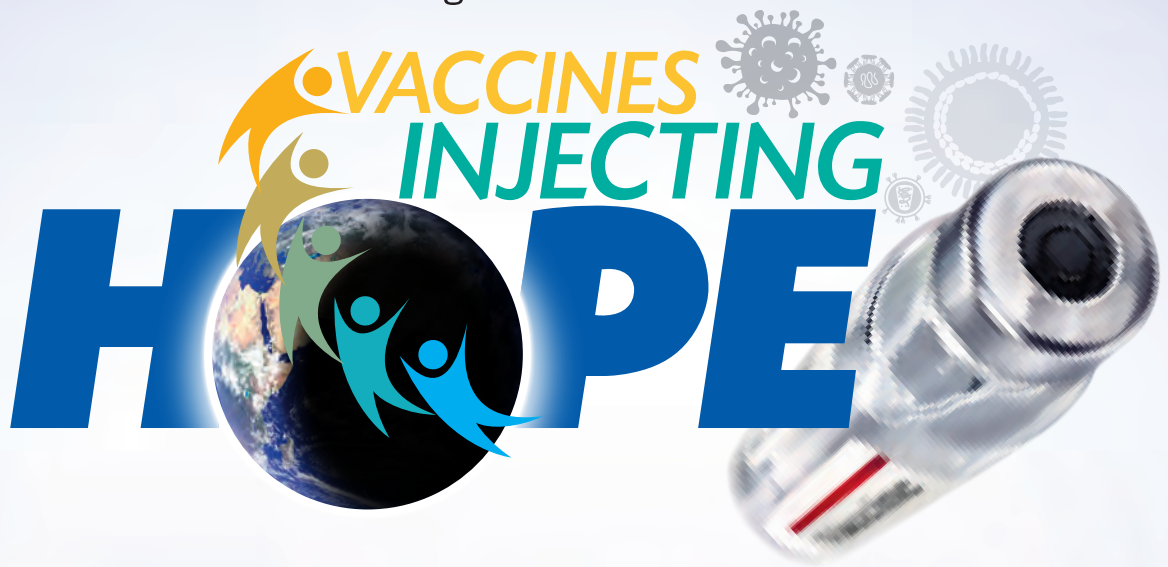


Travelling exhibition on



Travelling exhibition on

Vaccines Injecting HOPE



Research, Design &
Development



National Council of Science Museums

Ministry of Culture, Government of India
33, Block-GN, Sector-V, Bidhan Nagar, Kolkata-700091
www.vaccine-injectinghope.in

[/VaccinesInjectingHope](https://www.facebook.com/VaccinesInjectingHope) [/InjectingHope](https://www.instagram.com/InjectingHope)

www.ncsm.gov.in / [/ncsmgoi](https://www.facebook.com/ncsmgoi)

Exhibition Schedule and Venue

National Science Centre Pragati Maidan, Near Gate No.1 Bhairon Marg, New Delhi - 110001 nscd101@gmail.com www.ncsd.gov.in	Raman Science Centre & Planetarium Opp. Gandhisagar Nagpur-440018 ramanscn@gmail.com	Nehru Science Centre Dr. E.Moses Road, Worli Mumbai - 400 018 director@nehrusciencecentre.gov.in www.nehrusciencecentre.gov.in	Visvesvaraya Industrial and Technological Museum Kasturba Road, Bengaluru-560 001 vitmuseum@gmail.com www.vitmuseum.gov.in	Science City J.B.S. Haldane Avenue Kolkata-700 046 sciencecity.kol@gmail.com www.sciencecitykolkata.org.in
New Delhi Nov 15, 2022 to Jun 18, 2023	Nagpur Aug 5, 2023 to Dec 31, 2023	Mumbai Feb 10, 2024 to Jul 28, 2024	Bengaluru Sep 7, 2024 to Feb 28, 2025	Kolkata Apr 12, 2025 to Sep 30, 2025

content



Ministry of Culture
Government of India



Nationwide

National Council of Science Museums

Ministry of Culture, Govt. of India

www.ncsm.gov.in / [f](#) [t](#) [v](#) /ncsmgoi

◀ NORTH-EAST ZONE

Block-GN, Sector-V, Bidhannagar,
Kolkata - 700 091
Phone: (033) 2357 6357

◀ NATIONAL COUNCIL OF SCIENCE MUSEUMS

Block-GN, Sector-V,
Bidhannagar, Kolkata - 700 091

◀ CENTRAL RESEARCH & TRAINING LABORATORY

Block-GN, Sector-V, Bidhannagar,
Kolkata - 700 091
Phone: (033) 2357 9347 / 0850

◀ BIRLA INDUSTRIAL & TECHNOLOGICAL MUSEUM

19A, Gurusaday Road,
Kolkata - 700 019
Phone: (033) 2287 7241/7242

EAST ZONE

**NATIONAL COUNCIL OF SCIENCE MUSEUMS (Hqrs) &
Central Research & Training Laboratory, Kolkata**

- ▶ Regional Science Centre, Bhubaneswar
- ▶ Dhenkanal Science Centre, Dhenkanal
- ▶ Kapilas Science Park, Kapilas

Science City, Kolkata

Birla Industrial & Technological Museum, Kolkata

- ▶ Shrikrishna Science Centre, Patna
- ▶ North Bengal Science Centre, Siliguri
- ▶ District Science Centre, Purulia
- ▶ Bardhaman Science Centre, Bardhaman
- ▶ Digha Science Centre & National Science Camp, Digha

NORTH-EAST ZONE

- ▶ Regional Science Centre, Guwahati

NORTH ZONE

National Science Centre, Delhi

- ▶ Regional Science City, Lucknow
- ▶ Kurukshetra Panorama & Science Centre, Kurukshetra
- ▶ Palampur Science Centre, Palampur

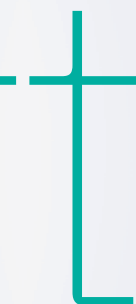
WEST ZONE

- ▶ **Nehru Science Centre, Mumbai**
- ▶ District Science Centre & Planetarium, Dharampur
- ▶ Regional Science Centre, Bhopal
- ▶ Goa Science Centre & Planetarium, Panaji
- ▶ Raman Science Centre & Planetarium, Nagpur

SOUTH ZONE

Visvesvaraya Industrial &

- ▶ **Technological Museum, Bangaluru**
- ▶ District Science Centre, Gulbarga
- ▶ District Science Centre, Tirunelveli
- ▶ Regional Science Centre, Tirupati
- ▶ Regional Science Centre & Planetarium, Calicut



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Smt. Droupadi Murmu
President
Republic of India



सत्यमेव जयते

राष्ट्रपति
भारत गणतंत्र
PRESIDENT
REPUBLIC OF INDIA

MESSAGE

I am happy to know that National Council of Science Museums (NCSM), Kolkata is organizing an exhibition titled "Vaccines: Injecting Hope". The exhibition will spread awareness about the significance of vaccines and the pivotal role they play in saving human lives.

The exhibition starting from New Delhi in November this year and travelling to other cities like Nagpur, Mumbai and Kolkata till September 2025 will boost awareness about the importance of vaccines in saving human lives. I appreciate NCSM for doing such a commendable job in creating awareness about vaccines. It is particularly important in the current scenario when we are emerging from the COVID pandemic. The ill-effects of the pandemic reduced substantially due to our vaccination drive. It is a matter of great pride that our country has administered more than 217 crore vaccine doses thereby creating a record.

On this occasion, I extend my warm greetings and felicitations to the National Council of Science Museums. I am confident that the exhibition will be beneficial for the society in popularizing vaccines. I wish the exhibition all success.

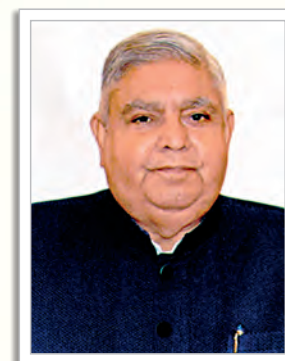
(Droupadi Murmu)

New Delhi
September 28, 2022



भारत के उपराष्ट्रपति
VICE-PRESIDENT OF INDIA

MESSAGE



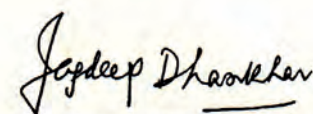
Shri Jagdeep Dhankhar
Vice-President of India

I am pleased to learn about an international travelling exhibition on the theme "Vaccines : Injecting Hope", that is being organised by National Council of Science Museums, Ministry of Culture, Government of India, in collaboration with Science Museum Group, London with the support of reputed scientific institutions like ICMR. I am also told that the exhibition during its almost three-year long journey from November 2022 to September 2025, will travel to New Delhi, Nagpur, Mumbai, Bengaluru and Kolkata, with an objective to educate the people and students about different aspects of research & development, production and delivery of vaccines.

I take this opportunity to compliment the organizers of this exhibition, the scientific community, the medical fraternity and the industry related to vaccine production for their immense contribution in the service of humanity, particularly during last two years. That we could develop and produce vaccines, medicines and devices in such a short time, speaks volumes about our scientific capabilities. I also pay my tribute to our frontline health workers and professionals. It was with their humongous effort that India could successfully launch world's largest vaccination programme.

I sincerely believe that this exhibition will convince people to overcome their vaccine-hesitancy and develop a scientific outlook towards pandemic and public health. I also urge all the eligible citizens to give up their vaccine-hesitancy and avail of Government's efforts to provide the precaution doze. A scientific outlook is the best guarantee against any future public health emergency.

I wish this educational journey every success in injecting the hope and trust among people. May this travelling exhibition spread scientific awareness among the remotest communities.


JAGDEEP DHANKHAR

3rd September, 2022



Dr. Mansukh Mandaviya
Minister of Health &
Family Welfare and
Chemicals & Fertilizers
Government of India

डॉ. मनसुख मांडविया
DR. MANSUKH MANDAVIYA



स्वास्थ्य एवं परिवार कल्याण
व रसायन एवं उर्वरक मंत्री
भारत सरकार

**Minister for Health & Family Welfare
and Chemicals & Fertilizers
Government of India**

MESSAGE

I am glad to know that the National Council of Science Museums is organizing an International Traveling Exhibition: "Vaccines: Injecting Hope" across the length and breadth of the country. I am confident that it will greatly help people in understanding and uncover the behind-the-scenes of the global effort to find and develop new vaccines at a rapid pace and to change public perceptions.

India is considered the Vaccine Manufacturing Hub of the world. Our country has achieved unprecedented success in terms of rapid development and production of Covid vaccines by assessing demand for National and extended international supply and its rollout for diverse groups in a phased manner. Our frontline workers, researchers, medical professionals, pharmacists, doctors and several others have made possible the deployment of affordable, quality, safe and effective vaccines to the citizens of the country. The world has been hailing India as we administered the 200-crore vaccine in just 18 months, thus registering another major milestone. The speedy development and manufacturing at scale have been a hallmark of the Indian Vaccine Industry.

National Council of Science Museums is known nationally and internationally for its commitment to communicating the message of science and technology to the masses which helps in raising awareness of the issues. Likewise, this exhibition intends to help people understand what is underpinning the current work to hunt for a vaccine for COVID-19 and other diseases.

Your initiative is special in many ways as it will immensely benefit to generate awareness about the importance of vaccines in human lives and also further help in making the world aware of India's contribution to keeping the world healthy.

I wish all the success for the International Travelling Exhibition

(Dr. Mansukh Mandaviya)

07 October, 2022

जी. किशन रेड्डी
संस्कृति, पर्यटन एवं
उत्तर पूर्वी क्षेत्र विकास मंत्री
भारत सरकार



G. Kishan Reddy
Minister of Culture, Tourism and
Development of North Eastern Region
Government of India



Shri G. Kishan Reddy
Minister of Culture,
Tourism & Development
of North Eastern Region
Government of India

Message

19 OCT 2022

It gives me immense pleasure to learn that an international travelling exhibition, "Vaccines: Injecting Hope" is being organized by the National Council of Science Museums (NCSM), an organization functioning under my Ministry in collaboration with the Science Museum Group, London, supported by Wellcome, ICMR and other scientific and research Institutions in India. The exhibition will be inaugurated in New Delhi in November 2022 and will travel to five metro cities in India namely Nagpur, Mumbai, Bengaluru and Kolkata till September 2025.

The COVID-19 pandemic's global impact has increased public interest in vaccinations to previously unheard levels and served as a powerful reminder of the need for vaccination efforts to foster confidence in science and innovativeness during our nation's worst moments. This exhibition, designed by NCSM will tell the behind-the-scenes story of the national effort to come up with combative and defensive interventions simultaneously in a time-sensitive and resource-intensive manner and unfold the conundrums regarding everything about vaccinations to sustain a general awareness amongst the people.

The untiring efforts of the scientists and frontline workers have proved to be fruitful because India has crossed the 200 crore COVID vaccination mark in just one and half year period. The vaccination programme was successful in saving millions of lives.

I hope the exhibition will be instrumental in raising awareness not only about the importance of vaccines in human lives but also tell the story of the extraordinary role played by the scientists, healthcare workers and government machinery in the vaccination programmes. I have also been informed that a Mobile Science Exhibition bus will ply to the nearby areas of the five metro cities and raise awareness among the people who are not able to visit the exhibition at the science centres. This is a wonderful effort of reaching out to the unreachable.

My best wishes are with the organisers for the grand success of the exhibition.

(G. Kishan Reddy)



Shri Arjun Ram Meghwal
Hon'ble Minister of State
for Culture
Government of India

अर्जुन राम मेघवाल, आई.ए.एस. (रिटायर्ड)
Arjun Ram Meghwal, IAS (Retd)



**MINISTER OF STATE FOR
CULTURE
GOVERNMENT OF INDIA
NEW DELHI-110 011**

Date : October 31, 2022

MESSAGE

It gives me immense pleasure to learn that the National Council of Science Museums (NCSM), an autonomous organization under the Ministry of Culture, Govt. of India, is organizing an international travelling exhibition, "Vaccines: Injecting Hope" in collaboration with the Science Museum Group, London, supported by Wellcome, ICMR and other research Institutions, in five metro cities in India, i.e New Delhi, Nagpur, Mumbai, Bengaluru and Kolkata from November 2022 to September 2025. NCSM has long been known for conceptualizing and developing very informative, educative and state-of-the-art galleries and exhibitions.

In our collective fight against the pandemic, India's Vaccination story, its robust Cowin platform, the untiring efforts of all stakeholders and the visionary leadership of Hon'ble Prime Minister Shri Narendra Modi have shown a guiding light across the globe. Through the Vaccine Maitri initiative, India has emerged as a global leader and strengthened the spirit of the developing world to fight against the pandemic. The COVID-19 pandemic's global impact has increased public interest in vaccinations to previously unheard levels. This exhibition will tell the behind-the-scenes story of the efforts by the scientists, volunteers, medical fraternity and frontline workers, as well as augment awareness about the importance of vaccines in human lives. Through the Mobile Science Exhibitions and outreach to a variety of diverse audiences, including those living in the remotest part of the country, it is expected that understanding of the importance of vaccines may grow significantly. Various programmes and events will also be organized as a part of the exhibition.

I hope the exhibition will play a very significant role in generating mass awareness about the issue.

My best wishes are with the organizers for the success of the exhibition.

(Arjun Ram Meghwal)

मीनाक्षी लेखी
MEENAKASHI LEKHI



विदेश एवं संस्कृति राज्य मंत्री
भारत सरकार
नई दिल्ली-110001
Minister of State for
External Affairs & Culture
Government of India, New Delhi-110001

Dated October 28, 2022
D.O. ML/MES/2022/00065

MESSAGE

I am glad to know that the National Council of Science Museums under the Ministry of Culture, Government of India has once again collaborated with Science Museum Group, London for the development of an international traveling exhibition, "Vaccines: Injecting Hope" after the grand success of the previous collaborative exhibition "Superbugs: The End of Antibiotics?". The exhibition is supported by Wellcome, UK, ICMR, India and some renowned research and scientific organizations like NIV, Pune, CSIR, AIIMS etc.

The COVID-19 pandemic was an eye-opener not only for the medical fraternity but for the cultural institutions also. Most of the museums and cultural organizations were closed for a very long period. It is a well-known fact that museums play a very important role in educating the masses in non-formal settings and raising awareness about community issues. During the pandemic, Community-centric and awareness-raising activities of museums were very distinctly missed by the visitors.

Vaccination is the most talked about topic in recent times due to the COVID pandemic, I hope this exhibition will be highly successful in raising awareness about the importance of vaccines in human lives not only in urban settings but the Mobile Science Exhibition bus on Vaccines will educate and aware people living in the remotest corners of the cities. Since NCSM is the pioneer in the field of reaching out to the unreached through Mobile Science Exhibitions, it is expected to raise its bar once again.

I convey my best wishes to the team and wish the exhibition all success.


(Meenakashi Lekhi)



Smt. Meenakashi Lekhi
Minister of State for
External Affairs and Culture
Government of India



Mr. Ian Blatchford
Director and Chief Executive
Science Museum Group

The pandemic is the defining story of recent years, one that could well be linked to the defining story of our age, that of climate change. The collapse of ecosystems, the rise of floods, droughts and extreme weather and other ruptures in the climate system are altering how we relate to other species on Earth, a change which will have impacts on our health and potential risk of infections.

As a globally celebrated alliance of science museums, the Science Museum Group is adding to its historical collections around both these existential threats to augment one of the world's most significant collections of science, technology, engineering and maths.

In response to the COVID-19 pandemic our curators have been actively and sensitively researching stories and identifying objects to collect on the nation's behalf that reflect the medical, public health, industrial and scientific responses to the COVID-19 pandemic from a range of different sources, both national and international.

These range from a Grayson Perry ceramic plot, “Alan Measles – God in the time of Covid-19”, to the empty vial and syringe used on Tuesday 8 December 2020 at 6.45am at Coventry University Hospital as the Pfizer/BioNTech vaccine was injected into a person for the first time anywhere as part of a mass immunisation programme. Some of the collecting was very close to home: during the pandemic, the Science Museum also became part of the narrative when it became the first national museum in the UK to host a vaccination centre and we were delighted to host the world's first Global Vaccine Confidence Summit.

The Group has been working hard on COVID-19 collecting with partner institutions, from the National Museums of Scotland to the National Council of Science Museums in India, who with the Guangdong Science Center in China have spent the past two years on our shared exhibition Injecting Hope, which describes the remarkable global effort that succeeded in creating effective COVID-19 vaccines and tackles one of the pandemic's most challenging issues, that of overcoming vaccine hesitancy.

The exhibitions all open in November in Delhi (National Science Centre), London (Science Museum), and Guangzhou (Guangdong Science Center). Tours will follow, with the one planned in India scheduled to reach audiences in Nagpur, Mumbai, Bangalore, and Kolkata. Thanks are also due to our long-term partner, the British Council, which is funding a contemporary artwork to appear on this tour.

The overall project is funded by Wellcome and The Huo Foundation and will build on our existing relationships with them and our esteemed international partners, following the recent success of the international touring exhibition about antibiotic resistance, Superbugs: The Fight For Our Lives.

The pandemic has driven the evolution of museums, compelling them along with many other organisations to engage with audiences online and to go beyond traditional 'material culture', where stories are usually told through objects, to find new ways to inform audiences about the threat posed by this invisible enemy and the scientific response.

Through collecting contemporary objects along with tackling timely subjects with exhibitions, events and online, museums can shed light on how science can shape our future, whether through the development of new therapeutics, monitoring the evolution of a virus, or by using computers to model future scenarios. They can also show how we, in turn, can shape science and provide a fresh perspective on culture because they lie at the nexus of science, industry, the public and government, along with heritage, history, contemporary research and the future. When it comes to addressing global threats the message of all these endeavours is clear: we can do so much more if we work together.

Ian Blatchford



India/UK Together
Season of Culture

MESSAGE

I am delighted the National Council of Science Museums, in collaboration with the Science Museum Group and supported by the Wellcome Trust, ICMR and other research institutions, has organised this tour of "Vaccines: Injecting Hope". The British Council is proud to have supported the exhibition, including the creation of an exciting centrepiece for this tour led by British artist Nigel Townsend and Indian artist Sushank Kumar.

Our contribution is part of British Council's India/UK Together Season of Culture, running from June 2022 to March 2023. This season marks the 75th year of India's independence and celebrates the deep cultural connections between our two countries, while addressing our shared challenges. People in both India and the UK will have the chance to experience innovative and exciting work from some of the best UK and Indian artists and institutions.

Thanks to global cooperation between researchers, scientists, health workers, volunteers and industries, several COVID-19 vaccines were developed, including in India. The rollout of vaccines in the country to more than a billion people has been globally recognized, resulting in saved lives not only domestically but also in several other countries where it supplied vaccines.

Raising awareness of the benefits of vaccination is vital in the global fight against disease. This travelling exhibition, organized by NCSM in partnership with the Science Museum Group in the UK, is a powerful contribution to addressing this challenge. I'm also impressed by their creation of a mobile version that will reach out to the rural populace.

I am honored to have been able to attend the exhibition's opening in New Delhi, and I wish its tour every success.



Mr. Scott McDonald
CEO, British Council

Scott McDonald



Shri Rajesh Bhushan, IAS
Secretary
Government of India
Ministry of Health and
Family Welfare



राजेश भूषण, आईएएस
सचिव
RAJESH BHUSHAN, IAS
SECRETARY



भारत सरकार
स्वास्थ्य एवं परिवार कल्याण विभाग
स्वास्थ्य एवं परिवार कल्याण मंत्रालय
Government of India
Department of Health and Family Welfare
Ministry of Health and Family Welfare

Message

National Council of Science Museums (NCSM), a premier scientific organization under the Ministry of Culture, Government of India, has collaborated with the Science Museum Group, London for an international traveling exhibition "Vaccines: Injecting Hope". The multi-city exhibition is a welcome move to bring the story of scientific process of vaccine development and its utilization to save millions of lives across the globe, closer to our young friends across various cities of India.

The COVID-19 pandemic has highlighted the tireless work of scientists, the role of technicians, frontline workers and health care workers in delivering healthcare services including vaccination to the community. Timely dissemination of right information and countering misinformation in the time of new age media was also a unique challenge that was overcome successfully. Government of India under the inspiring & visionary leadership of Hon'ble Prime Minister, took proactive and collaborative efforts to ensure that COVID-19 vaccines were available in India starting 16th January 2021. No wonder, India achieved 200 crore vaccine doses milestone within a short span of one and a half year. Achieving the above milestone is a remarkable feat was made possible because of efficient monitoring and close coordination with all stake holders. This has resulted in saving millions of lives & in providing necessary impetus to the national economy.

I am happy to know that the story of vaccines from development to its programmatic roll-out will be featured in the exhibition. This is one of the rare occasions when not only the importance of vaccination in saving lives will be highlighted but the role of people who work behind the scene will also be featured in the exhibition. I hope, our youth visiting the exhibition will become the ambassadors for spreading the positive message regarding vaccination. This will in-turn help in ensuring that no youth or pregnant women is left behind from the benefits of vaccination and thus spreading the message of injecting hope for a better life.

I wish the organizers from the core of my heart a grand success for the exhibition.

(Rajesh Bhushan)

Place : New Delhi
Date : 21-09-2022

गोविंद मोहन
सचिव
Govind Mohan
Secretary



भारत सरकार
संस्कृति मंत्रालय
नई दिल्ली-110001
GOVERNMENT OF INDIA
MINISTRY OF CULTURE
NEW DELHI-110 001



Shri Govind Mohan
Secretary
Government of India
Ministry of Culture

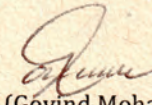
MESSAGE

I am delighted to know that the National Council of Science Museums (NCSM) under Ministry of Culture is organizing an international travelling exhibition "Vaccines: Injecting Hope" in collaboration with Science Museum Group, London and with support from Wellcome-UK, ICMR, and other premiere research institutions of India. Beginning November 2022 at Delhi, the exhibition is scheduled to travel to Mumbai, Nagpur, Bangalore and Kolkata till September 2025.

After the disastrous havoc wrought by the recent pandemic, it will be especially pertinent for our countrymen to understand the behind-the-scenes work that went into the quick development, production, transport and delivery of COVID vaccines. COVID-19 pandemic's global impact has increased public interest in vaccination to previously unheard levels. However, there is still a greater need to raise awareness, especially in far-flung areas.

To reach a variety of diverse audience, a Mobile Science Exhibition (MSE) bus has also been developed as a component of the travelling exhibition. I hope the exhibition will be helpful in increasing understanding of Vaccines and their long-term benefits.

I convey my best wishes to NCSM for grand success of the exhibition.


(Govind Mohan)



Dr. S Chandrasekhar
Secretary
Government of India
Ministry of Science and
Technology



डॉ. एस. चंद्रशेखर
Dr. S. Chandrasekhar



सचिव
भारत सरकार
विज्ञान एवं प्रौद्योगिकी मंत्रालय
विज्ञान एवं प्रौद्योगिकी विभाग
Secretary
Government Of India
Ministry of Science and Technology
Department of Science and Technology

19th September, 2022

MESSAGE

I am pleased to learn that the National Council of Science Museums (NCSM), an organization under the Ministry of Culture, Government of India has collaborated with the Science Museum Group, London. It also gives me immense pleasure to note that NCSM, with support from Wellcome-UK, ICMR-India, will host the International Travelling Exhibition "Vaccines: Injecting Hope" in five cities across the country, namely New Delhi, Nagpur, Mumbai, Bengaluru, and Kolkata, from November, 2022 to September, 2025. The exhibition would aim at shedding light on the global effort to create new vaccines quickly and to alter public perceptions of immunizations through the use of modern and historical pandemic paradigms.

In order to achieve significant mass immunity and safeguard the population that is least protected, it is imperative to determine vaccination acceptance among people, both nationwide and locally. I strongly believe that building future confidence of our population on vaccines will be largely dependent on holistic involvement of all and effective scientific communication. Thus, the exhibition will be helpful to those who are skeptical about the entire vaccination procedure and who require resources, knowledge, and assistance in order to make a positive decision.

I convey my best wishes to the organizers and hope for the success of the exhibition.

(S. Chandrasekhar)

डॉ. विनोद कुमार पॉल
सदस्य
Dr. Vinod K. Paul
MEMBER



भारत सरकार
नीति आयोग, संसद मार्ग
नई दिल्ली-110 001
Government of India
NATIONAL INSTITUTION FOR TRANSFORMING INDIA
NITI Aayog, Parliament Street
New Delhi-110 001
Tele. : 23096809, 23096820, Fax : 23096810
E-mail : vinodk.paul@gov.in

15th September, 2022

Message

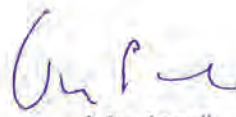
I am happy to learn that an international travelling exhibition "Vaccines: Injecting Hope" is being organised by the National Council of Science Museums, Ministry of Culture, Govt. of India in collaboration with Science Museum Group, London with an objective to tell the story of the global effort to find new ways to develop vaccines at a very rapid speed and look at vaccinations more broadly with a historical and contemporary view.

The COVID-19 outbreak was an eye opener for the need for multilevel robust health infrastructure with facilities for rapid tracing of the disease, finding the solution as soon as possible and delivering health solutions to the different sections of the society living in different terrains in no time. Continuous communication is the need of the hour to weed out the misconception, build confidence and develop a willingness to take medicines or vaccines not only for the sound health of the citizens but also of the nation.

Any pandemic may not only destroy lives but also devastate the economy of the nation. Therefore, I feel there is a strong need for a high level of awareness about health-related issues more specifically the vaccination programmes which acts as a preventive measure to counter the disease caused by microorganisms.

The team, the collaborators and the supporters, all are stalwarts in their fields. They have come together for a bigger cause. I hope this exhibition will be successful in raising awareness and building confidence about the importance of vaccines in saving lives.

I wish for a grand success of the exhibition.


(Vinod Paul)



Dr. Vinod K. Paul
Member
Government of India
National Institution for
Transforming India





Dr. Shekhar C. Mande
Chairman
Governing Body-NCSM
National Centre for Cell
Science, SPPU Campus
Ganeshkhind
Pune – 411 007



Ministry of Culture
Government of India



Message

I am greatly pleased to learn that the National Council of Science Museums (NCSM) is organizing an international travelling exhibition “Vaccines: Injecting Hope” in collaboration with the Science Museum Group, London and supported by Wellcome, ICMR and other premiere science and research Institutes. This travelling exhibition will be inaugurated in New Delhi in November 2022 and subsequently travel across Nagpur, Mumbai, Bengaluru and Kolkata, rounding off in September 2025.

I am also glad to know that a Mobile Science Exhibition on Vaccines will also be launched during the occasion to reach out to the unreached and create awareness about the Science of Vaccines in the nearby areas of the cities where the exhibition would be on display.

NCSM, like always, will be the major advocate in promoting an understanding and importance of vaccines in our lives through this exhibition and due to the recent pandemic, it will be more so relevant for our countrymen to know the behind-the-scenes work that went into the rapid development, production, transport and delivery of vaccines throughout the country.

I hope this exhibition will play a pivotal role in enhancing the public understanding of the effectiveness of vaccines and the importance of vaccination programmes.

I wish NCSM's visionary project, “Vaccines: Injecting Hope” all the success and hope its messages reach out to the last mile.

Dr. Shekhar C. Mande
Chairman, Governing Body-NCSM



डॉ. (श्रीमती) एन. कलैसेल्वी

सचिव

वैज्ञानिक और औद्योगिक अनुसंधान विभाग तथा
महानिदेशक

Dr. (Mrs) N. Kalaiselvi

Secretary

Department of Scientific & Industrial Research and
Director General



भारत सरकार

विज्ञान और प्रौद्योगिकी मंत्रालय

वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद

वैज्ञानिक और औद्योगिक अनुसंधान विभाग

Government of India

Ministry of Science and Technology

Council of Scientific & Industrial Research

Department of Scientific & Industrial Research



Dr. (Mrs) N. Kalaiselvi

Secretary,

Department of Scientific &
Industrial Research and
Director General

Message

I am happy to learn that the National Council of Science Museums (NCSM), under the Ministry of Culture, Government of India has collaborated with Science Museum Group, London for an international travelling exhibition "Vaccines: Injecting Hope" depicting the entire journey from vaccine development to their roll out, is scheduled to be inaugurated in New Delhi in November 2022 and will travel through Nagpur, Mumbai, Bengaluru and Kolkata till September 2025. CSIR, through its network of labs spread across India is providing all necessary support for this exhibition along with other scientific and research organizations.

The Council of Scientific & Industrial Research (CSIR), which is renowned for its cutting edge R&D knowledge base in a variety of S&T fields, has advantageously positioned itself to pursue focused R&D to develop, integrate, scale-up, and deploy necessary technological interventions for effectively combating the country's Coronavirus pandemic, with one major goal being to make India self-reliant in RT-PCR and Serological Testing.

This time, CSIR and NCSM have come together for this noble exhibition which is expected to raise awareness among masses about the importance of vaccine in our lives. A series of programmes and activities and digital and learning resources will definitely help in enhancing public engagement and understanding of vaccines.

Apart from raising awareness, I hope this exhibition will also inspire the youth of our country to follow the path of scientific research to advance knowledge in the field of Science and Technology in India.

I convey my best wishes for the success of the exhibition.

N. Kalaiselvi
(N Kalaiselvi)

September 20, 2022
New Delhi



ADAR C POONAWALLA
CEO
Serum Institute of India



Serum Institute of India PVT. LTD.
CYRUS POONAWALLA GROUP

Adar Poonawalla, CEO, Serum Institute of India

The 'Vaccines: Injecting Hope' is an encouraging initiative towards raising awareness on the benefits of immunization. Vaccines have always played a pivotal role in curbing diseases. The pandemic witnessed governments, scientists, volunteers, and global public-private health institutes working on a war footing to develop several vaccines, and ensuring that no one was left behind in accessing them.

The extraordinary innovation in vaccine development and manufacturing at scale has been key to ending the pandemic at a country level.

India because of its large vaccine capabilities was able to do this in world record speed. By dispelling vaccine hesitancy, we also witnessed one of the highest vaccination rates in the world.

Healthcare is the backbone of any country's economy and its prosperity. It thrives only when people work together collectively towards a shared goal of well-being and protection.

I would like to congratulate the Ministry of Culture, the Ministry of Health, and other partners on this endeavor and wish them all the best. With this, I hope that people across the country will understand the importance of vaccination for diseases beyond Covid.

ADAR C POONAWALLA
CEO
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राष्ट्रीय विज्ञान अकादमी, भारत

The National Academy of Sciences, India
5-Lajpatrai Road, Prayagraj (Allahabad) - 211002

Ajoy Ghatak,
President

MESSAGE

October 27, 2022

I have been informed that an international traveling exhibition, "Vaccines: Injecting Hope" is being organized by the National Council of Science Museums, Ministry of Culture, Government of India in collaboration with Science Museum Group and with support from Wellcome, UK, ICMR, India and other research and scientific organizations. The exhibition is scheduled to be inaugurated in New Delhi in November 2022 and further travel to Nagpur, Mumbai, Bengaluru, and Kolkata till September 2025 with an objective to tell the story of the global effort to find new ways to develop vaccines at the pandemic speed and look at vaccinations more broadly.

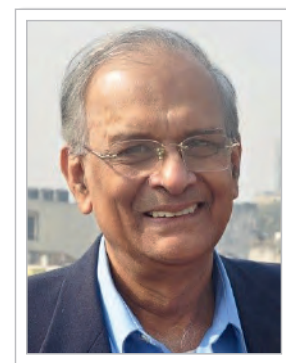
Since their inception, vaccines have played a very important role in saving human lives and proved to be a precautionary attempt against many dreadful diseases. The recent COVID 19 pandemic has distinguishably highlighted the importance and needs for vaccines. NASI and NCSM have collaborated on many River Gallery Projects and NCSM has successfully executed them. NASI during the pandemic period organized several webinars on Jagrukta Abhiyan for Covid-19 - an appropriate behavior. It was very heartening to see that many Biomedical Researchers/Doctors/Scientists participated in these and gave very valuable advice to the Society at different levels regarding the pandemic, the prevention, precautions, clarifying vaccine hesitancy, etc. so that more and more people can get vaccinated. Also, the efforts of the Scientists to produce vaccines at the right time in collaboration with industries were commendable.

Considering the track record of NCSM and collaborators, it is expected that the exhibition will be very successful in communicating the importance of vaccines in saving lives. Apart from raising awareness, I hope this exhibition will also inspire millions to follow the path of scientific research to advance knowledge frontiers in science and technology in India.

I convey my best wishes for the grand success of the exhibition

Ajoy Ghatak

President, NASI



Ajoy Ghatak
President, NASI

foreword

We are lucky to have been born when vaccines for many pathogens were already available.

Without vaccines, many of us may not have celebrated our tenth birthday. We must all salute the scientists who worked hard to invent vaccines for us. During the ongoing SARS-CoV-2 pandemic, if vaccines were not rolled out in record time, millions of more lives would surely have been lost from severe COVID-19. As our population expands, we are coming in closer contact with other animal species. There is also concomitant degradation of our environment. These are increasing our

chances of contracting life-threatening pathogens. We are endowed with natural protection against many pathogens and we survive infections because our immune defense system can expel many pathogens before they can cause major harm to us. However, the intrinsic make-up of many pathogens changes over time; they evolve. And, we meet new pathogens. Our natural immune system is often unable to cope up with these challenges effectively. Vaccines work with our natural immune system to protect us from the impact of exposure to pathogens.

It is important for us to learn and to appreciate how vaccines are invented. The science underlying vaccines and how these confer protection to us. Vaccines have a long history. Some diseases have been eradicated by systematic vaccination. Unfortunately, some of these diseases are making a comeback. Newer methods are being constantly developed to create more effective vaccines. When we learn and understand these methods, we get a better appreciation of the method of science and the public good that science creates.

Sometimes, we get severely ill from exposure to a pathogen even if we have been vaccinated against it. This has been witnessed in respect of SARS-CoV-2 vaccines. Not everyone responds equally well to vaccination. The variation in response, in part, is because our natural immune system does the behave in the same way in all of us. We need to understand the innate differences in our immune system and identify the specifics of what causes variation in vaccine response. Such understanding helps create more effective vaccines.

Vaccines are not harmful. In fact, exactly the opposite. However, a section of our fellow human beings believes that vaccines cause harm to us and they resist being vaccinated. Such vaccine-hesitant persons not only put their own lives at peril but also the lives of others, by themselves becoming infected because of lack of vaccination and then transmitting the pathogen to others.

The National Council of Science Museums (NCSM), in collaboration with the Science Museum Group, London, has developed an international travelling exhibition titled 'Vaccines: Injecting Hope'. It has been my privilege to be associated with the development of this exhibition. To commemorate the rollout of the traveling exhibition, NCSM has published this Souvenir containing articles by some of the most eminent scientists of the world who have been engaged in understanding the human immune system and contributing to the invention of vaccines. I express my deep gratitude to them for their contributions. I hope that readers of the Souvenir and viewers of the exhibition will enjoy the learning experience and benefit.

Partha P. Majumder

PhD, FNA, FASc, FNASc, FTWAS, National Science Chair
(Scientific Excellence) Government of India



Distinguished Professor &
Founder, National Institute of
Biomedical Genomics,
Kalyani



Emeritus Professor
Indian Statistical
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Preface

Museums are repositories of cultural memory – gathering material objects and information to guard against its anticipated losses.

Around the world, the treasure troves of our times sit proudly among those preceding ours – in climate controlled environments, in glass boxes, on wooden shelves and under shaded lights. Yet when COVID-19 comes unannounced, museums like ours, besides having to deal with many imponderables – ranging from frequent shutdowns, juggling to protect collections/exhibits, absorbing financial blows and protecting staff and assets while staying engaged with the public – aspire to document and narrate the true-tales that helped individuals and communities overcome these difficult times. We had to tell the story of Vaccines.

Three years ago, there was exactly zero awareness on COVID-19 - simply because it did not exist yet. SARS-CoV-2, the unidentified and unnamed coronavirus responsible for the disease, was to make a species jump to humans only in the fall of 2019. By December, clusters of people were to begin reporting sick with flu-like symptoms. By March 2020 it was to travel to 170 countries, afflicting more than 7,50,000 people and command the unwavering attention of the global scientific community. At the drop of a hat, we were to switch to the Pandemic Standard Time and science, as we had known it, was to be COVID-ized.

Pandemics and epidemics are known to have focused the energies of scientific research for ages. In the short while that it has been around, COVID-19 is perhaps both the most widely and intensely studied disease. Yet this time around, we got to witness – first-hand – how misinformation, heresies, hurried conclusions etc. can create an infodemic – far more potent and lethal than





the pandemic itself. Characterized down to the last atoms, recent research related to SARS-CoV-2 is to be credited for accurate and replicable testing mechanisms, safe and approved treatment protocols along with effective and potentially life-saving vaccines for children and adults - all developed at breakneck speeds. This led India – as many other developing nations battling the unknown and unforeseen, on multiple grounds – to script its own success story. We rested on the laurels of Science itself.

All along the SARS-CoV-2 was mutating to survive – growing more infectious and lethal. It has been successful in all that and more – but till date, it is far from bypassing our vaccine-induced immunity completely. Whether made from scratch using dead, weakened or fragmented pathogens or designed as are purposed chassis fitted with payload specific to the targeted virus – vaccines train our body's immune system to produce effective antibodies to neutralize such pathogens should an actual infection occur in future. The more the virus spreads, the more it mutates and allows itself the chance to grow stronger. But with a streamlined vaccine development system, years of investment in platform technologies, the ability to convert sequential processes into parallel ones gives us an edge this time around. It's like we are pointing a thousand guns at the SARS-CoV-2 – mutations may cause some of the guns to misfire, yet the virus is never left unscathed.

'Vaccines: Injecting Hope', a joint collaboration between National Council of Science Museum (NCSM), Science Museum Group (SMG), London, Wellcome Trust, ICMR and several like-minded institutions has been designed and developed to tell the story of this global effort to find new ways to defeat a deadly disease – with only Science by our side. It is meant to portray the necessities, possibilities and methods of development of vaccines – at pandemic speed – and look at vaccinations more broadly with a historical and contemporary view. The exhibition will set out the scientific principles underlying a vaccine's creation and efficacy, while capturing the behind-the-scenes work that accompanies their rapid development, production, transport, and delivery.

We understand that no matter what precautions we take today, the next pandemic will indeed be ready for us tomorrow. Pathogens have overcome our defenses before – they are doing it now. But if the lessons of the COVID-19 days are anything to go by – our resilience would also have been tuned to match the coming dangers. Hence the urgency to take the Vaccine story to the masses. After the grand success of the exhibition 'Superbugs: The End of Antibiotics?' this is another project where we have collaborated with the Science Museum Group, London for raising awareness about the importance of Vaccines in our lives. As a first, we have added one Mobile Science Exhibition (MSE) Van to travel to the nearby areas of each exhibition location. The MSE Bus will mainly take forward the message of the exhibition to areas with little access to the Museums. In the process, I hope, the project further strengthens the bond between the two leading Science Museums network in India & UK – with a shared passion for the culture of Science.

A.D. Choudhury
Director General, NCSM

VACCINES: Injecting Hope

–Communicating the Science of Vaccines

Museums and Science Centres play a vital role in communicating the science to audiences', especially contemporary topics connected with the lives of people. COVID-19 pandemic disrupted our lives and continues to disrupt even today. The story of development of vaccines and its roll out to combat this deadly disease that too at a pandemic speed is a fascinating one and needs to be communicated along with the science of vaccines to let people know the efforts, sacrifices made by a host of people – scientists, researchers, health workers, volunteers, policy makers and many more.

NCSM has joined hands with Science Museum Group London to develop the exhibition 'VACCINES: Injecting Hope' reflecting the spirit of international collaboration between two well recognized science centre networks SMG & NCSM in UK & India respectively. The exhibition is meant to share the expertise in disseminating awareness about contemporary topics in science having current and urgent relevance for mankind. The Injecting Hope exhibition is due to the tremendous success of the past collaboration for the exhibition on “Superbugs: The End of Antibiotics?” during 2019-20.

This time the scale of the exhibition was made big with display at five venues and the novel idea of including a Mobile Science Van to reach the rural audiences. The exhibition is now planned to tour five venues in India and includes the four metros - Delhi, Mumbai, Bengaluru, and Kolkata along with a stopover at Nagpur. The exhibition is expected to reach out to more than 2 million people from November 2022 to September 2025. It has been made possible with support from Wellcome.

Sometime in March 2021, a proposal was received from Science Museum Group London whether NCSM would like to join hands for the travelling exhibition whose working title was “Hunt for the Vaccine (HftV)”. That was the time when science centres/museums were struggling to remain open and survive amidst prolonged lockdowns and closure of public places to avoid the spread of the deadly SARS-CoV-2 virus. Due to restriction in travel, NCSM & SMG representatives interacted online several times to finalize the collaboration, which was then approved by our Governing Body considering the relevance and importance of the topic and to raise awareness about the Vaccines amongst the public.

Prior to finalizing the content of the exhibition a qualitative online research commissioned by SMG was conducted during August-November 2021 to explore the target audience's knowledge of vaccines and vaccine development and to identify what they would expect from an exhibition on Vaccines. Eleven ninety-minute focus groups online meetings were held in India at four metros, which gave lot of insight for the development of the conceptual frame work of the exhibition. This was followed by a detailed discussion between the two sides on the content suitable to Indian audience involving subject experts from India. At this stage the support



received from ICMR was laudable. The inputs received from Indian domain experts helped in visualizing the exhibition best suited for Indian audience specially the youth.

The exhibition will tell the story of the global effort to find new ways to develop vaccines and look at vaccinations more broadly with a historical and contemporary view. It will set out the scientific principles underlying a vaccine's creation and efficacy, while capturing behind-the-scenes work that accompanies their rapid development, production, transport, and delivery.

With the pandemic having provided a compelling reminder of how science and ingenuity is central to people's lives and created an extraordinary opportunity to engage a global audience, in this exhibition we aspire to tell that the vaccine story has countless heroes - from the research scientists in labs, to the engineers and technicians ensuring vaccine delivery, and the thousands who volunteered to be a part of clinical trials – we hope to provide a medium to tell this stories on the national scale. The new exhibition, with some local specific content, will also showcase the efforts and innovation made by India during the COVID-19 pandemic period.

The exhibition was made possible due to the vision of leadership in both the science centre networks i.e. SMG and NCSM to take up such an important topic for making a public awareness activity. One of the highlights of the exhibition is the collaboration between several institutions and individuals in India and abroad to come together to provide artefacts and materials suitable for display as a part of the exhibit. Special thanks to Mr. Sheldon Paquin, Ms Natasha, Mr. David, Mr Alex, Ms Helen Jones and several others from SMG for their continued support and collaboration. The NCSM Advisory Committee constituted under the Chairmanship of Prof. P.P. Majumder, with experts from all related fields helped lend form and structure to the core content – ensuring the scientific authenticity of all messages that go out as part of the exhibition. Collaboration with Serum Institute of India (SII), ICMR, NIV, AIIMS, CSIR, Klenzaid and several research institutions lent the strong foundation on which the exhibition stands.

The entire team of NCSM feels proud in bringing the exhibition and we all hope that a large section of audience specially the youth of the country would be benefitted and an awareness may be generated about Vaccines in general and their role in mitigating the challenge of preventable diseases. It is entirely upto us to let the lessons of the past lead us into a more scientifically conscious and healthy future.

Samarendra Kumar

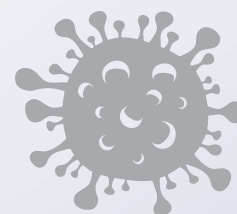
Dy. Director General & Director (Hqrs.), NCSM
ddg@ncsm.gov.in; skumar2@gmail.com



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Injecting Hope

(Previously known as Hunt for the Vaccine)

Vaccines are among the most successful and cost-effective healthcare interventions in human history. They save countless lives every year, as well as preventing long term health and social impacts caused by infectious diseases.

2019 saw the world facing a new global pandemic that threatened not only our health, but also had significant social and economic impacts, with many areas experiencing widening inequality, and women being disproportionately affected by the impacts of COVID-19, for example by taking on a higher proportion of unpaid caring responsibilities during school closures, and higher proportions of women being engaged in sectors such as hospitality, which closed during lockdowns. The combined impacts of COVID-19 on health, wellbeing and the economy meant there were high levels of political will and commitment to slow the virus spread and end the pandemic, with the development of vaccines high on the agenda.

COVID-19 vaccines were made available to vulnerable populations, such as older people or those with pre-existing health conditions, with unprecedented speed – less than a year after the sequence of SARS-CoV-2 was released.

Collaboration and co-operation between international partners and stakeholders were crucial to this rapid development of safe and effective vaccines. Scientists, developers and regulators around the world worked together, sharing information to aid the vaccine development efforts, alongside significant financial investments and focussing of human resources.

The publication of the sequence of SARS-CoV-2 in early 2020, combined with existing published research on coronavirus biology (based on SARS and MERS experiences) and decades of investment in vaccine platform technologies, meant that stakeholders were poised to act quickly to produce vaccines.

Vaccines were rapidly developed and tested in global clinical trials, with impressive results in reducing the most severe symptoms of disease. To date, 47 vaccines have been approved for use by at least one country, with 11 vaccines granted Emergency Use Listing by the WHO. This would not have been possible without collaboration on a global scale to rapidly conduct clinical trials, review safety and efficacy data and gain regulatory approvals.

The role of vaccines in ending the restrictions which were put in place during the COVID-19 pandemic has been clear, with rates of death and hospitalisations from SARS-CoV-2 infection falling after populations were vaccinated, and schools, workplaces and social venues re-opening.

Deborah King
Research Lead, Vaccines



However, the distribution of vaccines has not been equal. Whilst some countries such as the Americas, Europe and Asia boast high rates of vaccination, many countries, notably in Africa have low rates of vaccination against SARS-CoV-2, caused by early supply issues with doses not being shared equitably and lack of infrastructure to distribute doses received. As such they remain at risk from the most serious consequences of infection, further waves of infection and new variants arising. This situation emphasises the need for equity in access to vaccines globally, especially in countries with limited resources to produce their own vaccines.

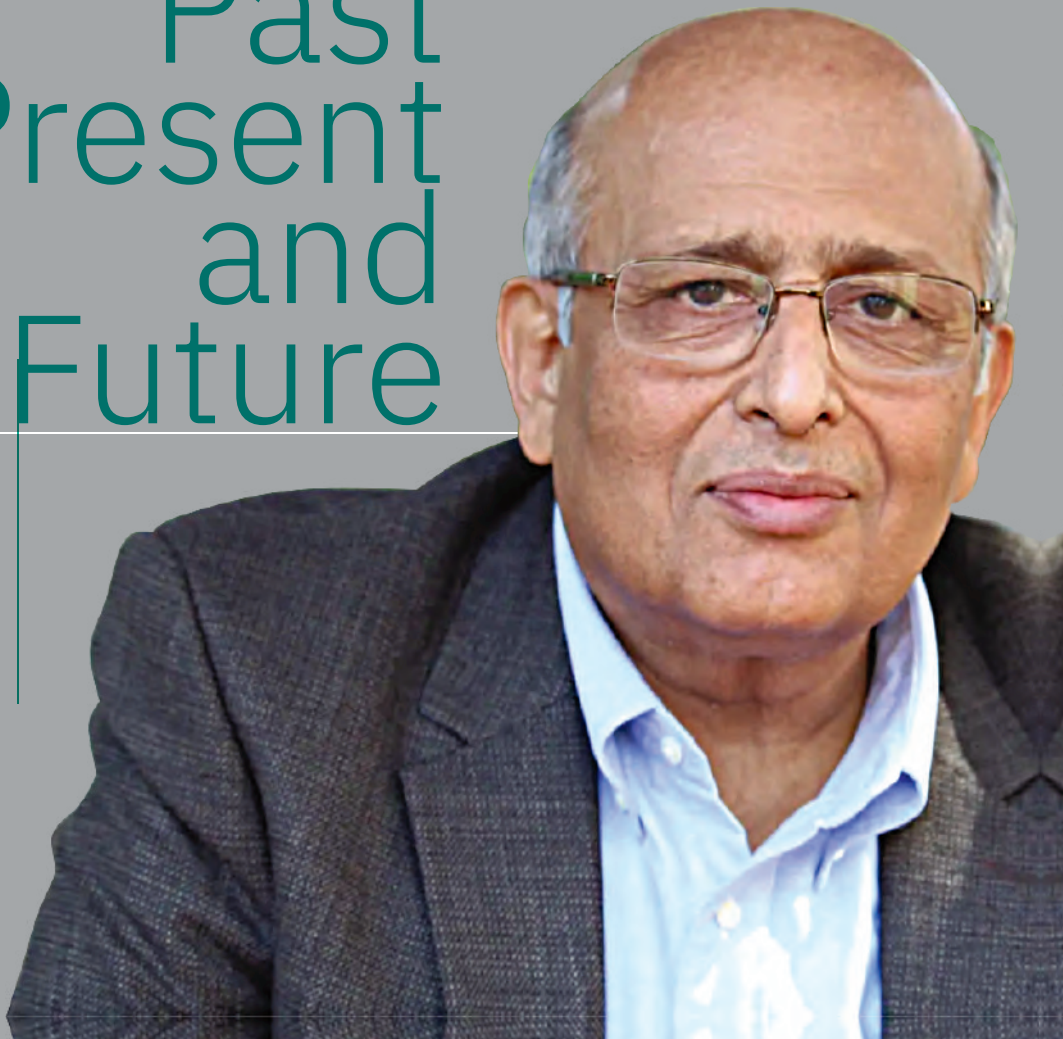
The pandemic has also highlighted the need to shift the focus from responding to pandemics and epidemics when they arise, to preventing outbreaks escalating in the first place. To achieve this, vaccine coverage rates need to be high and investment in global surveillance systems and resilient healthcare systems is required to allow life-saving vaccines to be delivered to vulnerable populations across the world as a preventative approach, rather than an intervention after the outbreak has already taken hold.

Moving forward we cannot be complacent. Stakeholders must continue to work together to leverage the momentum of the COVID-19 pandemic, continue to invest in science, surveillance systems and pandemic preparedness initiatives, and to commit to ensuring equitable access to vaccines for all diseases for those who need them most. COVID-19 showed us what was possible, that with collaboration, commitment and creativity, we can solve global health problems together.

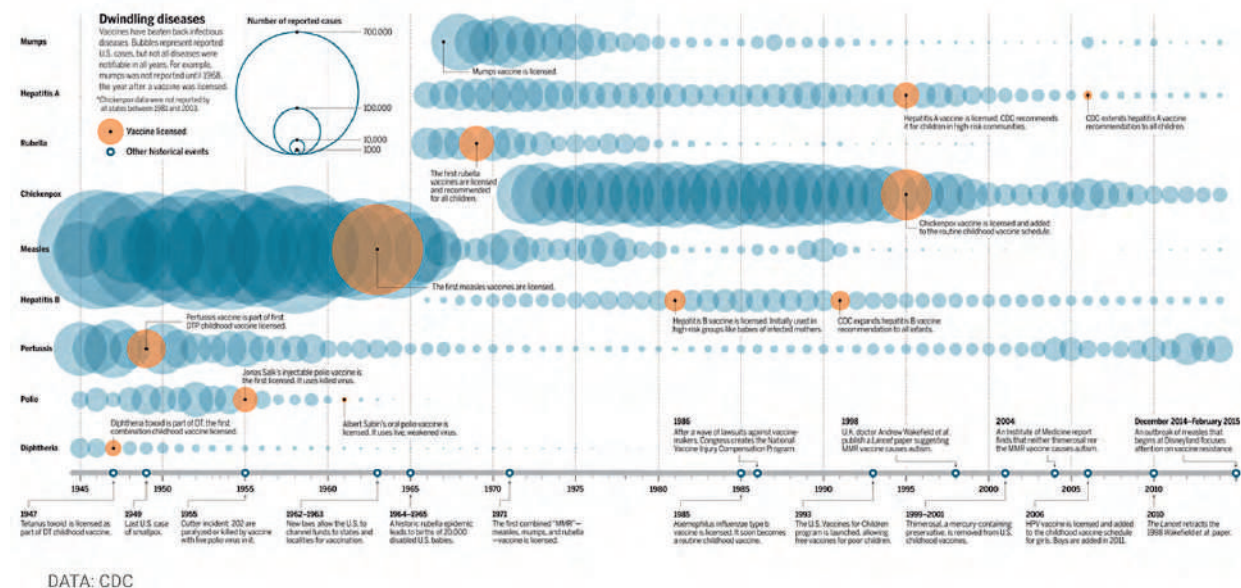
Vaccine

Past Present and Future

Shahid Jameel, PhD
Fellow, OCIS, and Green Templeton College
University of Oxford, UK
Visiting Professor, Ashoka University, India



Vaccines are among the biggest successes of medicine and public health. They save about 4-5 million lives per year and for every \$1 invested in vaccines, \$44 is estimated to return to the economy in saved healthcare costs and healthy children growing up into productive adults who contribute to the country's GDP. As effective public health tools vaccines have brought about the eradication of Smallpox and Rinderpest (a disease of cattle) and limited another dreaded human disease – Polio, to just two endemic countries. Accumulated data over the years and across every single bacterial or viral disease for which a vaccine is in use, show a dramatic reduction in the incidence of that infectious disease (Figure 1).



What is a vaccine and how does it work?

A vaccine is a biological preparation that contains something resembling the disease-causing organism (called pathogen) and provides active immunity to it. This could be a weakened or killed form of the pathogen, its toxins, or one of its surface proteins. Vaccines stimulate the body's immune system in a highly specific manner to recognize the pathogen, destroy it, and to retain memory for future encounters.

Vertebrates (including humans) have evolved two types of immunity to pathogens (Figure 2). Innate immunity is the first line of defence, which is non-specific and includes cells such as macrophages, neutrophils and granulocytes that engulf and destroy microbes. It also includes proteins such as complement and interferons that limit the spread of infection. Adaptive immunity is however highly specific for each pathogen. Detection of the pathogen or parts of it by specialised cells, some also involved in innate immunity (e.g., macrophages) stimulate two types

Figure 1

The value of vaccines.
Source: <https://www.science.org/doi/10.1126/science.356.6336.364>

of responses. The stimulation of B cells produces antibodies that bind to extracellular pathogens preventing their entry into cells, and target them for destruction. The stimulation of CD8+ T cells develops cytotoxic T lymphocytes (CTLs) that detect and destroy cells already infected by the pathogen. The CD4+ T cells help B cells make antibodies and CD8+ T cells become CTLs. Thus, the adaptive immune system follows a two-pronged approach – it destroys both extracellular and intracellular pathogens – to clear the infection. Importantly, once the infection clears, a small fraction of the activated B and T cells turn into memory cells, which are rapidly recalled to fight infection when the same pathogen infects again.

Vaccines develop both antibodies (called humoral immunity) and CTLs (called cellular immunity) – to varying degrees depending upon the type of vaccine. How successfully a vaccine develops memory B and T cells determines how long it will protect from future encounters with that pathogen. The type of immunity we develop on vaccination also determines whether the vaccine will protect from both infection and disease (called sterilising immunity) or from disease only. Most vaccines in use protect us from severe disease but not from infection.

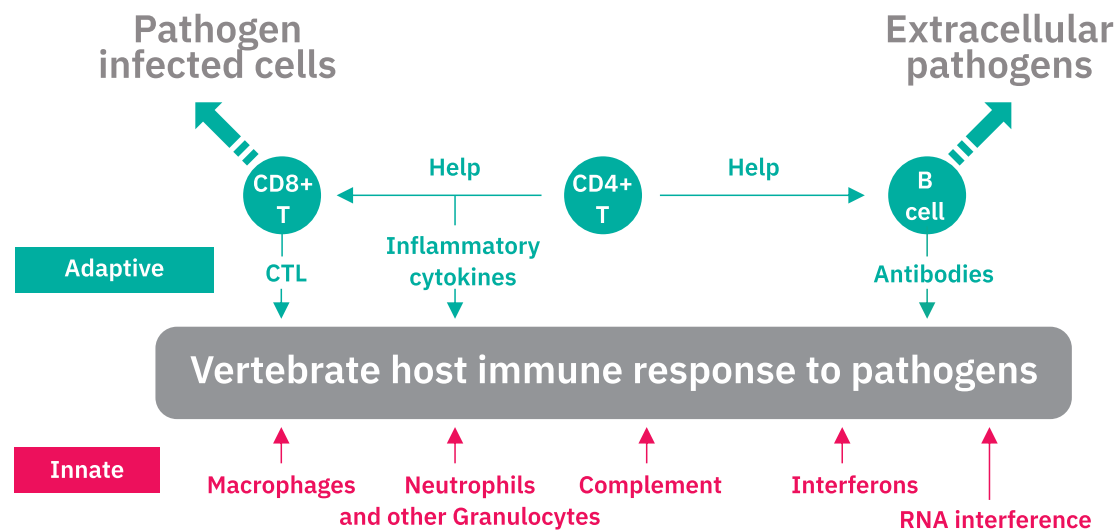


Figure 2

The innate and adaptive immune responses in vertebrates. Vaccines stimulate adaptive immunity similar to infection by the pathogen.

History of vaccination

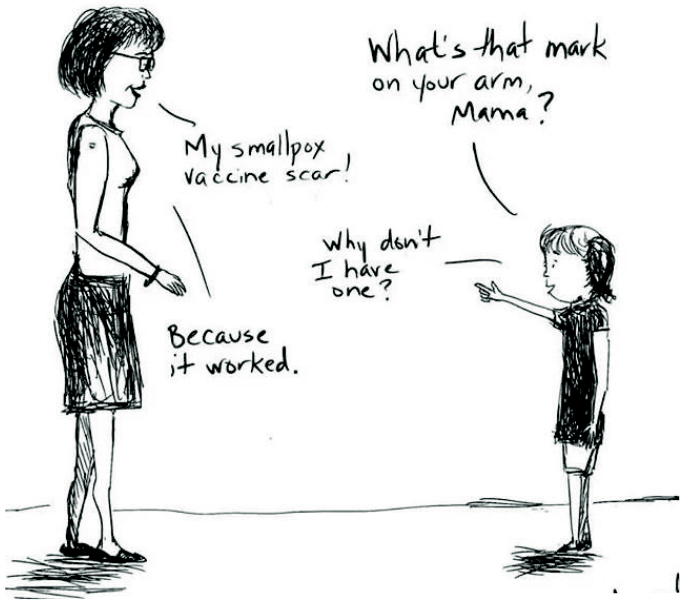
In common folklore, modern vaccination came into being on 14th May 1796 when the English physician Edward Jenner protected 8-year-old James Phipps from smallpox by inoculating him with pus from a cowpox pustule on the hand of milkmaid Sarah Nelmes. However, an ancient method called “variolation” was already being practiced for centuries in India, China, and the Orient. This involved introducing a tiny amount of pus from a smallpox pustule into the recipient's arm. If done well, variolation protected from smallpox; else it caused widespread infection, painful disease and sometimes death of the recipient.

Lady Mary Wortley Montagu (1689-1762) was an English aristocrat, writer, and poet. During the time she spent in Constantinople (now Istanbul) with her husband, the British ambassador to the Ottoman Empire, Lady Montagu learned the art of variolation and introduced it to 18th century Britain. In 1763 John Fewster, a local surgeon and apothecary in Gloucestershire serendipitously discovered cross-protection between cowpox and smallpox. However, it was Jenner who understood the implications of this

revolutionary medical advance and predicted in 1801 that vaccination would rid the world of smallpox. It took another 180 years for his prophecy to be realised (Figure 3). The vaccine used a virus called vaccinia, whose origin and animal reservoir remain unknown.

It was not until Louis Pasteur (1822-1895) and Robert Koch (1843-1910) developed the Germ Theory of Disease that microorganisms were firmly established as causative agents for infectious disease. Louis Pasteur's work on Rabies vaccine in the 1880s and that of Robert Koch on Anthrax (Plague), Tuberculosis, Cholera and the concepts of immunity initiated the development of several new vaccines. By the middle of the twentieth century, vaccines based on inactivated (killed) microorganisms and their toxins (toxoid vaccines) had been developed for several diseases such as Diphtheria, Pertussis and Typhoid.

Following establishment of the World Health Organization (WHO) in 1948, coordination of immunization as a major public health tool from the 1950s onwards, led to global programmes and the remarkable impact on child health that we enjoy today. In 1974, the Expanded Programme on Immunization was launched by WHO, setting a goal to reach every child in the world with vaccines for diphtheria, pertussis, tetanus, poliomyelitis, measles, and tuberculosis by 1990. Although global coverage of several childhood vaccines has reached ~80%, the deployment of many other vaccines is still poor (Figure 4). More than 19 million children did not receive basic vaccinations in 2019.



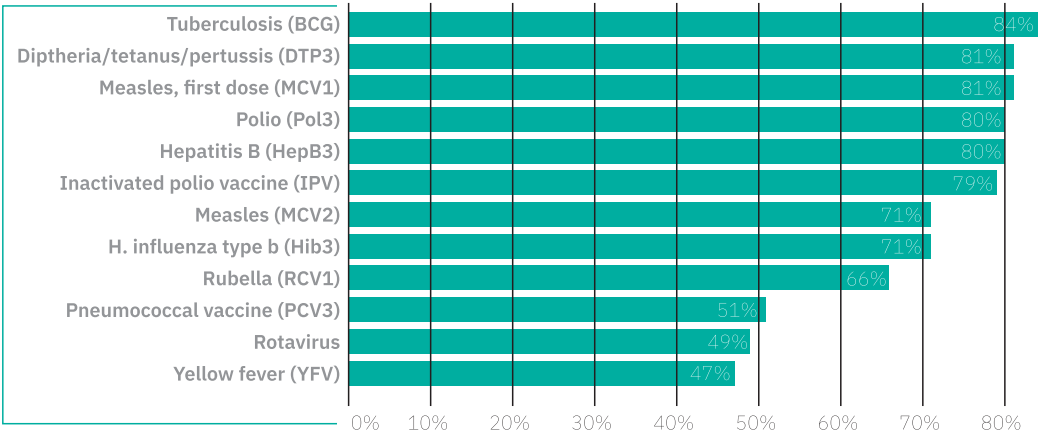
A cartoon depicting smallpox eradication due to global vaccination efforts started in 1968. The world was declared free of smallpox in 1980 and vaccination was stopped.

Figure 3

Source: https://www.reddit.com/r/europe/comments/klsvnv/vaccines_work_courtesy_of_dawn_mockler/

Figure 4

Global vaccine coverage by 2021.
Source: WHO/UNICEF through Our World in Data;
<https://ourworldindata.org/vaccination>.



New vaccines

The next conceptual leap was the use of recombinant DNA technology to develop a hepatitis B vaccine. The Hepatitis B virus (HBV) is a major cause for chronic Hepatitis that can progress to liver cancer. The unexpected discovery of “Australia antigen” in 1964, which was designated hepatitis B surface antigen (HBsAg) in 1972, and the molecular cloning and sequencing of the HBV genome in the late 1970s led to a recombinant hepatitis B vaccine. Successful cloning and expression of HBsAg in the yeast *Saccharomyces cerevisiae* led to the production of 22 nm empty particles, akin to that found in the plasma of infected persons, which was the basis for an earlier plasma-derived hepatitis B vaccine. This safe and effective vaccine was first approved by the US Federal Drug Administration in 1986. In 1991 the WHO advised all countries to implement universal hepatitis B vaccination by 1997. By the end of 2018, 189 countries had done so, with global coverage estimated at ~80% (Figure 4).

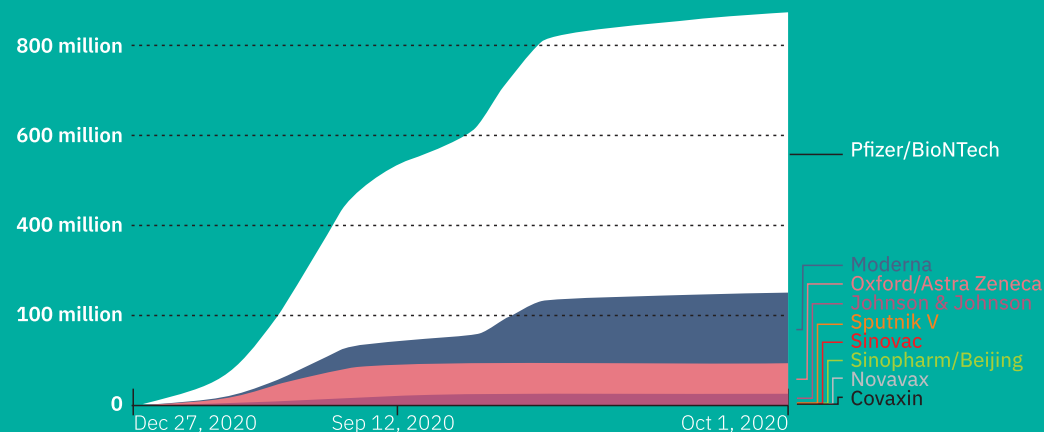
In 2006 a vaccine against human papilloma virus (HPV), which is the causative agent for cervical cancer, became the second vaccine produced using recombinant DNA technology that also protected from a human cancer. Though on the WHO's List of Essential Medicines, its global coverage remains low.

The emergence of Covid-19 has led to rapid innovation in vaccine technologies and the development, testing, licensure, and deployment of vaccines. Several vaccines against SARS corona virus 2 (SARS-CoV-2), the causative agent for Covid-19 received Emergency Use Approval in multiple countries within a year of the availability of the virus genome sequence. As of August 2022, Covid-19 vaccines have received 12 full approvals and 21 limited use approvals, and more than 120 clinical trials are ongoing for new vaccines. Over 12.75 billion doses of Covid-19 vaccines have been delivered globally, with about 68% of the world population having received at least one dose of a Covid-19 vaccine. While several countries have covered at least 70% of their population with two vaccine doses, only about 23% people in low-income countries have received one vaccine dose.

Three new technologies were tested with Covid-19 vaccines. Two of these are “genetic vaccines” that use either mRNA or DNA to deliver into cells the “code” for producing the SARS-CoV-2 Spike antigen. The third are “viral vector vaccines” that deploy another harmless virus to the same end. Examples of this include the Pfizer-BioNTech and Moderna mRNA vaccines, the Zydus-Cadila DNA vaccine and the Oxford/AstraZeneca and other viral vector vaccines. As of 1st October 2022, Pfizer/BioNTech (632 million doses), Moderna (153 million doses) and Oxford/AstraZeneca (67 million doses) are the most used vaccines across Europe (Figure 5).

Figure 5

Covid-19 vaccine doses administered by manufacturer in The European Union.
Source: Our World in Data;
<https://ourworldindata.org/vaccinations>



Future vaccines

Next generation vaccines will have to address two important challenges – cover multiple viral strains and variants and use a distributed manufacturing model to improve vaccine access.

Seasonal flu vaccines are valuable tools in mitigating flu but protect against only the narrow range of strains projected to be most problematic in a given year. This requires global year-round surveillance that is challenging and expensive. Even in the best years, effectiveness of seasonal flu vaccines are barely 60% but can be as low as 10%. Despite seasonal vaccines, influenza causes an estimated 290,000 to 650,000 deaths globally; a novel flu virus without a vaccine could lead to a pandemic that can kill millions. A broadly protective flu vaccine has been a goal for decades, and thanks to new vaccine targets and more effective delivery platforms, it seems attainable. A “universal” vaccine should be at least 75% effective in protecting all age groups for a minimum of one year against all influenza A strains and possibly also influenza B for three to five years.

The rapid emergence of SARS-CoV-2 variants and the inability of currently available Covid-19 vaccines to protect against breakthrough infection in fully vaccinated people has raised the bar to

develop vaccines that would protect against multiple variants. A mosaic nanoparticle vaccine has shown promise in pre-clinical studies and is being taken up for human trials. If successful, similar approaches could be used to develop pan-Coronavirus vaccines to protect against SARS as well as seasonal coronavirus respiratory infections.

Emerging and re-emerging infectious diseases are on the rise due to multiple factors related to ecology, environment, and climate change. The future belongs to preparedness instead of reacting to a disease once it has emerged. Of the 23 families of animal viruses known to infect humans, we have no vaccines against any virus belonging to 9 families. Even when available, the vaccines do not cover all members of a given family of viruses. This is the challenge and opportunity for the immediate future.

As seen during Covid-19, traditional live-attenuated or whole-inactivated vaccine approaches developed by classical methods were neither rapid nor effective in responding to the pandemic. Future vaccines against emerging infectious diseases will be based on newer gene-based antigen-delivery technologies, which were tested during the current pandemic. The ability to quickly synthesize nucleic acids has made it possible to rapidly translate sequences identified in the field into candidate vaccines. These sequences were communicated electronically without sharing physical samples, which is a good justification for sequencing-based surveillance and vaccine production to be broadly distributed throughout the world. Pfizer's partner BioNTech is developing mRNA vaccine factories in shipping containers that can be taken to parts of the world which lack their own vaccine-manufacturing capabilities (Figure. 6). The first such “factory” is expected to be deployed in an African country towards the end of 2022. If successful, this disruption can dramatically improve vaccine access.

Instead of being a bolt from the sky, like all other developments in science, vaccines and immunization practices have evolved in time. This process was helped along by conceptual breakthroughs that have become more frequent as we improve our understanding of other sciences. It speeded up with our understanding of “germs” that cause disease to a point where we now understand better the molecular basis of disease. New developments in life sciences, artificial intelligence and engineering are already impacting how we develop, manufacture, and deploy vaccines. However, as we have seen during the current pandemic, challenges of equity and access remain. Science has brought us to a point where we can make a big jump in preventing infectious disease. Social science must simultaneously find ways to improve trust and reduce human greed for vaccines to reach all.



Has the Coronavirus changed our Perspective of Science?

Roger Highfield, Science Director, Science Museum Group

Never before has science been so consistently on the minds and lips of people around the world. Never before have so many of the world's researchers focused so urgently on a single topic. Never before, has science been so supercharged.

I have written about many public health emergencies, from the rise of HIV to when mad cow disease spread from cattle to people. But the coronavirus pandemic reached altogether a different level in terms of the impact and response, changing both the way we view science and the way that science is done.

Unsurprisingly, surveys reveal that the pandemic brought the public closer to science, so they viewed it more warmly. Globally, those who said they trust scientists 'a lot' has risen from 34% in 2018 to 43% by

the end of 2020. Perhaps most remarkable of all is that the public could see science at work, and they were gripped by the unfolding drama.

I discovered their fascination first hand. I started to write long form blogs about COVID19 science in the spring of 2020, in a question and answer format, and, due to the interest, ended up writing more than two books' worth, dozens of blogs that covered topics ranging from the art of COVID to the science of vaccine development and, for more specialist audiences, organised a special edition of a Royal Society journal, Interface Focus.

During the pandemic, the public could see the scientific process and how science works. They witnessed researchers struggling to understand and quantify the threat and weigh up the possible responses through the cracked crystal ball of modelling (with the old caveat that all models are wrong, but some are useful), then witness how that understanding transferred into policy.

With tens of millions of lives at stake and no treatments or vaccines to hand, scientists initially fell back on tried and tested principles of contact tracing and isolation. As the story developed, a handful of doctors and researchers became household names, creating some unlikely stars who I have no doubt will help inspire the next generation of scientists—hopefully a more diverse one.

Scientists raced to understand the virus's biology, to find treatments and find ways to bring the pandemic under control. Perhaps there is no better example of the power of science than the race to develop an effective COVID19 vaccine, the subject of the exhibition we have been working on with the Guangdong Science Center in China, and the National Council of Science Museums in India. Within 11 months the first vaccine was produced – a process that often takes 10 years. Most remarkable of all, scientists showed the value of a brand-new way to train a person's immune system to recognise a microbial invader, using scraps of RNA genetic code.

As the pandemic unfolded, the public could see that great science rests on both experimentation and theory. The debate in Britain about the value of facemasks is a good example of how you need both. Anyone who adopted a mechanistic view would find it hard to imagine how face masks would not reduce the shedding of infectious droplets and aerosols into the environment by asymptomatic or pre-symptomatic people. Yet their introduction was questioned initially because of the initial lack of good experimental evidence of their value, in the form of randomised controlled trials, along with, perhaps, an element of racism and exceptionalism—'we Brits don't wear masks.'

This is just one example of how the public got a ringside view of how science is done. Yes, science is the most powerful way we have to understand the world, but you have to do it properly. You have to design the experiments as carefully as you possibly can and, when the results are in, consider any alternative reason for your results, even those that render it dull or undermine your hypothesis.

The scramble to fight COVID-19 also showed the public how science is ultimately a human endeavour. There

were those scientists who published prematurely so their results can be applied as soon as possible. Others hurried a piece of work because the results may be so significant and the rewards – both financial and reputational - may be great; some made mistakes, and a few were plain dishonest. Enthusiastic but inexperienced scientists from outside the medical sciences both muddied waters and wasted time. COVID-19 was another reminder, as if we need it, that scientists are human beings.

In the great majority of cases, though, especially if the results are indeed significant, the truth was eventually revealed in follow up research, though it does take time. We saw false hopes raised over treatments such as hydroxychloroquine and blood plasma infusions but, as others tried to validate this work, those hopes were eventually dashed.

But while COVID-19 highlighted the seamier side of science, it has also brought out the best in people too. I have never seen the global research community rally so effectively around one cause. Within weeks of the first case of COVID being reported, Chinese researchers had identified the virus they suspected of causing this novel respiratory disease and had decoded an initial genome sequence. It took a matter of days for scientists at Oxford, the US National Institutes of Health, which partnered with the biotech company Moderna, and the German firm BioNTech to design a vaccine based on the virus spike protein. The UK's Medical Research Council, of which I am a member, took early calls for proposals in February 2020 and the research community mobilized to submit and review grants more rapidly than ever before. Covid-19 UK genomics (Cog-UK) became a major effort in charting the evolution of the virus and development of new strains. The world's largest vaccine manufacturer, the Serum Institute of India, committed to produce billions of doses.

Scientists acted with unprecedented speed and coordination to deliver us an armamentarium of tools to confront this global threat, not just vaccines but tests and drugs too. The UK launched Recovery, the world's largest trial of drugs for COVID-19 that revealed, for example, the value of dexamethasone, a cheap and widely available steroid. The pandemic helped cut red tape when it came to approving vaccines, where the usual approach of working in series, as it were transformed to parallel working, in an effort to get a vaccine as quickly as possible. Francis Collins, the director of the US National Institutes of Health (NIH), said the response was unprecedented: "It has been all hands on deck."

The phenomenal effort will change science – and scientists – forever because it shows that in extremis, we can work together to find practical solutions and do extraordinary things.

The way scientists interact with each other may also be changed by COVID-19. While there will always be a desire to meet at conferences and discuss novel results and new ideas, the pandemic showed that scientists can present their results worldwide on BioRxiv at the touch of a button, speak to colleagues on Zoom, and get access easily to much of the data they need. The pandemic encouraged them to share new ideas and data immediately and transparently rather than await publication in a well-respected journal, which could take

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months and sometimes more than a year. Video conferences cut carbon emissions and they can be more inclusive too—for some disabled scientists, for those who lack childcare, ample funding, or those who face travel restrictions. In this way, the pandemic has helped to foster a new research environment, one that is now structured for collaboration and communication above all else.

The public also witnessed debates between scientists and policymakers. The mantra in the UK at least is that scientists advise, and ministers decide. But they don't necessarily agree. In the UK, there was an early spat over how, rather than set up centralised laboratories, hundreds of scientists working in small laboratories could create a 21st-century scientific flotilla of 'little ships' to avert Britain's threatened coronavirus crisis by increasing testing. The battle over the value of modelling continues, though it is hard to see how ministerial judgement offers a better alternative, even if your mathematical model is built on assumptions and incomplete data.

A key question remains. Will the sense of shared purpose, quick data sharing and transparent cooperation seen in the pandemic be fleeting or will it mark the start of a new era of scientific collaboration and global partnership? Above all else, can the increased levels of trust in science be maintained? In the wake of COVID-19, politicians around the world should be reminded that the extraordinary speed of vaccine development was only possible because it rested on research that had been conducted for decades. Science is a tradition built on centuries of incremental progress.

Let's hope that new collaborations, funding routes and systems for sharing data and genetic surveillance will be maintained to shape research from now on. Imagine the exponential increase in the power of science to do good if our collaborative efforts thrived—a global scientific community that works across borders and subject boundaries, where researchers are all united against the most pressing social, economic and environmental problems of our time. We all need to be ready because many of the root causes of climate change also raise the risk of yet another pandemic.

Roger Highfield

Science Director, Science Museum Group



5 steps to design a new vaccine



1

Select a Disease

There exist many diseases that can be prevented by vaccines and vaccines can also reduce the risk of diseases spreading to others. Using traditional research and development methods, the time taken to develop a vaccine for a new pathogen (a disease-causing agent) typically takes between five to ten years, but for some pathogens it has taken longer, if achieved ever (Excler et al., 2021). During a disease outbreak or global pandemic, the pressure to develop a vaccine against new pathogens in a rapid time is more acute. The quick turnaround for the development of COVID-19 vaccines has been unprecedented, as has been the increased collaboration between industry and academia. For example, the Oxford-AstraZeneca vaccine was developed by Oxford University, with AstraZeneca gaining marketing rights to supply the vaccine on a not-for-profit basis to low- and middle-income countries (LMIC), and to high income countries during the pandemic.

Research still continues to improve vaccines, make them more cost-effective, and develop vaccines for more diseases, both old and new. Once a pathogen of interest has been identified, scientists need to make an informed decision about how to target the pathogen. They must utilize what is known about the pathogens structure, lifecycle and behaviour as well as how our immune system is likely to target it and the vaccine type most likely to complement these factors.

2

Decide on a Vaccine Strategy

Vaccines typically target one or more components on the surface of, or within the pathogen, which we call antigens. These are often made up of proteins or sugars, or a combination of both. Antigens are unique to different pathogens, but related pathogens often have similar antigens. If scientists have previously identified the weak spot or 'Achilles heel' of a related pathogen, there is a good chance the same approach will work. For many vaccines, scientists attempt to mimic the natural immune response to a pathogen, which often protects us following exposure. However, for some more complicated pathogens, such as malaria, natural immunity often only protects against disease, not infection, and so inducing a novel immune response may offer more complete protection.

The different approaches to vaccine development can be divided into broad categories that have unique strengths and weaknesses identifying them as a preferred option for a new vaccine. These include whole pathogen vaccines, subunit vaccines, virus-like particles (VLPs), nucleic acid vaccines and viral vectored vaccines (<https://vk.ovg.ox.ac.uk/vk/types-of-vaccine>). It is important to note that not all approaches might work for a given antigen or disease as every vaccine interacts with our immune system in a different way.

3 Make the Vaccine

For the active components of a vaccine, manufacturing methods, the associated development timelines and relative costs are highly determined by the vaccine approach selected. However, many approaches share several core technologies. It is important to note that vaccines are typically manufactured first in pre-clinical batches at small scale before they are made to 'Good Manufacturing Practice' (GMP) standard for use in humans. Part of the challenge is making sure that methods used for small scale manufacture can be scaled up accordingly.

Traditional methods, such as whole pathogen vaccines and sub-unit vaccines are typically cheap, but manufacturing often requires tailored solutions. Newer platform or 'plug and play' technologies such as viral vectors, VLPs and mRNA vaccines often have higher initial production costs but are quicker to progress, as different vaccines can be manufactured using the same manufacturing set-up. In time such costs will drop, especially with economy of scale, as has been seen with adenoviral vaccines during the COVID-19 pandemic. Reduced costs also have important consequences for providing affordable vaccines for LMICs.

At this point, it is also important to consider the non-active ingredients added to vaccines. Like additives to food, many of these fulfill the primary purpose of improving product stability and longevity (<https://vk.ovg.ox.ac.uk/vk/vaccine-ingredients>). The ability for vaccines to be stored at higher temperatures is a goal that vaccine developers strive towards, but for newer vaccines such as mRNA vaccines further research is still required to reduce the requirements for ultra-cold storage. There are also some ingredients that must be considered for inclusivity, for example, due to allergy or religious objection. The latter may also be applicable to the manufacturing process of the active component despite ingredients not being in the final product.

4 Test with Pre-clinical Trials

Before vaccines can go into clinical trials in humans, they must undergo pre-clinical trials, typically in animal models to ensure the vaccines are both safe and induce a functional immune response. The majority of pre-clinical work takes place in mouse models, which offer flexibility and cost-effectiveness. In some cases, however, mice are poorly representative of disease progression in humans or the human immune response to disease, and more representative models, including non-human primates (malaria, Ebola virus) or pigs (Influenza) may be more suitable. For novel 'One Health' vaccines, pre-clinical animal models, often livestock, are not just used as human proxies but are selected with the intent to use the same vaccine in both the livestock and humans in the future.

Any talk of animal research comes with discussions over the ethical considerations of such work. In modern scientific research, all animal work must be strongly justified, and strict standards of care followed. Scientists are actively looking into reducing dependence on such models through various initiatives like the '3Rs' (<https://nc3rs.org.uk/who-we-are/3rs>), but a vaccine developed entirely in an animal-free system is still a long way off.

5 Test with Clinical Trials

As we have outlined, there are many steps needed to bring a vaccine to market. The last step is testing through clinical trials, which are divided into phases. Phase I is to test healthy volunteers (a few dozen) to look at how safe the vaccine is, whether it has immunogenicity to produce an immune response, and if it has any adverse effects. Next is to move to more people (several hundred) in a phase II trial for efficacy of whether the vaccine works by protection against disease in a 'target population' who are ideally at most at risk of the disease. This may include children, the elderly or individuals in a country that is endemic for the disease of interest (i.e. it is circulating regularly). The last phase III is testing for efficacy and safety in many people (several thousand). 'Challenge trials' or human infection studies (CHIMs) can speed up process by infecting and then carefully monitoring healthy volunteers with a pathogen to test new vaccines (Kirchhelle & Vanderslott, 2021).

What then are the key measures of vaccine success? The most important measures as mentioned are tested across the stages of clinical trials: safety, immunogenicity, and efficacy. A vaccine however does not need to be 100% protective to have an impact. Significantly reducing serious disease and preventing hospitalizations, as seen during the COVID-19 pandemic, can be just as impactful.

The future holds many challenges for vaccine development as some diseases (e.g. HIV/AIDs and leishmaniasis) are still lacking effective vaccines. New development and delivery techniques present greater opportunities, including for diseases not typically thought of to be prevented via vaccines, such as cancer. However as Professor Dame Sarah Gilbert recently highlighted at the 44th Dimbleby Lecture, investment is still needed:

“One particular area where investment is clearly needed is vaccine manufacture. Both nationally and internationally we must improve, and spread out, our capacity to manufacture vaccines at scale. That means supporting research into manufacturing methods; and investing in facilities – and, crucially, the scientists and engineers who are going to work in them. We particularly need to ensure Africa has its own modern manufacturing capabilities to ensure its own local supply”.

Visit the 'Vaccine Knowledge Project' based in the University of Oxford at <http://vk.ovg.ox.ac.uk/> for more information about vaccines, including about types of vaccines and their ingredients.

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VACCINES: SAVING HUMAN LIVES FOR CLOSE TO A MILLENNIUM AND STILL TEACHING US ABOUT PROTECTIVE IMMUNITY

It was an English woman who introduced the age-old ritual of protecting people from small pox infections practised in the east to the west.

Small pox, caused by an infection now known to be by the variola virus, had been ravaging human communities since the prehistory. There has even been evidence of small pox in Egyptian mummies, dated 1500 years BCE. In the 18th century Europe was ravaged by the disease. Family of this English woman, Lady Mary Wortley Montagu, was also not spared. Mary Montague is credited for first bringing the practice of variolation, as this eastern practice was called, to the West and popularizing it. She came across the practice in Istanbul in Turkey, where her husband served for two years as a British ambassador in Constantinople.

Small pox caused fluid-filled blisters (or pustules) on the skin as well as other linings of the body and often these blisters dry up and fall off causing scabs to form. Mary encountered this practice in Turkey, wherein powdered smallpox scabs or fluid from pustules were rubbed into superficial scratches made in the skin of healthy individuals, with a belief that it would prevent from contracting small pox. Mary took account of anecdotal evidence for the efficacy of this method and wanted her son Edward to be variolated. It was 1718 AD. The method worked in some healthy individuals by preventing them contracting the disease, although a lot of them got the infection from the variolation practice itself, mostly a milder form of the disease, in some though it led to full-blown disease. Nevertheless, Mary, when back in England after her sojourn in the East, tried her best to popularize it. It was not the first time that the West was in the know of this practice. Even before Mary reached Constantinople, an Italian Physician named Emmanuel Timoni encountered the practice, in Constantinople itself, and wrote about it in a British Journal in 1714. But his account was barely paid any attention to.

The geo-historic origin of this practice of variolation to protect against small pox is not established. In ancient China and India variations of this practice might have started as reported by different British officers who later came to serve the British colonies there. For example, in China powdered scabs from the patients of small pox having milder symptoms used to be blown into the nostrils, referred to as a method of 'nasal insufflation'. In India a practice quite similar to the Turkish one had been reported by British officers stationed here. It was done by a group of itinerant experts, called 'Tikadars'. This name led to modern vaccines being still referred to as 'Tika' in Indian languages.

But it was Edward Jenner, the eighteenth century British physician, who first showed that by using similar pustular material from cows suffering from cow pox, due to infection with a different pathogen (now recognised as the vaccinia virus) that caused very mild disease in humans, the risk of severe disease due to variolation could be avoided while retaining its protective property against small pox in humans. It was termed vaccination (originating from Latin word 'Vacca' for cattle). In 1796 Jenner inoculated an eight year old boy named James Phipps (the son of his gardener) to test his hypothesis. Of note here, the original observation of infection with cow pox protecting humans from contracting small pox was reported by many contemporary physicians in Europe, Jenner is credited

for generating a clear hypothesis, testing it and in that process developing a defined vaccine to induce protective immunity.

Protection from infections is referred to as 'immunity' by us and modern biology has taught us that in all multicellular organisms like us, wherein billions of cells make up the whole body, there are cells commissioned to solely deliver this function of immunity. We call them as immune cells, they constitute the whole blood cell portion of the circulating blood (also present in different organs and tissues in the body in great numbers) and come in different flavours. The flavours or types relate to cells that perform different assigned functions, talk to each other and develop protective immune functions in the body. The intricate biology of these immune cells constitutes the domain of immunology. The practitioners of immunology, the immunologists, strive to better understand the functions of the immune cells, so that they can be tinkered to achieve protection against various diseases wherein immune cells are involved, among them a major focus is of course on infections.

How did the methods of variolation or vaccination work? What these methods essentially constituted of was exposing a healthy body to the pathogen-derived materials, in albeit low doses or from a less severe but related pathogen (like cow pox as opposed to small pox). At the time of Jenner there was no knowledge about immune cells in the body. But in retrospect we understand that these innocuous exposures of pathogenic material actually served to train the immune cells in the body. Now we know

that trained immune system are better-equipped when they encounter the actual pathogen (like small pox) later on, act faster and prevent the pathogen from causing life-threatening disease. Thus the science of immunology, which in the modern times deal with developing newer vaccines against existing and emerging human pathogens, actually saved millions of human lives even before the scientific domain was formally in existence.

Jenner might not have been aware of the immune cells and the exact bodily mechanisms of immunity, but the concept of vaccination developed by him and other contemporary physicians that used cow pox pustular fluid to induce immunity against small pox, already pointed to plausible commonalities of how the body reacts against different pathogenic microorganisms. Immune cells and their functions in the body provide such commonality of reaction against pathogenic microorganisms. Modern vaccines also follow a quite similar concept. They consist of either specific molecular components of a microorganism like virus or bacteria (e.g. hepatitis B vaccine) or killed or weakened whole microorganisms (e.g. polio vaccine, mumps vaccine, chicken pox vaccine, measles vaccine, flu shots or Covaxin, the recently developed Indian vaccine against SARS-CoV-2 virus). On vaccination the immune system in the body is trained to recognize these entities on encountering a live potentially disease-causing, i.e. pathogenic microorganism and reacts against its invasion.

While the intricate details on how different immune cells cooperatively function to generate this protective immunity after vaccination is beyond the scope of this article, we can think of an allegory to understand the basic principles. Immune cells act as sentries in the community of cells in a multicellular organism, just like the sentries that were commissioned in any human community from the very beginning of social living (in fact very often immune cells are referred to as immune sentinels in core immunological parlance as well). Vaccines can be thought of means to show the sentries fragmented images of potential wrongdoers. The sentries memorize those images and on future encounter with wrongdoers, which are closely reminiscent of the memorized images, they affect a vehement protective drill. 'Memory' is also a frequently used word in immunological parlance, as the potential for trained immune system to recognize a pathogen on a later encounter is referred to as the

'immune memory'. Protective potential of a given vaccine depends on how well it generates this immune memory. A natural infection, by a live pathogenic microorganism, also induces similar immune memories. Again extent of such immune memories determines whether an individual succumbs repeatedly to the same microorganism or how long an individual is protected from the same.

We are not going to delve deeper into how the immune cells get trained, generate memory or react against pathogenic microorganisms, much of which is now well established due to extensive research in this domain since the early twentieth century. Nevertheless, it will be useful to understand that the molecular entities in the pathogenic microorganisms that help create the 'images' are mostly proteins that are present in those pathogens. We know that in a cell all the functions are largely governed by proteins, and protein are synthesized following a defined code scripted in a corresponding gene along the DNA strands the cells harbour inside their nucleus. In between the code written on the DNA and protein synthesis comes the role of cellular molecules called messenger RNAs, which transfer the coded information from the DNA to the protein synthesizing machinery. On the other hand the molecular entities in immune cells that are responsible for recognizing such pathogen-origin proteins are also mostly proteins, again coded in the DNA of the host.

This protein nature of the pathogen-derived molecular entities as well as the recognition modules on the immune cells is important in

understanding modern vaccines, both in terms of their effectiveness as well as failures. A major impetus in the modern vaccine development efforts are on making vaccine based on the DNA or mRNA sequences that code for the specific pathogen-derived proteins. The reason for the interest in this approach is that these molecules are easily synthesized in laboratories, easily customizable for emerging pathogens and have potential for faster scaling-up. In the recent pandemic of SARS-CoV-2 coronavirus we have seen successful implementation of such modern approaches (e.g. the Covishield vaccine used the DNA code for the coronaviral protein provided within another virus not supposed to cause disease in humans, the mRNA vaccines on the other hand utilized mRNA molecules corresponding to a coronaviral protein).

These basic molecular level details of immune recognition also should help us understand the oft-encountered vaccine failures. The DNA or RNA in the microorganisms accumulates variations in their sequences as the microorganisms proliferate and transmit between hosts. These variations are reflected into the proteins they contain, which are used by the immune cells in our body to recognise them. Now a change in such proteins may lead to recognition failure, rendering the immune memories generated by past vaccination (or even natural infections) useless, making the host susceptible to infection by such changed microorganisms. We have encountered this in many infections, as well as during the recent pandemic. This is the reason the flu shots need to be redesigned with every season of flu. This is the reason the so-called 'break-through infections' keep happening by the emerging strains of coronavirus in vaccinated individuals. In fact, very few pathogenic microorganisms generate life-long immune memory on vaccination or infection, as that requires them to be very stringent about allowing variations in their genetic codes.

We have come a long way since the days of variolation. While we presently have vaccines to protect against just a few infectious microorganisms that cause human diseases, even those few vaccines among themselves could save billions of lives since they have been in use. A number of infectious microorganisms could be eradicated from large parts of the world thanks only to these vaccines. Knowledge in biotechnology and immunology is accumulating in great pace and enabling scientists to improve efficacies of existing vaccines and generate vaccines against difficult microorganisms by adopting novel approaches. Principles of vaccination are even being adopted in tackling several non-infectious diseases, e.g. cancer, and being proven to be successful in a number of contexts. Thus the vaccines predate the science of immunology but remain the mainstay for translating modern science of immunology for human benefits till date and will remain so for quite a sometime in the perceivable future.



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The recent pandemic was a global moment of learning

Governments rapidly came to understand the importance of supply chains, disaster preparedness and public messaging during the turmoil. For scientists, this was also a time to fully realise the potential of mRNA vaccines, rapid data collection techniques and streamlined medical testing practices.

Yet through all of the upheaval in this era of quick decision making, a very consistent value rung true across the globe: the significance of international partnership and collaboration.

It is in this enterprising spirit of transparency and teamwork that Injecting Hope also emerges, bringing together museum networks in India, China and the UK to help tell this painfully learned lesson of recent history. It has been a real pleasure seeing these three national tours of this exhibition take shape. My colleagues have truly embraced the partnership in the same spirit as the story we are seeking to tell. Through this collaboration, Injecting Hope will feature in national tours in India, China and the UK with shared resources and expertise, creating something across all three countries that would be greater had they been developed in isolation. Ironically, it has been the normalisation of remote working spurred on by pandemic that has allowed this exhibition to be a work of collaboration, with endless hours of video calls spanning far too many time zones. The collaborative nature of this project has shone through every aspect of the exhibition.

Of particular note in Injecting Hope in all of its iterations is its use of art. Across all three countries, stunning art pieces have been developed to reflect the content and unique aspects of the national tours. In the UK, etched and illuminated planes of glass first greet the visitor upon entering the exhibition space, creating a dazzling visual representation of the SARS-Cov 2 virus. In China, an immersive experience challenges visitors to reflect on the international trauma slowly making its way into the past via a walkthrough visual timeline. Here in India, the sculpture and animation piece - funded generously by the British

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Council - connects India's powerful past with its present, drawing a link between the first vaccination programs (when it was still the unrefined process of variolation) and the modern day. It is inspiring to see how consistently the interplay of science and art has been embraced internationally through this project and it is most fitting to feature these powerful displays at the juncture between the scientific and the deeply human act of working to alleviate suffering.

It is my sincere hope that the partnerships that have emerged across the globe in these painfully eventful two years remain for many years to come. Initial genetic testing from China, research and development in of Europe, and production capacity of India synchronised to deliver this symbol of international friendship and hope for the future. From my own much smaller standpoint, I also hope that this project represents the second of many more exhibitions developed together across borders to showcase human ingenuity when it has the most profound impact. One of the Science Museum Group's mission statements is to 'inspire futures', which often is in reference to our visitors; perhaps this is also an opportunity for Injecting Hope to inspire our own future as well, connecting us with the National Council of Science Museums and the Guangdong Science Centre far down the line.

It has been a real pleasure working on Injecting Hope and I would like to extend my sincere thanks to the project teams at the NCSM, GSDC and SMG for their tireless efforts in making this exhibition a come to fruition. Also, thank you to Wellcome for believing in the exhibition and empowering us to embark on this journey together.



A Curator's View

Mrs. Natasha McEnroe

Keeper of Medicine, Science Museum, London

From the earliest days of the COVID-19 pandemic, curators at the Science Museum in London have sought out objects and stories that would enable us to preserve this important moment in history for future generations to study and understand. The curators' perspective, as historians of medicine, helped us to address a difficult question. How, when collecting objects that represent contemporary medical science, do we know what will be seen as important in the future? Which inventions are ground-breaking, and which might fade away? What material might reflect direct experience of medical practitioners – or patients? Items in museum collections relating to previous pandemics are often rare, so when COVID-19 began, the Science Museum curators were aware that material of interest for historians of the future was at risk of not being saved unless they acted fast. Now, nearly three years after the pandemic began, the Science Museum holds over 1000 objects relating to COVID-19 – ranging from items associated with testing technology and vaccine development to personal ephemera, artworks and shop signage. Collecting material relating to COVID-19 at a time when the pandemic was still happening proved to be a challenge – medical practitioners and scientists were occupied on important work, and often much of society was in lockdown or enforced isolation.

At the Science Museum, our aim is to reveal the wonder of science, inspiring young people to seek careers in science, technology, engineering, and maths. But communicating the complex and rapidly changing world of science in ways that are understandable to our visitors is often a challenge. We communicate scientific endeavour in a variety of ways – through live events, digital interactives and – most importantly – through displaying and interpreting actual objects in exhibitions or galleries. To inform and entertain our audiences, our communication needs to be easily interpreted and for its relevance to be clear. For our visitors, the reality of seeing a piece of history in person can inspire and inform in a way no other method can.

In order to collect and to communicate authentic science stories effectively, our most important tool is that of collaboration. Working with partners allows us to not only reach wider audiences but also to think more creatively than we would if working alone. The exhibition *Injecting Hope: the race for the COVID-19 vaccine* is an excellent example of this. Three key partners – the Science Museum Group in the United Kingdom, the Guangdong Science Centre in

China and the National Council of Science Museums in India – have come together to address one of the most important issues of our time – communicating how scientists worked to protect the global population against COVID-19.

Our aim was simple. To create a shared vision for exhibitions across the three partners that explored the science behind COVID-19 vaccines, to open simultaneously in the three countries in November 2022. Although the exhibition structure and narrative are the same, each country would interpret it differently, depending on the needs of its audiences. As is often the case, the journey experienced along the way has been as interesting as the outcome of the exhibition. We found, after much discussion, that the issues that preoccupied us – as British science communicators – were strangely similar across our Indian and Chinese colleagues. Among those issues the most important – to India, China and the UK – was how to use our positions as respected authorities of science to increase confidence in vaccines and to answer questions that our visitors might have about vaccine research and development.

Our approach was agreed. The structure of the exhibition should increase our visitors' knowledge of the hidden work of vaccine development, trials and regulation,

and demonstrate the planning behind distributing vaccines across the global population. To begin by explaining the basics – what actually is a virus? How do vaccines work? – our visitors can gain a clearer understanding of fundamental interactions that take place within the human body and our wider environments. Moving to vaccine development, we explain how years of research into vaccines and viruses enabled scientists to move quickly when developing COVID-19 vaccines – and how global collaboration is at the heart of this story. Our ambition was to answer any concerns that our audiences might have about vaccine safety, by explaining exactly how new vaccines are trialled, tested and approved – and how the established system was accelerated and streamlined in order to save lives, but without sacrificing any of the safety checks. Young visitors may well learn of potential careers in science that they didn't know existed – that of laboratory technician or drug regulator, perhaps.

The practical challenge of distributing vaccines across our populations is also explained in the exhibition. Transport systems, volunteers, medical staff and even the military were called on to aid the distribution of vaccines. Perhaps inevitably, access to vaccines is not equal to everyone across the world, and how to reach people in isolated communities has been a particular problem. We also know that our visitors are interested in human stories and sharing the work of real people behind the scenes, creating and distributing COVID-19 vaccines can make the story more accessible and relevant to our audience. One unexpected advantage of partnership working, as well as exploring ideas, has been sharing images, digital games and interactives. This sort of international collaboration has benefits for the exhibitions across all countries – by providing an international perspective, and by using the same digital resources, when appropriate.

The Indian, British and Chinese partnerships chose to use one unusual way of exploring science communication creatively – through contemporary art. In the UK exhibition, visitors will be met by a striking glass sculpture of the COVID-19 virus' characteristic spiked shape, exploring the dramatic yet elusive impact of the virus in a visually stunning way. The exhibition will

end with another sculpture, as beautiful as the first, although tiny – this final artwork is made of silver and demonstrates the interaction of virus and human antibodies. The Injecting Hope teams in India and China are yet more ambitious still, commissioning original pieces of artwork specially for the shows. These will showcase the rich history of vaccination and the contemporary science behind vaccine development, including an animation, soundscape, and a vision of a bamboo forest with front line workers and key technologies that emerged during the pandemic.

Injecting Hope brings together key strategic aims held by the Science Museum in London. To reveal the wonder of science, to ignite curiosity in our visitors, inspiring them to learn more and aim high is at the heart of all our work. A result of the curatorial work involved in collecting material relating to COVID-19 more broadly, the international collaboration behind Injecting Hope allows us to focus on one of the most important – and hopeful – aspects of the pandemic – its vaccines.



Biocontainment during vaccine development

Dr. Pragya D. Yadav

ICMR-National Institute of Virology, Pune

Biocontainment facilities are necessary to support preclinical and clinical research for the development of vaccines and therapeutics for high risk group pathogens. These facilities play an important role in the high risk group virus propagation, evaluation of live virus vaccine candidates for genetic stability/reversion to virulence as well as immunogenicity and protective efficacy studies for various vaccines.

For containing the pandemic, accelerated research in the direction of vaccine and therapeutic development was the major agenda for the scientific community around the world. India's journey towards vaccine development started in early March 2020, when the SARS-CoV-2 was isolated at the Indian Council of Medical Research-National Institute of Virology (ICMR-NIV), Pune. ICMR-NIV, Pune has Biosafety level 3 and -4 laboratories specially designed to handle high risk pathogenic agents. The samples received from laboratories throughout India from the COVID-19 patients in the initial days of pandemic were used for the virus isolation and the virus was successfully isolated in the BSL-4 facility during the early March, 2020 when cases started peaking in the country. All the initial virus characterization experiments were performed in this containment facility before the virus transfer to the industrial partner i.e., the Bharat Biotech International Limited (BBIL), Hyderabad. Inactivated viruses have been traditionally used in vaccine development and have been licensed for decades with well-established safety profiles. This traditional platform required a



set up for virus propagation in bulk i.e., a biosafety level-3 laboratory. Thus, BBIL with prior experience in developing inactivated vaccines and with the BSL-3 facility was chosen by ICMR for collaboration and the virus was transferred after initial characterization at ICMR-NIV on April 30th 2020. BBIL worked on the vaccine candidate characterization and production and simultaneously ICMR-NIV worked on animal model selection and characterization. ICMR-NIV also supported BBIL by providing R&D support during the development of vaccine to assess the quality of purified inactivated virus stock, sharing protocols, reagents, sample testing etc.

Susceptibility studies in animal models were performed in the BSL-4 facility using various laboratory animal models. Syrian hamster model was chosen as the small animal model for challenge studies and was characterized for the disease. The preliminary immunogenicity studies and safety studies were performed in small rodents and rabbits in ABSL-2 facilities. The dose of vaccine candidate and the combination with adjuvants were studied. The immune response evaluation of the vaccine candidates in different doses was performed to understand the immunogenicity in combination with adjuvants. Based on these, 3 candidates were selected for further evaluation. The protective efficacy and live virus challenge studies were performed in immunized Syrian hamster and rhesus macaque models in the BSL-4 facility. Based on the remarkable immunogenicity and protective efficacy of these vaccine candidates in animal models, it was further progressed to clinical trial phase.

Biocontainment facilities require highly qualified, diverse, sustainable workforce that is properly and continuously trained. The team was trained to work under the biosafety demands of strict laboratory environments i.e., with specialized personal protective equipment, mandatory vaccinations and quarantine regulations. In case of vaccine development, a multi-disciplinary team of scientists/ technical staff with subject matter expertise across a broad spectrum of disciplines were required. We had veterinarians, clinicians, molecular biologists, virologists, immunologists, laboratory animal technicians and computational scientists in our team. Challenges are also there in experimentation in ABSL-4 facilities that house laboratory rodents and non human primates. This include animal husbandry practices to be followed for laboratory animals like daily room cleaning, feeding, watering and decontamination/waste disposal in relatively confined areas of the facility. Training and knowledge of practice of safety measures to minimize risk for physical injury to animal care staff and scientists as well as performing basic procedures like animal handling, anesthesia, vaccine administration, sample collection, and necropsy are necessary. The risk assessment was performed for each procedure and standard operation protocols were made for the animal experiments. The experiment duration was about one and a half months for the nonhuman primates and two months for the small animal experiments.

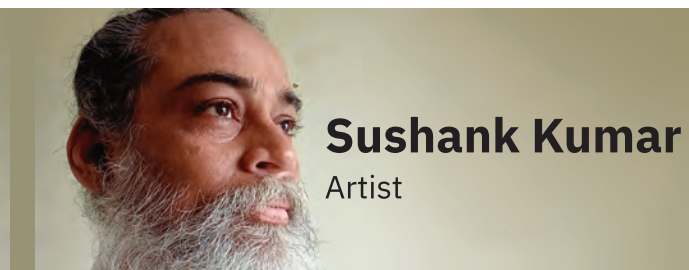
The journey towards COVAXIN development will be remembered proudly as an important contribution to this country. All the experiments right from the virus isolation, propagation, live virus neutralization assays till the challenge experiments in animal models were performed in the containment facilities. The availability of containment facilities and trained workforce in the ICMR-NIV, Pune helped in this smooth workflow. The need for containment facilities across the country was felt during the COVID-19 pandemic. The emerging infectious diseases can pose unexpected threats to the mankind in this era of globalization and containment facilities are an important requirement for development of vaccines and therapeutics.



Nigel

Producer/Director

Townsendnigel@theatreofdebate.co.uk



Sushank Kumar

Artist

india.sushank@gmail.com

Through the

Through The Lens is a collaboration between Indian Artist Sushank Kumar, and the British Theatre group The Theatre of Debate, which seeks to explore our relationship with Vaccination historically and in the light of the recent Covid 19 pandemic.

By interrogating historical responses and contemporary perceptions the work brings together sculpture and animation engaging our audience' in a debate about our understanding of the role of Vaccination across different culture in today's world.

The centrepiece of The Lens is a sculpture by Sushank Kumar "Injecting Hope"— a totem to the Vaccine, and the hope vaccination offered to humanity. It questions what Vaccination means to us in society in the light of our experience with Covid 19.

In the sculpture the Vaccine takes centre stage driving downward from on high through to a swirling vortex out of which the forms of today's 'Corona Warriors' – the researchers/health workers who both developed the vaccine and brought treatment to those affected by Covid 19 emerge. Above the vortex are mirrors that reflect the viewer, and ask them to insert themselves into the vortex, to explore their own position and perspective.

Framing the sculpture, we have the enlarged image of the Irish portrait painter Thomas Hinkey's "The Three Queens of Mysore" [circa 1805] confronting the viewer – one of the first examples of public health messaging in Art promoting the idea of Vaccination from Smallpox.

Alongside the image is "The Lens" – three animations developed by The Theatre of Debate, expand of the experience of bringing this Vaccination to people, and the importance and challenges of communicating it to a new audience.

The animations – in the form of monologues by characters from the painting, consider how: the smallpox vaccine was developed and transported; the reception and attitudes to vaccination the time; the role of the Queen of Mysore in shaping the message of vaccination; the impact of art as a public health strategy; and the success of vaccination amongst the population.

Lens

Moving in the space between the sculpture and the projections the viewers put their recent experiences literally in historical context, contrasting and comparing attitudes to Vaccination. Discussing what it means to produce and transmit a vaccination roll-out, and considering the how medical advancement moves from scientific problem solving to an event of cultural meaning – portraying the strength of scientific invention, human resilience, and hope for a brighter future.

“The Lens”: Theatre of Debate

Producer/Director: Nigel

Script: Sudha Bhuchar | www.bhucharboulevard.com

Animation: Tony Pickering | www.pick-art.co.uk

Sound: David Pickering | www.dave-pickering.squarespace.com
www.Theatreofdebate.co.uk

Injecting Hope

Artist: Sushank Kumar

Team Detail...

Ratna Gupta (HR cum purchase manager and project manager)

Piyush Tikku (Assistant project manager)

Short period working Artist

Mr Sumant | Mr Vijay | Mr Garav (Jr.) | Mr Viswanath Kashyup (Jr.)

Technical Assistant (overall)

Mr Harkesh Gaud (Sr.) | Mr Dharmender Kumar (Sr.)

Mr Vinod Yadav (Jr.) | Mr Rajdev Manghi (Jr.)

Moulding and Caster team and box (nine person team)

Mr Manohar and his team (Ajay, Harkesh, Ranjan)

Studio attendant & House keeping

Mr Sonu | Ms Sunita | Ms Kusum

And multiple daily wages worker

Supported by

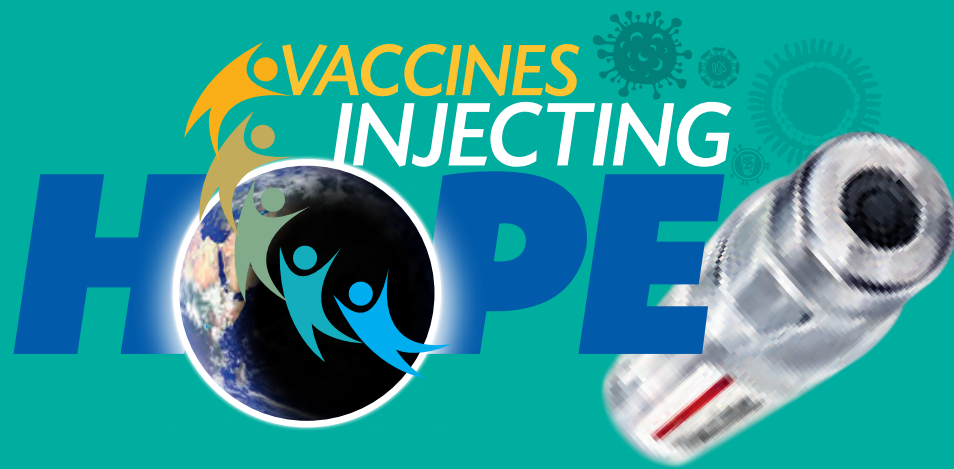


India/UK Together
Season of Culture



Travelling exhibit

ion



Overview

Introduction

The New Virus: Arrival of COVID-19

Designing a New Vaccine

Trials, Results and Approvals

Scaling-up and Mass Production

Vaccine Rollout

Living with COVID-19

The objective of the exhibition is to tell the story of the global effort to find new ways to develop vaccines at pandemic speed and look at vaccinations more broadly with a historical and contemporary view. The exhibition will set out the scientific principles underlying a vaccine's creation and efficacy, while capturing the behind-the-scenes work that accompanies their rapid development, production, transport, and delivery.

The COVID-19 pandemic has provided a compelling reminder of how science and ingenuity is central to people's lives and created an extraordinary opportunity to engage a global audience. This story has countless heroes, from the research scientists in labs, to the engineers and technicians ensuring vaccine delivery, and the thousands who volunteered to be a part of clinical trials. The exhibition is intended to deliver the story of vaccine on a global scale and shall try to raise awareness among masses about the importance of vaccines in our lives.

The exhibition is designed in a modular manner, which can if necessary, enable changes to interpretation and content based on major new global developments in the vaccine story. It will remain open to change but it also must keep in mind the content is not solely driven by the ongoing global pandemic. The exhibition will look at vaccinations more broadly with a historical and contemporary view, the degree of each based on the audience. The exhibition intends to help people understand what is underpinning the current work to hunt for a vaccine for COVID-19 and other diseases and the content must educate, inform, and enable audiences to make choices after visiting the exhibitions. To do that, we can provide context - where did viruses come from, how did we first discover and understand the nature of viruses, how can we fight them and what can we as individuals do to prevent the spread?

It will also highlight the global issue through a series of programme & events, digital and learning resources etc. for enhanced public engagement and understanding of the vaccines.

As a part of the travelling exhibition, a Mobile Science Exhibition (MSE) van is also being developed which will travel to the nearby areas of each exhibition location. The MSE van will mainly communicate the message of the exhibition in rural areas. The exhibition with some local specific content will showcase the efforts made by India during the COVID-19 pandemic period to fight the dreaded infection and also the story of vaccine development in India.

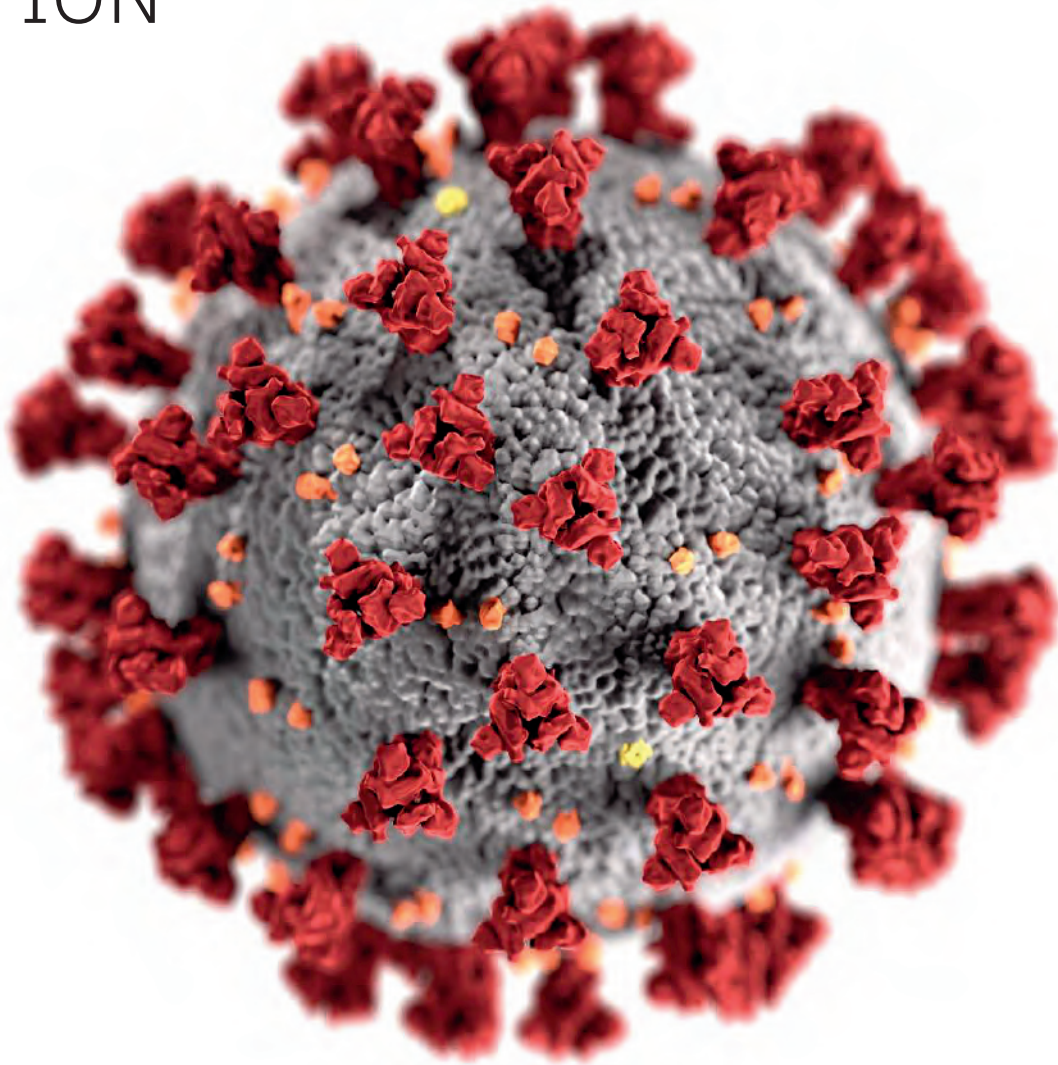
The background of the page features a hand in a white glove holding a syringe and a vial. The syringe is filled with a blue liquid, and the vial is labeled 'COVID-19 Coronavirus Vaccine'. Surrounding these elements are various pink and red icons representing different types of viruses and bacteria. In the bottom right corner, there is a small illustration of a vaccine vial and a syringe. The word 'Introduction' is written in a large, red, serif font in the center of the page.

Introduction

The exhibition starts with an immersive visual montage of the series of events witnessed worldwide during the COVID-19 pandemic. Saluting the human endeavor that led to the development of vaccines, an eye catching central Art Installation marks the global efforts that contributed towards the making of the vaccine. The exhibition celebrates the science and the spirit of the people involved.

A

SECTION



THE NEW VIRUS ARRIVAL OF COVID-19

COVID-19 is the disease caused by a new coronavirus called SARS-CoV-2. The World Health Organization (WHO) on March 11, 2020, has declared the novel coronavirus (COVID-19) outbreak a global pandemic, following a report of a cluster of cases of 'viral pneumonia' in Wuhan, People's Republic of China.

With the arrival of the new virus, utter chaos spread across countries and in no time, world witnessed one of the deadliest pandemics in human history. This section tells the story of the virus with special emphasis on COVID-19.

B

SECTION



DESIGNING A NEW VACCINE

A vaccine is a biological preparation that provides active immunity to a particular infectious disease. While the vaccine vial may look like a colorless liquid, a lot goes into making the same. This section gives a brief overview of the vaccine with a special emphasis on the procedures being followed in our country to make vaccine against COVID-19.

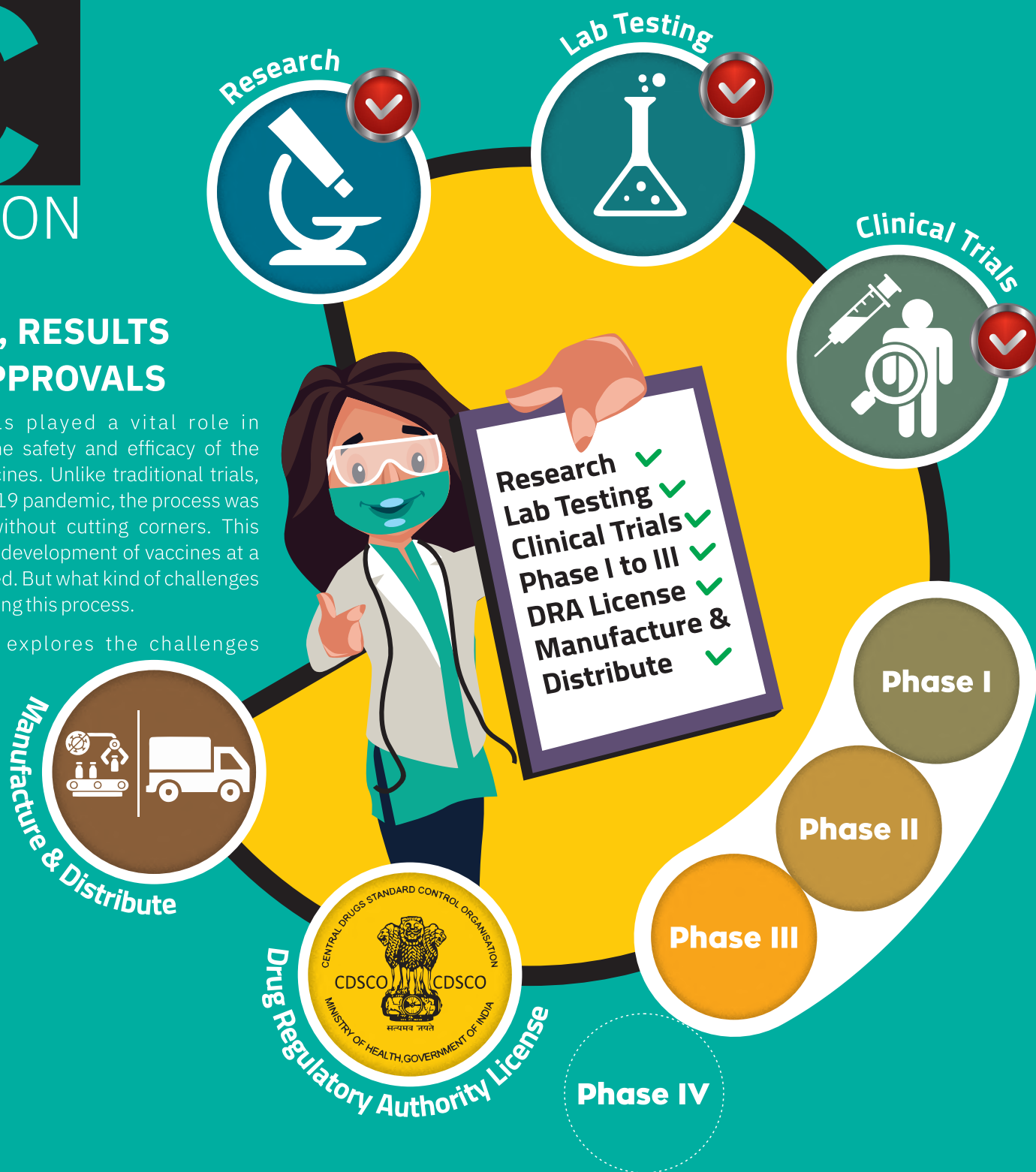


C SECTION

TRIALS, RESULTS AND APPROVALS

Clinical trials played a vital role in ascertaining the safety and efficacy of the candidate vaccines. Unlike traditional trials, during COVID-19 pandemic, the process was fast tracked without cutting corners. This resulted in the development of vaccines at a pandemic speed. But what kind of challenges were faced during this process.

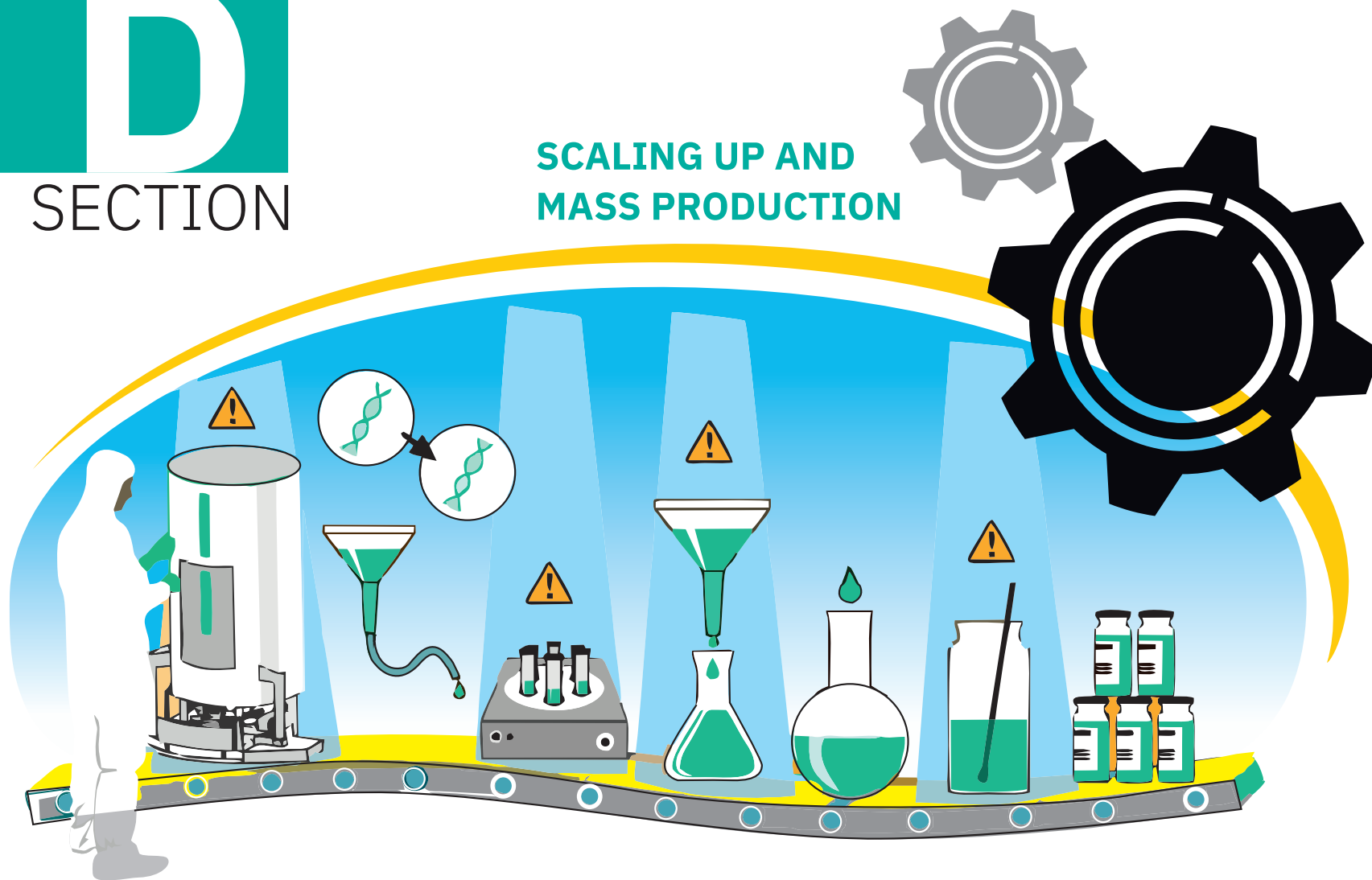
This section explores the challenges involved.



D

SECTION

SCALING UP AND MASS PRODUCTION

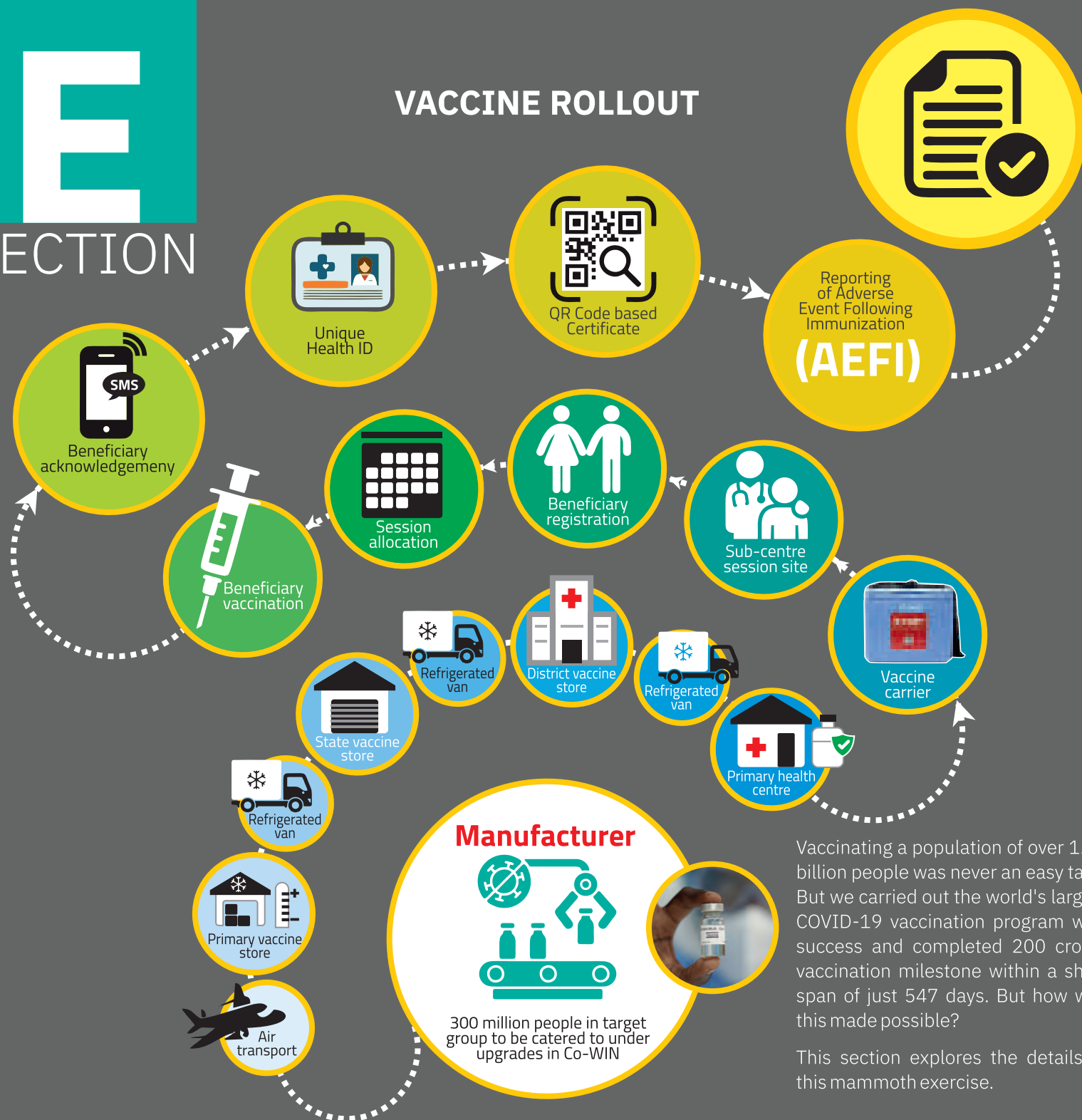


Scaling up vaccine production from beaker to bioreactor is critical for inoculating global population against disease. In most instances, vaccine development begins in a small beaker on a lab bench which must be rapidly scaled up — initially to meet the requirements of clinical trials and subsequently, when approved, to immunize billions of people.

This section highlights special equipment like Bioreactors and how Indian companies like Serum Institute of India, Pune and others played a crucial role in vaccine manufacturing on a large scale.

E SECTION

VACCINE ROLLOUT



Vaccinating a population of over 1.35 billion people was never an easy task. But we carried out the world's largest COVID-19 vaccination program with success and completed 200 crores vaccination milestone within a short span of just 547 days. But how was this made possible?

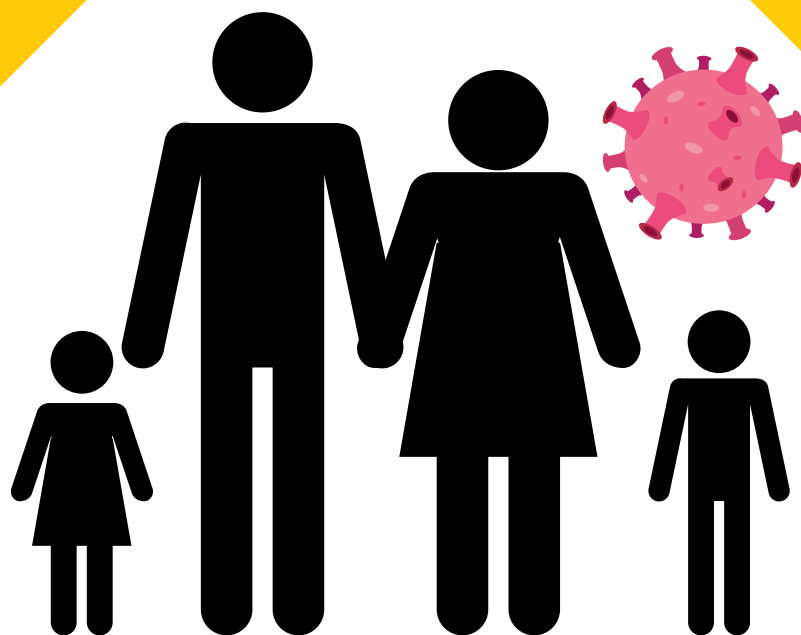
This section explores the details of this mammoth exercise.

F

SECTION

LIVING WITH COVID-19

COVID-19 may never go from our society. It may remain as an endemic. But this pandemic has taught us many things that we would have never thought to experience in our lives. We have witnessed people suffering, coping with the shortage of supplies, and losing our loved ones. But human endeavor has helped to tackle this pandemic. Numerous innovations done during this period is going to help us in days to come. This section deals with the interesting innovations that took place during this time.



India Innovates

Ramping-up Essentials

Liquid medical oxygen

The production of Liquid Medical Oxygen (LMO) has been maximized to meet the present demand of Covid-19 patients and the domestic production currently exceeded 9,400 Metric Tonne per day



Alcohol based sanitizer

India's hand sanitizer production capacity went up by a staggering 1,000 times to 30 lakh litres per day from an annual production of mere 10 lakh litres



Syringes

More than 5,900 syringes were produced per minute by Hindustan Syringes & Medical Devices



PPE kits

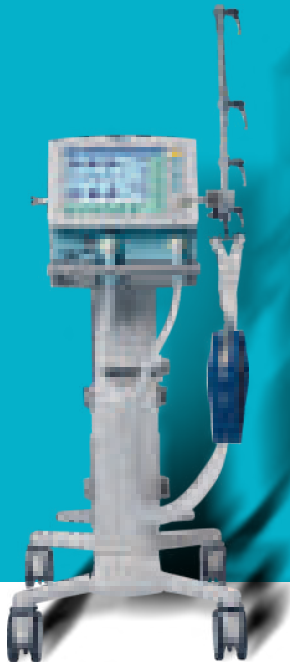
From nowhere, India now produces nearly 4,5000 PPE kits every single day. In 60 days, the PPE industry in India witnessed 56 times growth. India became the world's 2nd largest PPE manufacturer in just 60 days



Critical Care Equipment

Ventilators

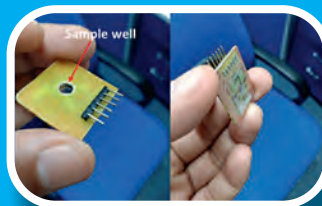
From producing almost no ventilators domestically, India indigenously manufactured 60,000 ventilators in just 3 months



Micro PCR with disposable chip

Handheld Polymerase Chain Reaction (PCR) system for DNA sequence amplification

Developed by CSIR-Central Electronics Engineering Research Institute (CSIR-CEERI)



Bilevel Positive Airway Pressure (BiPAP) System Portable Ventilator

The ventilator provides timed breath delivery with Pressure Support Ventilation

Developed by CSIR-National Aerospace Laboratories (CSIR-NAL)



RT-LAMP Diagnosis of COVID-19

It is a nucleic acid-based test carried out from nasal/throat swab sample from patients whose sensitivity and accuracy almost matches the current gold standard qPCR test

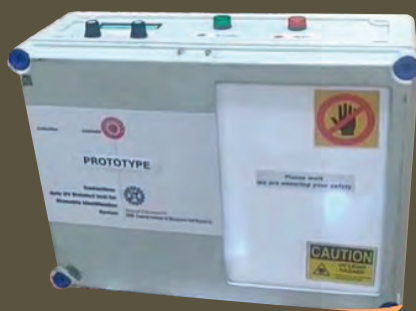
Developed by CSIR-Indian Institute of Integrative Medicine (CSIR-IIIM)



Critical Care Equipment

Contactless Auto UV Disinfect Unit

This will provide UV based contactless and automatic disinfect solution to biometric identification systems and other systems which are used by number of persons and there is a risk of transfer of germs, bacteria or viruses from the surfaces of interactive parts such as touch screens, keypads and thumb scanners of the devices from one user to another user.



Disinfectant Spray (JeevNasi)

CSIR-Institute of Minerals and Materials Technology (CSIR-IMMT). Effective aerosol-based spraying system that uniformly spreads a minimum amount of disinfectant, while covering the maximum area.



Apps

AarogyaSetu, myGov, Cowin

A cloud-based IT solution for planning, implementation, monitoring, and evaluation of COVID-19 vaccination in India. More than 50 countries have shown interest to use this portal.



Robots

UV Disinfectant Sanitizer Robot (Prabha), Milagrow Seagull, delivering robots, assisting robots

Uses 254 nm wavelength UV rays which is effective in destroying and deactivating all kinds of pathogens like viruses, bacteria, mold, and fungus including COVID.



Drones

Sanitizing drones, drones for delivering supplies (i-Drone)

'i-DRONE'

Drones were flown to difficult geographical terrains to deliver vaccines and medical supply, during the pandemic.



Hygiene

Sanitizers, portable hand wash, disinfectant, sanitizing tunnel. Face shield, medical-gown



New innovations

One breath ventilator, schoker, sparshless touchless lift panel, CPAP, 3D-printed splitter, sanitizing tunnel, infusion pump, DailyObjects Wield-UV-C Pocket Sterilizer, no touch door handles, CoronaOven, Vistar, MylabCoviSelf - COVID-19 Rapid Antigen Self Test Kit, OzGen18, Botanical Disinfectant Fogger

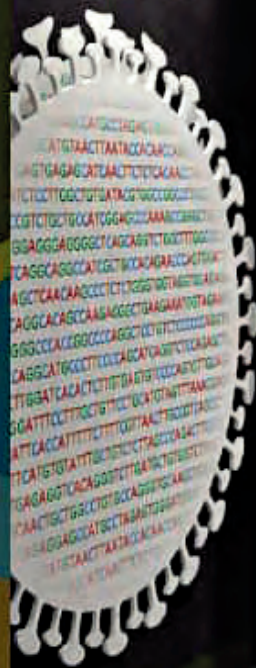


vaccine story hotspo

DIG
OPMENT

COVID-19

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THE STARTING GUN



हिन्दी
VACCINE
INGREDIENTS

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OUR FIRST SHOTS

हिन्दी
OUR FIRST SHOTS

BSL 4 SUIT

हिन्दी
MODES OF
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VACCINES SAVE LIFE

हिन्दी
DESIGNING
A NEW VACCINE

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Vaccine story on wheels





Mobile Science Exhibition

A mobile science exhibition is being organized along with the main exhibition. The purpose of this exhibition is to travel extensively in the rural areas and spread awareness about the science of vaccines. A host of interactive educational activities are also being planned for the student community, who will visit this bus.

Hop on the van to know more about it.

1964



FIRST LADY

WHO STUDIED CORONAVIRUS

June Almeida peered into her electron microscope in 1964, she saw a round, grey dot covered in tiny spokes.

She and her colleagues noted that the pegs formed a halo around the virus—much like the sun's corona. What she saw would become known as the coronavirus, and Almeida played a pivotal role in identifying it. That feat was all the more remarkable because the 34-year-old scientist never completed her formal education.

Edward Jenner

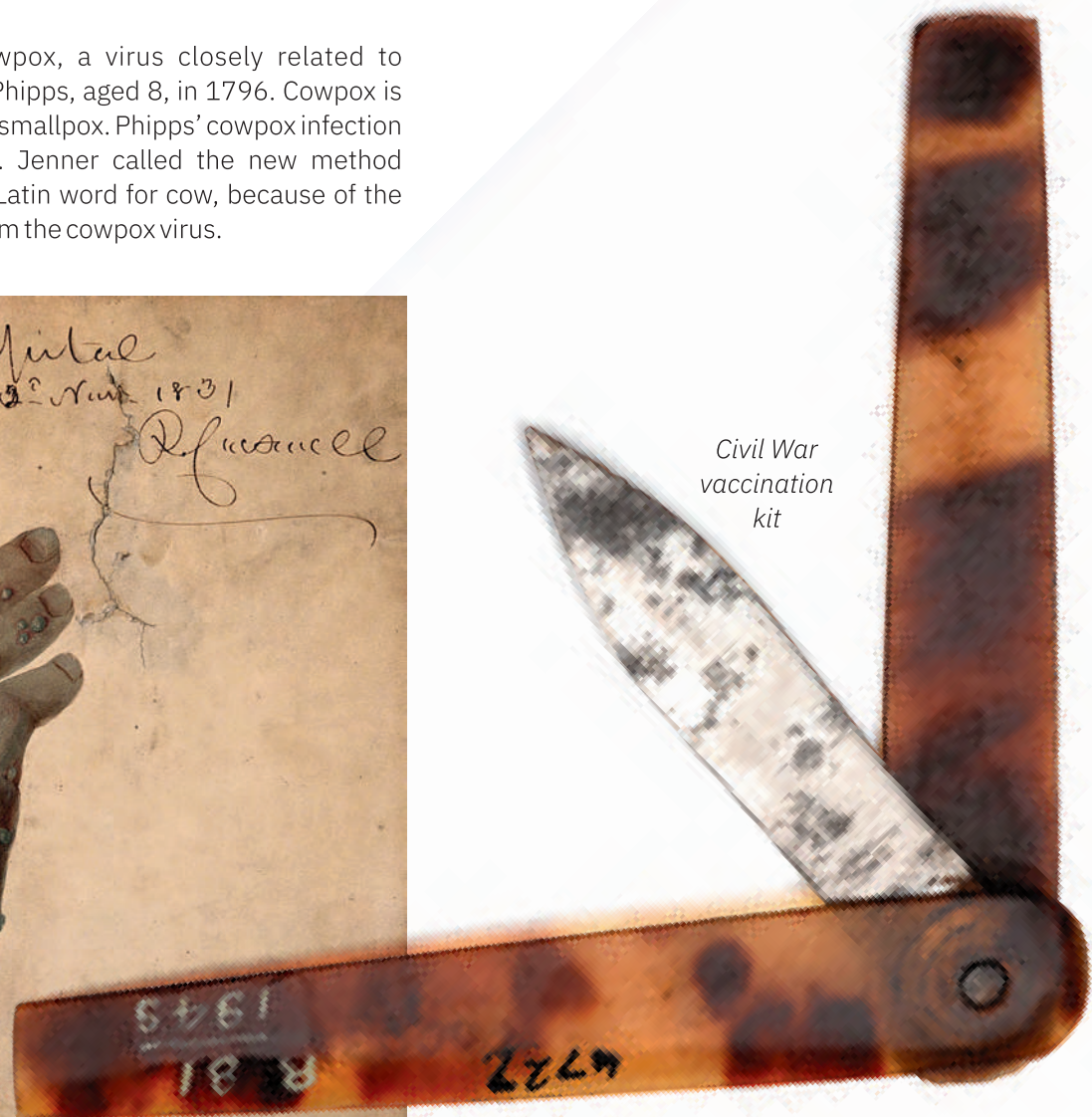
English Doctor



Jenner used scabs from cowpox, a virus closely related to smallpox, to vaccinate James Phipps, aged 8, in 1796. Cowpox is similar but less dangerous than smallpox. Phipps' cowpox infection protected him from smallpox. Jenner called the new method 'vaccination' after 'vacca', the Latin word for cow, because of the origin of this first vaccination from the cowpox virus.



Civil War
vaccination
kit



Pandemics

Very few phenomena throughout human history have shaped our societies and cultures the way outbreaks of infectious diseases have. Pandemic outbreaks have decimated societies, determined outcomes of wars, wiped out entire populations, but also, paradoxically, cleared the way for innovations and advances in sciences (including medicine and public health), economy, and political systems.

Some of the major pandemics that have occurred over time:

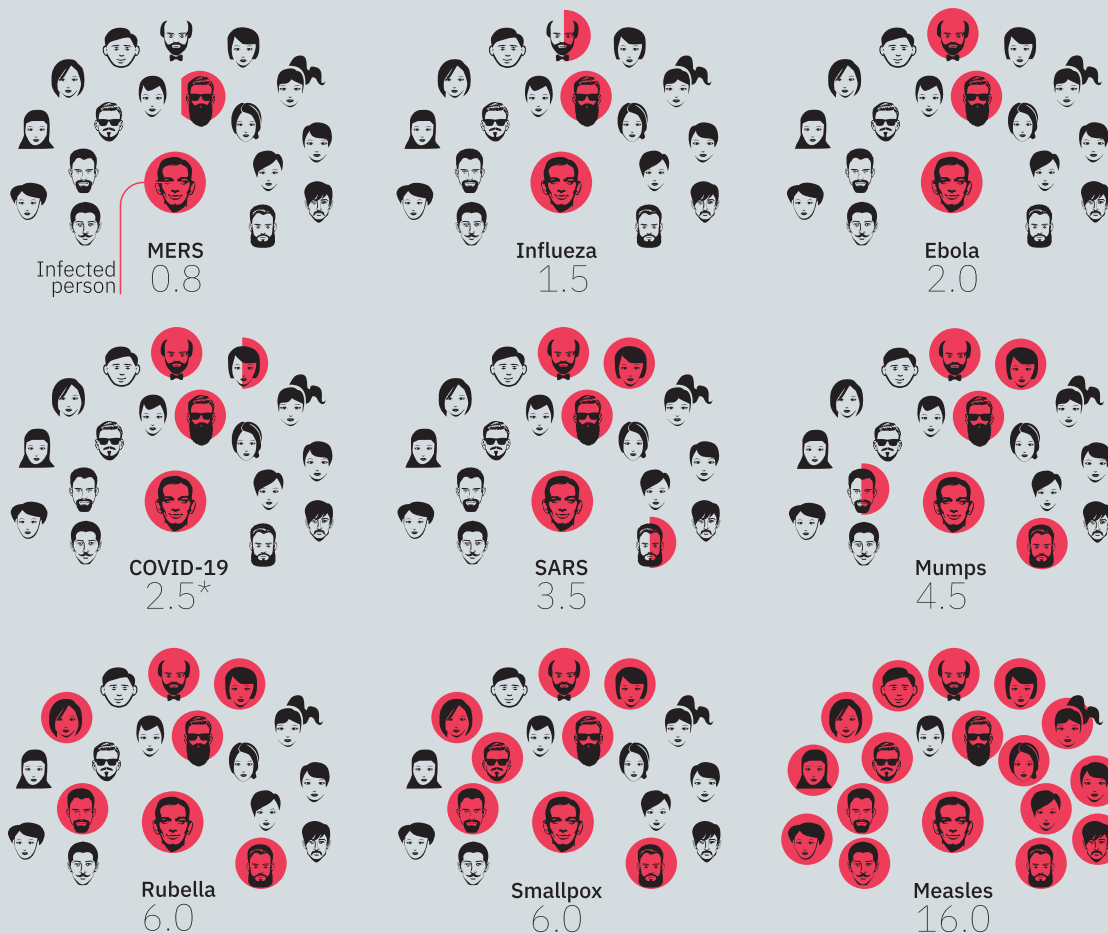
Name	Time period	Type / Pre-human host	Death toll
Antonine Plague	165-180	Believed to be either smallpox or measles	5M
Japanese smallpox epidemic	735-737	Variola major virus	1M
Plague of Justinian	541-542	Yersinia pestis bacteria / Rats, fleas	30-50M
Black Death	1347-1351	Yersinia pestis bacteria / Rats, fleas	200M
New World Smallpox Outbreak	1520 – onwards	Variola major virus	56M
Great Plague of London	1665	Yersinia pestis bacteria / Rats, fleas	100,000
Italian plague	1629-1631	Yersinia pestis bacteria / Rats, fleas	1M
Cholera Pandemics 1-6	1817-1923	V. cholerae bacteria	1M+
Third Plague	1885	Yersinia pestis bacteria / Rats, fleas	12M (China and India)
Yellow Fever	Late 1800s	Virus / Mosquitoes	100,000-150,000 (U.S.)
Russian Flu	1889-1890	Believed to be H2N2 (avian origin)	1M
Spanish Flu	1918-1919	H1N1 virus / Pigs	40-50M
Asian Flu	1957-1958	H2N2 virus	1.1M
Hong Kong Flu	1968-1970	H3N2 virus	1M
HIV/AIDS	1981-present	Virus / Chimpanzees	25-35M
Swine Flu	2009-2010	H1N1 virus / Pigs	200,000
SARS	2002-2003	Coronavirus / Bats, Civets	770
Ebola	2014-2016	Ebolavirus / Wild animals	11,000
MERS	2015-Present	Coronavirus / Bats, camels	850
COVID-19	2019-Present	Coronavirus – Unknown (possibly pangolins)	6.6M (as of Oct. 19, 2022)

resource : <https://www.weforum.org/agenda/2020/03/a-visual-history-of-pandemics/>

Scientists use a basic measure to track the infectiousness of a disease called the reproduction number — also known as R0 or “R naught.” This number tells us how many susceptible people, on average, each sick person will in turn infect.

RO (basic reproduction number) of disease

A measure of how many people each sick person will infect on average



Measles turned out to be most infective among all others.

Studies show that rising global connections, urbanization, rise in population and increasing interaction with wild animals are the driving force behind the major pandemics.

Fortunately pandemics have helped in the progress of science manifold and now the world has vaccines for most of the deadly pathogens.

The current pandemic has also helped in the development of vaccines in less than a year, which was unthinkable before. Scientists are already developing technologies which may squeeze the number of days for vaccine production to as low as 100 days. This will ascertain that we are better prepared to tackle any future potential pandemic much earlier, resulting in saving billions of lives.

resource : <https://www.weforum.org/agenda/2020/03/a-visual-history-of-pandemics/>

Timeline of Vaccines

3000 BC
and before

The Story of Smallpox

The war between humans and microbes goes back to millennium. The earliest evidence of smallpox is on the mummified corpse of Egyptian Pharaoh Ramses V whose skin was found to be covered with bumps. The fatality rate was as high as 30%. Those who survived were often scarred or blinded.



Traces of smallpox pustules found on the head of the 3000-year-old mummy of the Pharaoh Ramses V. (Photo courtesy of World Health Organization)



The virus travelled the globe as civilizations got connected through trade.

2300 BC-
1000 AD



Origin of Vaccination

The origin of vaccination goes long back in time. As early as 1000 AD, the Chinese were using variolation, using smallpox to prevent smallpox?

1000 AD- 1780AD

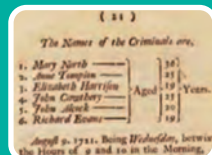
1717



Lady Mary Montagu with her son, Edward Wortley Montagu

A Woman's Quest To Stop A Deadly Virus

In 1717, Lady Mary Wortley Montagu, the wife of the British ambassador, learned about variolation in Constantinople. In 1721, at the urging of Montagu and the Princess of Wales, several prisoners and abandoned children were inoculated by having smallpox inserted under the skin. Several months later, the children and prisoners were deliberately exposed to smallpox. When none contracted the disease, the procedure was deemed safe and members of the royal family were inoculated.



6 condemned criminals in the Newgate Prison



5 orphans from Saint James parish Westminster

1767

India's Story of Variolation

In 1767, Dr John Zephaniah Holwell, a physician of British East India Company suggested that smallpox had existed in India from time immemorial.



STORY

At least hundreds of years back, in Bengal region of India, a few people were practically 'selling the disease...' and people were lining up to buy it. These healers would take a piece of cloth and wrap the person's upper arm, a small cut is made, just enough to draw blood. Then, they were applying the dried smallpox scabs taken from patients who had survived the disease previously. Most people would get sick but recover and never get re-infected from this disease. This procedure by which pus is taken from a smallpox blister and introduced into a scratch in the skin of an uninfected person to confer protection is called 'variolation' or 'inoculation'.



Although variolation method dramatically reduced infection-induced fatality rates, it still carried risks, including the potential to trigger new smallpox outbreaks.

It was observed that 3 percent of people were still dying even after this procedure

1780-1880

1796



BIRTH OF FIRST VACCINE-

In 1796, English doctor Edward Jenner vaccinated a child named James Phipps with pus taken from a cowpox pustule.

1880



Chicken cholera

Louis Pasteur and the development of Attenuated Vaccine-Fowl Cholera

In 1880, Pasteur and his colleague Charles Chamberland showed that injecting Chicken cholera germs from a weaker strain of germ provides immunity to the chickens against cholera and they don't die. This way Pasteur had found a way of producing the resistance without the risk of the disease.

1880-1970

1884

First LIVE VIRUS VACCINE

Louis Pasteur saved Joseph Meister from rabies death by inoculating him with a dehydrated rabid rabbit spinal cord

In 1884, together with Charles Chamberland and Emile Roux, Louis Pasteur announced the discovery of Rabies Vaccine.

He suspended sections of spinal cord from rabid rabbits inside flasks to dry in a moisture-free atmosphere. Virulence gradually declined until finally disappearing. Louis Pasteur injected these spinal cord sections into rabid dogs, followed by preparations of increasing virulence. They did not develop rabies.



1937

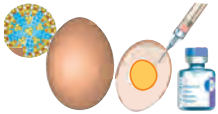
EXPERIMENTAL TRANSMISSION OF VIRUS TO LABORATORY ANIMALS-

Yellow fever disease is caused by a virus and is transmitted to people by insects and also from one person to another. Max Theiler succeeded in transmitting the virus and through continuous experimentation, a weakened form of the virus was obtained that could make apes immune. In 1937 Theiler succeeded in obtaining an even weaker variant of the virus. This variant, 17D, came to be used as a human vaccine.



1970-2022

1936



Influenza virus grown in embryonated eggs allows development of inactivated influenza vaccines.

1963

Albert Sabin develops the live attenuated oral vaccine against poliomyelitis



The vaccine everyone was waiting for — polio vaccine

Jonas Salk grew poliovirus in monkey kidney cells. This virus was isolated and inactivated with formalin. When the "dead" poliovirus is injected into the bloodstream, it can't cause an infection because the virus is inactive; but the immune system creates antibodies to fight the virus as it can't distinguish an activated virus from an inactivated one. Those antibodies persist and protect the person from future poliovirus infection.

Albert Sabin

1971



Maurice Hilleman licences MMR, a trivalent live attenuated vaccine against measles, mumps and rubella.

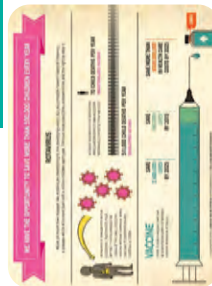
Toxoid vaccines the next routinely recommended vaccines were developed early in the 20th century. These included vaccines that protect against pertussis (1914), diphtheria (1926), and tetanus (1938). These three vaccines were combined in 1948 and given as the DTP vaccine

1980

After a global eradication campaign against this disease, smallpox disease was eradicated in 1980.



1998



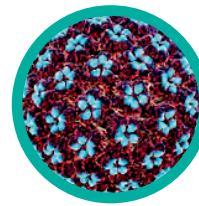
Rotavirus

The first FDA approved vaccine was licenced in 1998 but it was withdrawn in less than a year for a proven association with intussusception. A safer vaccine against rotavirus was licensed in 2006.

2006

HPV vaccine

The first HPV vaccine became available in 2006. More than 120 million doses have been administered since 2006.



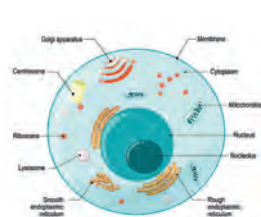
2009

Vaccines against 2009 H1N1 pandemic strain and high dose influenza vaccine are licensed in US.



2013

Genome derived fully synthetic RNA vaccine against pandemic influenza in the laboratory in one week.



2019

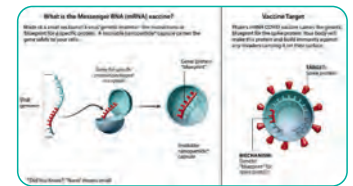
Ebola Vaccine

The first ebola vaccine was approved in 2019. It was found to be 95-100% effective against virus.



2020

Genome derived synthetic RNA and viral vector based vaccines against pandemic SARS-Cov-2 virus were produced and initiated clinical trials in less than 3 months.



2021

COVID-19 vaccines like Covishield, Covaxin, Janssen, Moderna, Sinopharm etc. were given EUL in 2021 which were administered intramuscularly.

2022

Bharat Biotech's INCOVACC, the world's first Intra Nasal vaccine, receives approval for emergency use in India on September 06, 2022

Designed & developed by NCSM

In collaboration with Science Museum Group

Wellcome, ICMR and British Council

About the Organisers



Ministry of Culture
Government of India



National
Council of
Science
Museums

National Council of Science Museums (NCSM), a premiere institution in the field of science communication, is an autonomous organization under the Ministry of Culture, Govt. of India. Primarily engaged in popularizing Science and Technology through a network of science centres, Mobile Science Exhibitions (MSE) units that visit rural schools and organise plethora of activities for public and students in particular, NCSM has now become a trend setter in the field of science communication both at national and international level. Presently NCSM, with its Headquarters in Kolkata, administers and manages 26 science museums/centres spread across the country and is the world's largest network of science centres and museums that functions under a single administrative umbrella with an annual reach to about 15 million people. Innovation Hubs set up by NCSM, provide expert guidance and professional lab equipment facilities to young students to nurture creativity, innovation and engagement in science. 37 hubs are functional in science centres across the country reaching about 10,000 students annually through each hubs. For further information please visit <http://www.ncsm.gov.in/>



The Science Museum Group is the world's leading group of science museums, welcoming over five million visitors each year to five sites: the Science Museum in London; the National Railway Museum in York; the Museum of Science and Industry in Manchester; the National Science and Media Museum in Bradford; and Locomotion in Shildon. We share the stories of innovations and people that shaped our world and are transforming the future, constantly reinterpreting diverse collection.

Standout objects include the record-breaking locomotive Flying Scotsman, Richard Arkwright's textile machinery, Alan Turing's Pilot ACE computer and the earliest surviving recording of British television. Our mission is to inspire futures - igniting curiosity among people of all ages and backgrounds. Each year, our museums attract more than 600,000 visits by education groups, while our touring exhibition programme brings our creativity and scholarship to audiences across the globe. More information can be found at <https://group.sciencemuseum.org.uk/>.



Wellcome exists to improve health for everyone by helping great ideas to thrive. We're a global charitable foundation, both politically and financially independent. We support scientists and researchers, take on big problems, fuel imaginations and spark debate. www.wellcome.ac.uk



India/UK Together
Season of Culture

Collaboration with the British Council

India/UK Together, a Season of Culture, celebrates the friendship between the UK and India. Marking the 75th anniversary of India, this cultural exchange will showcase events online and in person, with an exciting lineup of music, theatre, cinema, literature, fashion and visual arts. With equality, diversity and inclusion at its heart, we are celebrating a diverse community of artists, innovators and educators from India and the UK. Through this initiative, we are exploring our cultures, our shared planet and our relationship with digital technologies that will shape our future together. NCSM has signed a MoU with British Council India to support the exhibition with the commissioning of an Art Installation for the exhibition “Vaccines: Injecting Hope”

Partnerships with organizations in India

NCSM is collaborating with various scientific organizations in India such Indian Council of Medical Research (ICMR), Council of Scientific and Industrial Research (CSIR) and its labs, National Institute of Biomedical Genomics (NIBMG), Kalyani, National Institute of Virology (NIV), Pune, Serum Institute of India (the largest manufacturer of Vaccine in the world), Bharat Biotech (manufacturer of 1st Indian Vaccine COVAXIN), AIIMS and reputed hospitals and other institutions to collect relevant information, data and display items.

For details, Contact: National Council of Science Museums Ministry of Culture, Government of India 33, Block-GN, Sector-V, Bidhan Nagar, Kolkata-700091 Ph: +91 33 2357 9347, 2357 5545, 2357 0850, Fax: +91 33 2357 6008 e-mail: ddg@ncsm.gov.in, director_hqrs@ncsm.gov.in, Website: www.ncsm.gov.in //ncsmgoi (FB/T/YT)

Exhibition Schedule and Venue

**Nov 15, 2022 –
Jun 18, 2023**



National Science Centre
Pragati Maidan, Near Gate No.4
Bhairon Marg, New Delhi – 1
nscdl01@gmail.com
www.nscd.gov.in

**Aug 5, 2023 –
Dec 31, 2023**



**Raman Science Centre &
Planetarium**
Opp. Gandhisagar
Nagpur-440 018
ramanscn@gmail.com

**Feb 10, 2024 –
Jul 28, 2024**



Nehru Science Centre
Dr. E.Moses Road, Worli
Mumbai - 400 018
director@nehrusciencesciencecentre.gov.in
www.nehrusciencesciencecentre.gov.in

**Sep 7, 2024 –
Feb 28, 2025**



**Visvesvaraya Industrial &
Technological Museum**
Kasturba Road, Bengaluru-1
vitmuseum@gmail.com
www.vismuseum.gov.in

**Apr 12, 2025 –
Sep 30, 2025**



Science City
J.B.S. Haldane Avenue,
Kolkata-700 046
sciencecity.kol@gmail.com
www.sciencecitykolkata.org.in

Acknowledg

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Individuals:

Dr. Vinod Kumar Paul (Member NITI Aayog, Professor AIIMS New Delhi)

Mr. Adar C Poonawalla (CEO, Serum Institute of India, Pune)

Prof. Partha Pratim Majumder (Distinguished Professor & Founder Director, NIBMG, Kalyani, West Bengal)

Prof. (Dr) Balram Bhargava (Ex-DG at the ICMR, New Delhi and Secretary, Department of Health Research)

Dr. Priya Abraham (Director, ICMR-NIV, Pune)

Dr. Venugopal G Somani (Drugs Controller General of India, CDSCO, New Delhi)

Dr Rajni Kant, Scientist 'G' & Director, RMRC, Gorakhpur, Head, RMPPC & CU, ICMR

Prof. Shankar Prinja, Executive Director (HP&QA), National Health Authority, GoI & Prof. of Health Economics, PGIMER, Chandigarh

Dr. Umesh Shaligram (Director of R&D, Serum Institute of India, Pune)

Mr. Hamish Shahani (Managing Director & CEO, Klenzaid, Mumbai)

Mr. Girish Krishnamurthy (MD & CEO of Tata Medical & Diagnostics, Bengaluru)

Dr. Pragya Yadav (Scientist & In-charge, Maximum Containment Facility, ICMR-NIV, Pune)

Dr. Nivedita Gupta (Head of Virology, ICMR, New Delhi)

Dr. Sanjay Kumar Rai (Professor, Centre for Community Medicine, AIIMS, New Delhi)

Dr. Rakesh Aggarwal (Director of JIPMER, Puducherry)

Prof. Arindam Maitra (Officiating Director, NIBMG, Kalyani, West Bengal)

Dr. Rajesh Deshmukh (District Collector, Pune)

Sri Narayan Swaroop Nigam (Secretary of Health & Family Welfare, Govt. of West Bengal)

Dr. Asim Kumar Das Malakar (Family Welfare Officer & Jt. DHS (FW), Govt. of West Bengal)

Prof. Baquer Mazhari (Professor, Department of Electrical Engineering, IIT Kanpur)

Prof. J Rajkumar (Professor, Department of Mechanical Engineering, IIT Madras)

Prof. Vivekanandan Perumal (Professor, KSBS, IIT Delhi)

Dr. Shailesh Pawar (Scientist, ICMR-NIV, Pune)

Prof. Robin Shattock (Head of Mucosal Infection and Immunity within the Department of Medicine at Imperial College, London)

Dr. Souvik Maiti (CSIR-Institute of Genomics and Integrative Biology, New Delhi)

Dr. Jayanthi Shastri (Chair of the Department of Microbiology, TNMC & BYL Nair Hospital, Mumbai)

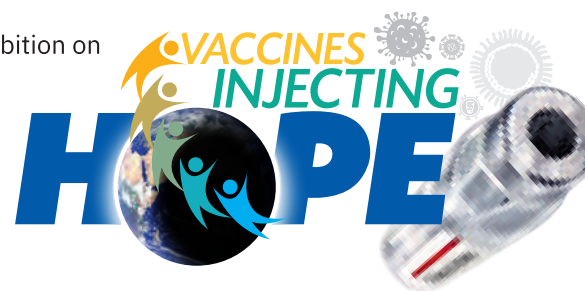
ement

Dr. Kalpana Mehta (Professor & Head, Nephrology Department, T.N. Medical College & B.Y.L. Nair Ch. Hospital Mumbai)
Dr. Renuka Munshi (Professor & Head, Clinical Pharmacology, TNMC & BYL Nair Hospital, Mumbai)
Dr. Rujuta Hadaye (Professor & Head of Department of Community Medicine, TNMC & BYL Nair Hospital, Mumbai)
Dr. Shahkar Nahvi (Asst. Professor, IUST J&K, India)
Dr Vikram Rajan , MBBS, MD (Paediatrics), Nagpur
Dr. Chandrakant Pawar (Medical Superintendent, Kasturba Hospital, Mumbai)
Mr. Tripan Das (State Consultant- Vaccine & Logistics, National Health Mission, Govt. of West Bengal)
Mrs Asha Tulsankar (ASHA Worker, Vashi Naka -Chembur, Mumbai)
Sh. Manish Kumar (Health Worker, AIIMS, New Delhi)
Shri Amol Dhamdhare (Among the first COVID patients tested positive in Mumbai)
Dr. Sangeeta Praveen Savan
Ms. Sujata Pandurangrao Jogdand
Trial Volunteers
Dr. Anjan Mukherjee , MD, Microbiology, Apollo Multispeciality Hospitals, Kolkata, West Bengal, India
And several others scientists, researchers & individuals who directly or indirectly have supported the exhibition.

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Wellcome (UK)
SCIENCE Museum Group (UK)
The Indian Council of Medical Research (ICMR), New Delhi
All India Institute of Medical Sciences (AIIMS), New Delhi
World Health Organization (WHO)
United Nations Development Programme (UNDP), New Delhi
British Council (UK)
Topiwala National Medical College & B.Y.L. Nair Charitable Hospital , Mumbai
Haffkine Institute , Parel, Mumbai
Kasturba Hosiptal , Chinchpokli, Mumbai
National Institute of Virology , Pune
Institute of Competiveness
NITI Aayog , New Delhi
Central Drugs Standard Control Organization (CDSCO), New Delhi
JIPMER , Puducherry
Imperial College , London, UK.
National Institute of Biomedical Genomics , Kalyani, West Bengal
Klenzaids Pvt Ltd , Mumbai
Serum Institute of India , Hadapsar, Pune
Tata Medical and Diagnostics Limited , Mumbai, Bengaluru
Islamic University of Science & Technology , Jammu and Kashmir
IIT Kanpur IIT Madras IIT Delhi
CSIR-Institute of Genomics and Integrative Biology (IGIB), New Delhi
Stanford Medicine , USA
Lions Club of Contai , West Bengal
Ministry of Health & Family Welfare , Govt of India, New Delhi
World Economy Forum , Switzerland
PGIMER , Chandigarh
Department of Health and Family Welfare , Govt. of West Bengal
National Health Mission , Govt. of West Bengal
Tata Medical Centre , Kolkata
PIB ABP Pvt. Ltd The Statesman
Our World in Data, Visual Capitalist
and several others...

Travelling exhibition on



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Deputy Director General & Director (Hqrs.), NCSM

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Dr. Raj Mehrotra,

Curator, National Science Centre, Delhi
during 15.04.2021 to 20.04.2022

And dedicated design, exhibition, technical & logistics team

SMG

Roger Highfield, Science Director, SMG

Sheldon Paquin, Partnerships Manager, SMG

Natasha McEnroe, Keeper of Medicine, Science Museum, London

Alex Fairhead, Group Head of Exhibition Services, SMG

David Dewhurst, Digital Experience Manager, SMG

Rachel Dargavel-Leafe, Project Delivery Manager, SMG

Gemma Levett, Associate Director of Public Engagement, SMG

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for the travelling exhibition

Vaccines Injecting Hope

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DDG & Director(Hqrs.), NCSM, Kolkata

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