP.

Both the assays are rapid, cost effective, sensitive and adaptable for multiple detection platforms.
COVID-19
The Virus

Biorepositories
41790 clinical samples and 17 viral isolates collected; ~6000 biospecimens shared for > 30 requests from academia and industry.
INSTITUTE OF LIFE SCIENCES
BIOREPOSITORY FOR COVID-19

Quality assessment and selection of samples for storage

VIRUS
- Viral aliquots
- Viral Cultures
- Viral RNA

BLOOD
- Plasma
- Serum

OTHERS
- Sputam
- Stool
- Oropharyngeal Swab
- Urine

To establish organized and dedicated biorepositories of well characterized clinical samples of COVID-19 patients

To conduct research to better understand the COVID-19 disease in the Indian scenario.

To use these samples to promote research and development towards indigenous diagnostics, therapeutics and vaccines

To promote academia, industry and commercial entities for developing novel solutions for COVID-19 prevention control and treatment

208 Individual COVID-19 patient samples collected

- Symptomatic: 81
- Asymptomatic: 127
- Non-COVID: 65

Day 0-5 and 8-10 of hospitalization (> 1 month has been planned)

Day 0-5 and 8-10 of hospitalization

Day 0-5 of hospitalization

-
SERVICES PROVIDE BY THE NATIONAL CELL REPOSITORY OF DBT-NCCS
TO FACILITATE THE NATIONAL EFFORTS AGAINST COVID-19

The national cell repository of DBT-NCCS has set up a biobank to preserve and share COVID-related bioresources for research. 127 samples of peripheral blood mononuclear cells (PBMCs) and plasma from SARS-CoV-2 infected and convalescent COVID patients have been preserved at NCCS so far, in association with the B.J. Medical College, and the AFMC, Pune.

Biorepository for COVID bioresources
- 24 cell cultures have been supplied to 15 organizations across India (national research organizations, medical college, University and industry).

Providing cell cultures to facilitate COVID-related research
- The national cell repository of DBT-NCCS has set up a biobank to preserve and share COVID-related bioresources for research.
DBT- THSTI NATIONAL BIO-RESOURCE CENTRE FOR COVID-19

COVID-19 Bioresources

- Resource available
  - COVID-19 sera panel of 100 participants (100 ul sera each)
  - All samples are positive for SARS-CoV2 infection tested by RT-PCR
  - Stratified by <6 days, 7-14 days, 15-21 days and > 22 days post symptoms

- Biospecimen/Metadata/Data Access and Sharing SOP for COVID-19 Bioresource
- COVID-19 Biological Sample Access Request Form
- COVID-19 Clinical Sample Access Request Form

IN-HOUSE DEVELOPMENT

- Antibody detection kit (IgG, IgA)
- Antigen detection kit

OUTCOMES

Technology transfer

- Antibody kit to Xcyton Diagnostics
- Antigen kit to MolBio Diagnostics

APPLICATIONS

- Evaluation of longitudinal antibody response
- Multiple sero-surveillance studies (Mumbai, Pune, AIIMS-Delhi, Patwal)
- Serological evaluation in fragile population: pregnancy for transplacental transmission & breast milk (ORCHESTRA)
INTERDISCIPLINARY EFFORT:
DBT CONSORTIUM FOR COVID-19 RESEARCH

Day 0
Clinical data: Contact history, symptomatology, comorbidities, hospitalization & treatment history, clinical outcomes

Day 10-28
Blood (10 mL), NP/OP

6-10 weeks
Blood (25 mL) (Serum, PBMCs)

6 months

12 months

COVID-19 cohort
DBT AI: NCR Biotech Science Cluster (THSTI, RCB, NII, ICGEB); DU-South campus: Coordinated by THSTI
Hospitals: LNJP, ESI hospital, GCH, Al-Falah, SGT medical college, Medanta hospital, LHMC

4179 enrolled; 3040 positive

Proportion of severe COVID: 21.7%

INTERCOVID (42 sites from 22 countries; 200/2000 women from India): Women with antenatal SARS-CoV-2 at higher risk for preeclampsia, PTB, perinatal complications

Seroconversion rates: Asymptomatic: 65%; mild-moderate 90%, severe 100%

Cellular immune response being evaluated
COVID-19

Therapeutics and Genome Analysis
DBT-RCB has set an in vitro cell culture-based assay to test the antiviral activity of potential molecules against SARS-CoV2.

Services have been widely utilized by the academia and industry.

**Cytotoxicity Testing**
1299 samples

**Antiviral Testing**
509 samples

**IC50 determinations**
21 samples
We have isolated viruses from four clades:

- **Clade 19A**: 5 isolates
- **Clade 19B**: 3 isolates
- **Clade 20A**: 5 isolates
- **Clade 20B**: 4 isolates

**Viral Genome Copies vs Passage**

![Graph showing viral genome copies vs passage number]

**qPCR result of Spike gene**

of passage 3-10 of 14743 and 16015 strains
PLANT PRODUCED FLAVONOIDs AND Glucosinolates AS ANTI SARS-COV2 AGENTS BY DBT-NIPGR

In silico studies indicate binding of 38 molecules out of 6000 flavonoids to coronavirus protease (Mpro).

6 most potential flavonoids (Kaempferol, Kaempferol 3-O-rutinoside, Quercetin, Rutin, Myricetin) are currently being tested for anti-viral activity in cell cultures and subsequently in animal models in collaboration with RCB.

Plant secondary metabolites, flavonoids, as anti SARS CoV2 agents

Glucosinolates as anti SARS CoV2 molecules

Glucosinolates and their hydrolysis products are reported to have activity against influenza viruses, including SARS.

6 potential glucosinolates (Sinigrin, Glucoraphanin, Glucomoringin, Allyl-ITC, Sulphoraphane, Gluconasturtiin) from Brassica, Moringa and biofortified mustard have been purified.
Polypyrrollic photosensitizers and their nanoformulations for antiviral photodynamic therapy

Preparation of photosensitizer nanoformulations following chemical and photophysical characterization

Determination of the photodynamic antimicrobial efficacy of the polypyrrolic photosensitizer nanoformulations

Polypyrrolic photosensitizer nanoformulations demonstrated promising antiviral efficacy during in vitro study with SARS-CoV-2

Memorandum of Agreement has been signed between DBT-RCB and DBT-CIAB for testing antiviral activity using SARS-CoV-2
STUDIES ON POTENTIAL OF NATURAL GARLIC ESSENTIAL OIL AS A POTENTIAL INHIBITOR OF ACE 2 PROTEIN AND THE MAIN PROTEASE PDB6LU7 OF SARS-COV2

Extraction of garlic essential oil from garlic cloves

Detection and quantification of volatiles in garlic essential oil

In vitro assay of garlic essential oil against ACE 2 protein and the main protease PDB6LU7 of SARS-CoV2

Hydro-distillation
Solid-liquid 1:2 w/v
80-90°C, 1.5 h

Extraction of Garlic Essential Oil

Garlic Essential Oil (1.3 g)
ARTIFICIAL-INTELLIGENCE BASED CLASSIFICATION OF CHEST X-RAY IMAGES INTO COVID-19 AND OTHER DISEASES – DBT-ICGEB

Chest X-ray Images: Normal, COVID-19, non-COVID-19, pneumonia, TB

Augmentations

Training Datasets

Training Dataset (90%)

Internal Validation Dataset (10%)

External Validation Dataset

Artificial Intelligence Model Training

Model Selection
HUMAN MONOCOLONAL ANTIBODY
AGAINST COVID-19

Successfully generated panels of human monoclonal antibodies from memory B cells derived from Covid-19 recovered individuals from India.

The monoclonal antibodies show neutralizing effect and are being further characterized functionally & structurally.
In vitro mode of action of AQCH against Dengue suggested that it interferes with the endosomal release of the viral RNA.

Since all +strand RNA viruses use the similar endolysosomal pathway for the release of their genetic material, this drug candidate had a strong case for testing its efficacy against novel COVID-19.

Anti-COVID-19 activity of AQCH was confirmed against COVID-19 at ICGEB, Trieste through In vitro studies.

Human safety studies of AQCH completed and phase II clinical trials for anti-COVID-19 treatment is in progress.
A joint DBT-AYUSH action plan formulated and implemented

Network programme launched involving four DBT's institutions along with NMPB and CCRAS of Ministry of AYUSH

About 50 plants known in traditional system of medicine in tribal areas of Odisha to be screened

Fifteen medicinal plants along with eight traditional Ayurvedic formulations shortlisted

Initiated screening of selected medicinal plants and traditional Ayurvedic formulations focusing on in vitro tests against SARS-CoV-2 along with testing immuno-pharmacological, toxicological and drug interaction studies
DBT-ILS evaluated traditional knowledge-based medicinal plants for SARS-CoV2 virus

24 plant species traditionally known for anti-viral activities collected from Similipal Biosphere Reserve and Gandhamardhan Hills.

High content and high throughput screening initiated with various solvent extracts.

Aim to identify bioactive fractions with capability to restrict growth of SARS-CoV2 virus.

Assessing bioactive fractions/compositions with capability to induce immunity to be used as prophylactic composition against SARS-CoV2.
Repurposing of anti-dengue botanical drug (AQCH) for COVID-19 (developed jointly by ICGEB, CSIR-IIIM and Sun Pharma)

AQCH has shown anti-SARS-CoV-2 activity in in-vitro studies

Human safety studies of AQCH completed and drug has been found safe at the recommended dose for Phase II clinical trials

First phytopharmaceutical drug approved by DCGI for Phase II clinical trial for COVID-19

Clinical trials in progress across 10 centres in India covering 200 patients.
DBT- RGCB SCIENTISTS DEPLOYED TWO VERSIONS OF SARS COV2 PSEUDOVIRION ASSAY

Being used for the testing of anti Covid solutions from industry and Academia

More than 200 samples tested

CURRENTLY BEING USED FOR THE VALIDATION OF PRODUCTS FROM ALL OVER INDIA
GENOME ANALYSIS OF SARS-COV 2

- Coordinated by National Institute of Biomedical Genomics (NIBMG-Kalyani), West Bengal. Four other National clusters, ILS-Bhubaneswar, CDFD- Hyderbad, InStem-NCBS, Bangalore and NCCS-Pune have actively participated in sequencing and analysis.

- Other collaborating National Institutes and clinical organizations involved are ICMR-NICED, IPGMER-Kolkata, IISc-Bangalore, AIIMS-Uttarakhand, MAMC-Delhi, THSTI-Faridabad, GMC-Aurangabad, MGIMS-Wardha, RMRC-Bhubaneswar, AFMC and BJMC-Pune and other hospitals.
PAN INDIA 1000 SARS-COV-2 RNA GENOME SEQUENCING CONSORTIUM

Participating Institutes:
- West Bengal - NIBMG
- Telengana - CDFD-NIAB
- Odisha - ILS
- Maharashtra - NCCS
- Karnataka - InStem-NCBS
- North-East - IBSD
- Kerala - RCB
- Delhi - NII-ICGEB-NIPGR
- NCR cluster - THSTI-RCB-NBRC
- Punjab - NABI

Work Plan/Strategy
- Nasal/Oropharyngeal Swabs, BAL, Autopsy
- Viral Genome Sequencing of 1000 RT-PCR Positive Cases
- Outbreak tracking, Viral Evolution, Host Genomic Correlates of Susceptibility/Resistance
- Host Exome Sequencing
- Patient Data on infection severity, history & other lab tests
HAPLOTYPE DISTRIBUTION: REGION WISE

- Within haplotypes different states appear to have different proportions.
- East and North are similar. West and South are similar.

![Graphs showing haplotype distribution in different regions of India.](image)

Legend:
- 20A = A2a
- 20B = A2a
- 20C = A2a
- 19A = O; A2; A3
- 19B = B1, B4
TEMPORAL CLADE DIVERSITIES:
PAN INDIA

- Haplotype diversities peaked between March-May, early part of the outbreak.
- By June A2a (20A/B/C) emerged as predominant haplotype.
- The temporal haplotype diversities landscape appears to be similar PAN India.
ASSOCIATION OF HIGH VIRAL LOAD WITH A2A (CLADE 20)

Marginally significant association of sequences belonging to 20A, 20B and 20C with lower Ct values of diagnostic Real Time PCR assay compared to those belonging to 19A and 19B
The Consortium has achieved its initial goal of completing the sequencing of 1000 SARS-CoV-2 genomes with samples across 10 states covering different zones within India. The sequence data will soon be released in public domain (GISAID database).

Initial results indicate that multiple lineages of SARS-CoV-2 are circulating in India, probably introduced by travel from Europe, USA and East Asia. In particular, there is a predominance of the A2a haplotype (20A/B/C) with D614G mutation, which is globally reported to be associated with enhanced transmission efficiency.

Future Directions:

- Study the implications of mutations in Virus Entry, Immunogenicity and Pathogenesis using VLP model
- Identify host genetic polymorphisms that either confer susceptibility or protection from the viral infections.
- Investigate the Viral and Host genetic determinants of disease severity
Ascertain Status of new variants of concern of SARS-CoV-2 (SARS-CoV-2 VUI 202012/01) in the country

To establish a sentinel surveillance for early detection of genomic variants with public health implication

To determine the genomic variants in the unusual events/trends (super-spreader events, high mortality/morbidity trend areas etc.)

Status of the new variant
Detection of genomic variants with health implications
Identify variants in unusual events/trends

NIMBG, Kalyani
ILS, Bhubaneshwar
NCCS, Pune
inStem, Bengaluru
CDFD, Hyderabad
CSIR-IGIB, New Delhi
ICMR-NIV, Pune
NIMHANS, Bengaluru
CSIR-CCMB, Hyderabad
NCDC, New Delhi
COVID-19
The Virus

Other Interventions
INSTEM DEVELOPED GERMICIDAL CHEMICAL THAT CAN BE “COATED” ON FABRIC TECHNOLOGY TRANSLATED COMMERCIALLY

**Re-usable:**
Can be used for 90 days with 30 wash cycles
- Antibacterial
- Antiviral
- High Breathability
- High Bacterial Filtration Efficiency
- High Particle Filtration Efficiency
- Fluid Splash Resistant

**Tested at:**
The South India Textile Research Association (SITRA)
Coimbatore

**Effective against:**
SARS-CoV-2 pseudovirus
Gram negative bacteria
Gram positive bacteria
Multiple enveloped viruses
DBT-IBSD Imphal, Manipur; Gangtok, Sikkim; Aizawl, Mizoram and Shillong, Meghalaya distributed masks and sanitizers to different frontline workers on a weekly basis.

Vulnerable sections of society such as vegetable vendors, farmers, taxi drivers, senior citizens and orphans were the other target groups for distribution of masks and sanitizers.
Well-timed lockdowns can significantly alter disease dynamics and prevent the maximum number of active cases from breaching the hospitalization threshold, i.e. the capacity of the available healthcare facilities.

Computations models can be a powerful tool to suggest lockdown windows for maximal effectiveness for arrest of COVID-19 spread while minimizing strain on the available healthcare infrastructure.
OTHER INTERVENTIONS
BY DBT-RGCB

ACE2 HA Stable cells for SARS CoV2 Research

DBT-RGCB developed the following cell lines and validated their utility using pseudovirion assay and fluorescent RBD & S1 protein

- HEK293 Stably expressing human ACE2 HA
- HEK 293 stably expressing human ACE2 – myc
- DLD cells stably expressing h ACE2

Cell resources developed by DBT-RGCB for research community

- DLD stable cells expressing human ACE2- EGFP
- DLD stable cells expressing human ACE2 –Cereulean
- DLD stable cells expressing SARS CoV2- RBD EYFP
- HEK 293 stable cells expressing human ACE2 EGFP
- HEK 293 stable cells expressing human ACE2 –Cereulean
- HEK 293 stable cells expressing SARS CoV2- RBD EYFP

A SARS CoV2 Permissive Cell line expressing human ACE2

The cell line validated for pseudovirion assay and Viral propagation is available from Layog Life Sciences, a biotech incubator company at bio-nest
COVID-19
Capacity Building and Outreach
‘Training Program to Strengthen the Clinical Trial Research Capacity in Neighboring Countries’ initiated on 22nd Sept and various modules are planned for next 02 months.

- Afghanistan
- Bhutan
- Bangladesh
- Maldives
- Mauritius
- Nepal
- Sri Lanka

DBT India and BIRAC, through their Ind-CEPI Mission are committed to capacity building and regional networking for clinical trials: GCP, Ethics in Clinical Research, GCLP and Vaccine trials in population.
A MACHINE LEARNING APPLICATION FOR RAISING WASH AWARENESS DURING PANDEMIC

DBT/Wellcome Trust India Alliance fellow Dr Tavpritesh Sethi at IIIT New Delhi and his team has developed android based app “Wash Karo” that functions as a complete Infodemic Management Suite. It was presented at WHO, Geneva on April 8, via video conferencing.

Wash Karo aims to provide the right information to the right people in the right format at the right time.
DBT organized a six-part webinar to highlight the response of DBT, its AIs, PSUs and the start-up community in the development of diagnostics, vaccines, monoclonals, novel protection equipment. The panelists included Dr Renu Swarup, and senior leadership from BIRAC, C-CAMP, AMTZ and AIs at the forefront of the COVID-19 response. The series received over 7300 registrations, participation of 3300+ in addition to approx. 4500 views on the social media.
ASK THE EXPERT SERIES

To contain the spread of misinformation and fear on COVID-19, THSTI and DBT/Wellcome Trust India Alliance partnered with IAVI and Nature India to organize a series of 8 webinars in which experts answered questions about COVID-19. The webinar was an opportunity for media professionals and those seeking credible information on the pandemic to interact with experts to better understand COVID-19’s science and public health impact, as well as best practices and tools of fact-checking and reporting. These webinars were attended by over 2000 people.
DBT ORGANISED WEBINARS ON THE SCIENCE OF COVID-19 VACCINE DEVELOPMENT, PRODUCTION AND IMPLEMENTATION

DBT organised two webinars on key elements of COVID-19 vaccine development, production and implementation. These webinars witnessed participation from policymakers, regulators, scientists, vaccine manufacturers and public health experts.
In response to Hon'ble PM's Jan Andolan on COVID-19, DBT, AIs and PSUs undertook pledge, placed hoardings at various places and ran a social media campaign towards behavioral change.
DBT/Wellcome Trust India Alliance developed 5 COVID-19 infographics. Beyond English, these have also been translated into over 12 Indian languages, and distributed widely including government departments.
THSTI published comics in English, Hindi and Punjabi to bust some COVID-19 myths on the spread and prevention of COVID-19.
InStem published a graphic novel in English, Marathi, Hindi, Kannada to spread awareness about the COVID-19 is to create awareness in non-specialist readers, especially children, about the current health crisis.
DBT/Wellcome Trust India Alliance partnered with teams in the UK and South Africa on an innovative digital comic for young adults (YA) aged 16-25, Planet DIVOC-91, which would provide an alternative, character-based narrative about a pandemic. The project is a collaborative effort with involvement of scientists and researchers from a wide range of disciplines spanning infectious diseases, behavioural sciences, health economy, health inequalities and more. As well as being an opportunity for young people to respond to the science and research, the project aims to influence future decision making and policy.
DBT/Wellcome Trust India Alliance supported a 3-D podcast series, “Scrolls and leaves”, that explores the history of science and medicine and its interplay with trade and geopolitics to help us make sense of the current pandemic.