DOE COVID-19 S&T Response: The National Virtual Biotechnology Laboratory

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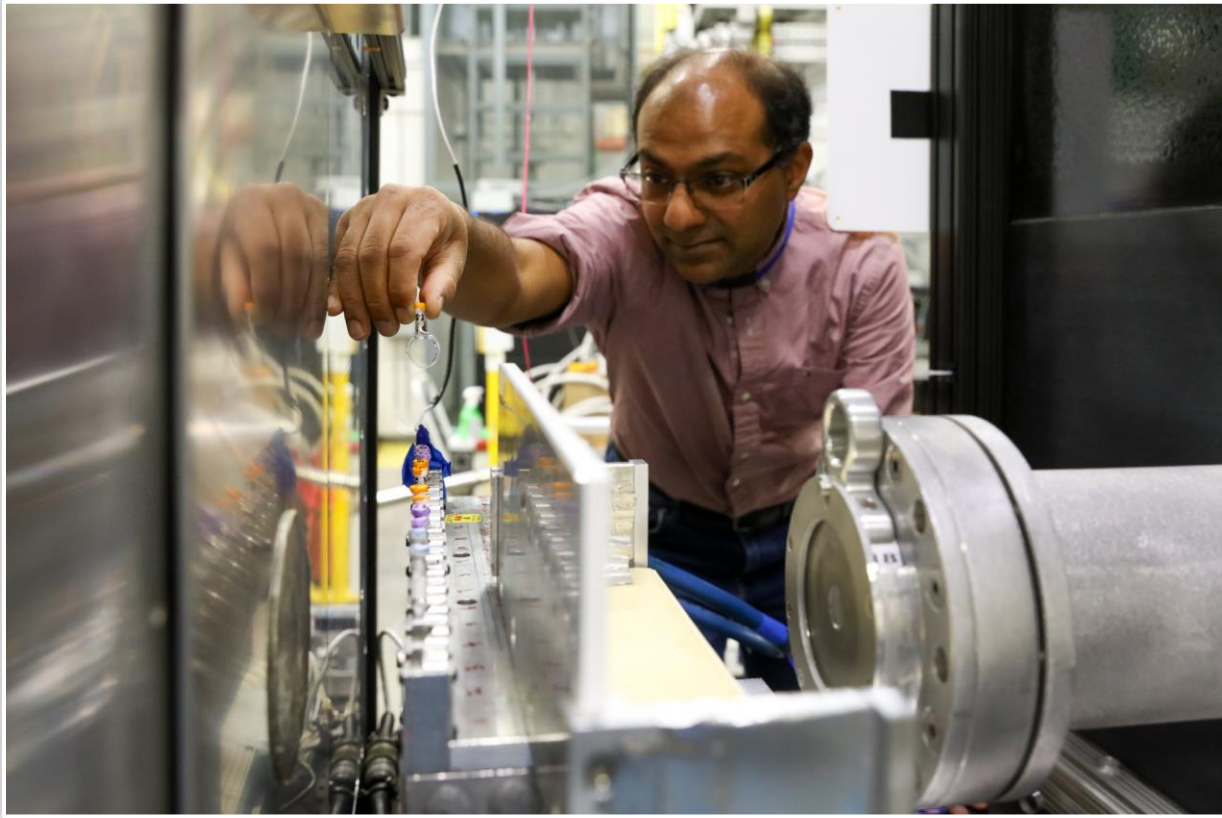
U.S. DEPARTMENT OF ENERGY

DOE Laboratories have broad capabilities for addressing the COVID-19 crisis

Scientists and engineers with deep expertise relevant to:

- Development of analytical technologies and trace detection
- Design and discovery of antiviral drugs and vaccines
- Advanced manufacturing to address supply chain issues
- Predictive modeling for emergency response and epidemiology
- Molecular and structural biology



High Performance and Leadership Computing Facilities

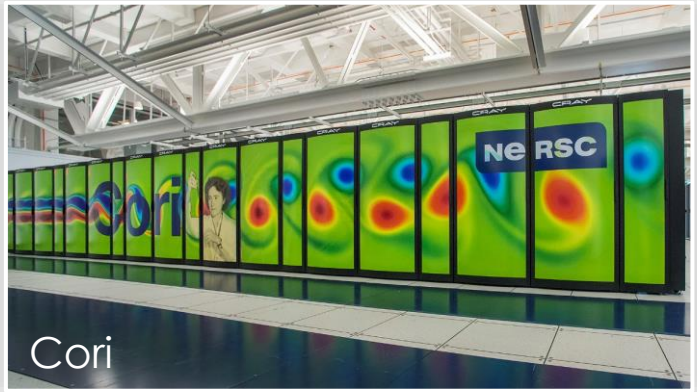
Computational modeling and simulation

- Protein–small molecule docking for drug discovery
- Optimization of protein–antibody interactions
- Pandemic modeling to assist local, state, and federal officials
- Modeling fate and transport of virus in buildings and transportation venues

COVID-19 HPC Consortium

- Government, industry, and academic members
- Providing access to the world's most powerful computers

Summit



Cori

Theta

Light and Neutron Sources

High-throughput structures of proteins

Examination of enzyme reactions during virus replication

Virus–membrane interactions

Dynamic studies of drug and antibody interactions with proteins

Nanoscale Science Research Centers

Small molecule synthesis for antiviral assays	Deuteration for structural studies	Electron microscopy for materials characterization	Scanning probes for examining surface contamination	Polymer and materials synthesis

DOE's National Virtual Biotechnology Laboratory includes expertise and capabilities across all of its 17 National Laboratories

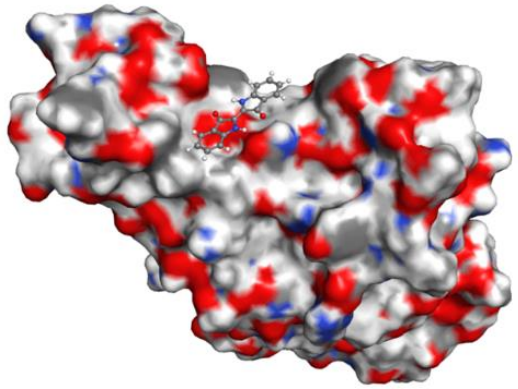
- Initiated in March 2020
- Funded by CARES Act
- Supported national, state, local decisions makers
- Collaborated with industry, universities and other federal agencies

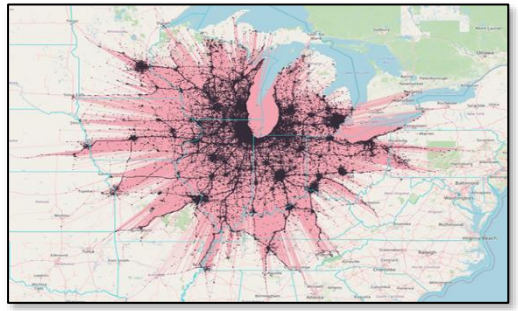
NVBL has focused on five topics

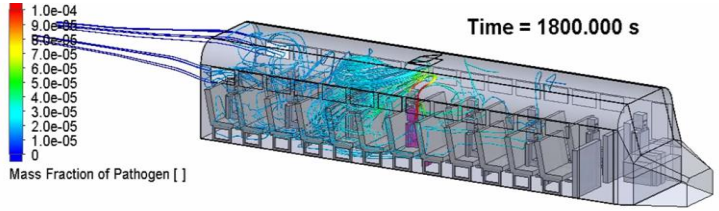
- Addressing supply chain bottlenecks by harnessing advanced manufacturing
- Medical therapeutics: computational drug discovery and structural biology
- Innovations in testing capabilities
- Understanding fate and transport of virus in the environment
- Epidemiological modeling and logistical support

https://science.osti.gov/nvbl

NVBL Success Stories







Determining virus structure and detectability

DOE user facilities provided insight into structure of the virus and supported vaccine development

Supported CDC, FDA, and other federal agencies in virus testing, including identifying contaminated test kits

Accelerating therapeutic treatments

Computationally screened billions of compounds against hundreds of virus targets

Studies of candidate drugs with proteins at DOE X-ray and neutron sources expedite drug discovery

Providing critical supplies

Established new supply chains for face masks, testing kit supplies, and ventilators

Established alternative testing instruments and reagents

Created hundreds of new jobs

Understanding disease spread

Provided high-resolution epidemiological, infrastructure, and economic modeling/ analysis to decision makers

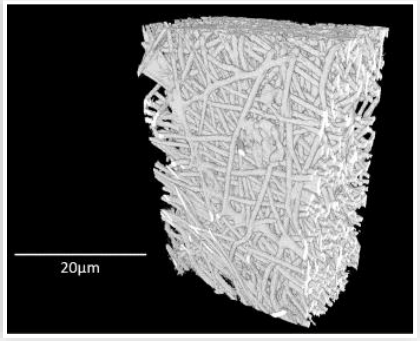
Established methods to understand and control risk in buildings and other environments

Advanced Manufacturing: Face Masks

- Developed melt blown filter media for reusable respirators
- Developed novel in-line charging device to electrostatically charge the melt blown material

N95 filter material production at ORNL

- Characterized materials at x-ray sources and nanoscience centers
- Verified filtering efficacy by aerosol testing



NanoCT image of ANL N95 electrospun filter media acquired at APS

- Designed, built, and assisted in installation of a custom electrostatic charging device at Cummins facility
- Enabled production of N95 filter media for millions of masks/day

- DemeTECH now producing masks using filter media
- 2 additional production facilities
- 600 jobs created
- NIOSH certification, October 7, 2020

Advanced Manufacturing: Thermo Fisher production of 8M automated test kits/week

- LLNL and ORNL developed design and low-volume tooling for viral transport media (VTM) for COVID-19 samples
- LLNL validated use of 3D printing for swabs, enabling production of up to 250k/day
- ORNL and SNL worked with HHS to validate sterilization procedures for Coke preforms for test kits, enabling 2 million tests/week
- Transition to Thermo Fisher Scientific for production

Outcome

- New $40M factory in Lenexa, KS
- 300 new employees

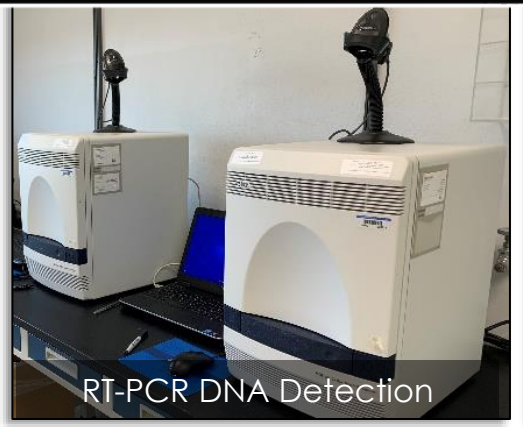
Testing: Established Alternative Reagents, Protocols, and Instrumentation for Nucleic Acid Tests

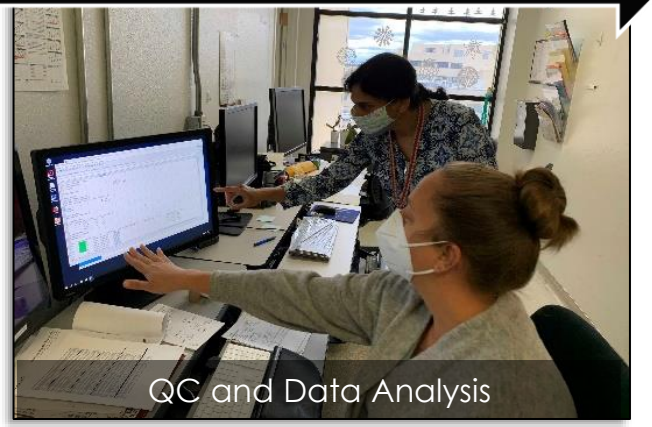
Canonical nucleic acid testing protocol


Collection and Transport


Sample Accession


Virus Extraction


RT-PCR DNA Detection

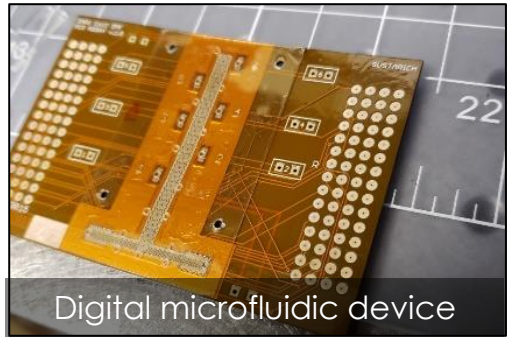

QC and Data Analysis

Alternatives

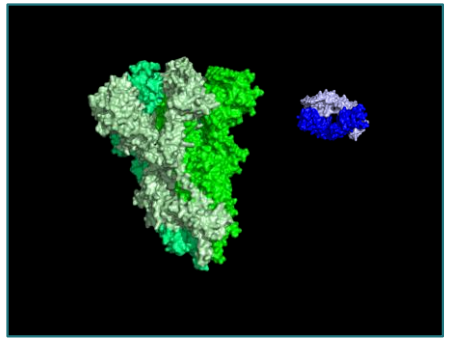
- Nasopharyngeal swabs
- Sputum
- Breath
- Viral transport media (4)
- Inactivation efficiency

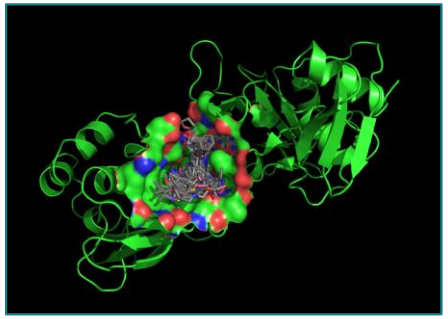
- Pooling studies
- Automation
- Extraction (3)

- Test validation
- Target erosion
- New RNA targets
- FDA Test Panel
- Isothermal amplification
- Digital Microfluidic Device for droplet PCR assays


Digital microfluidic device

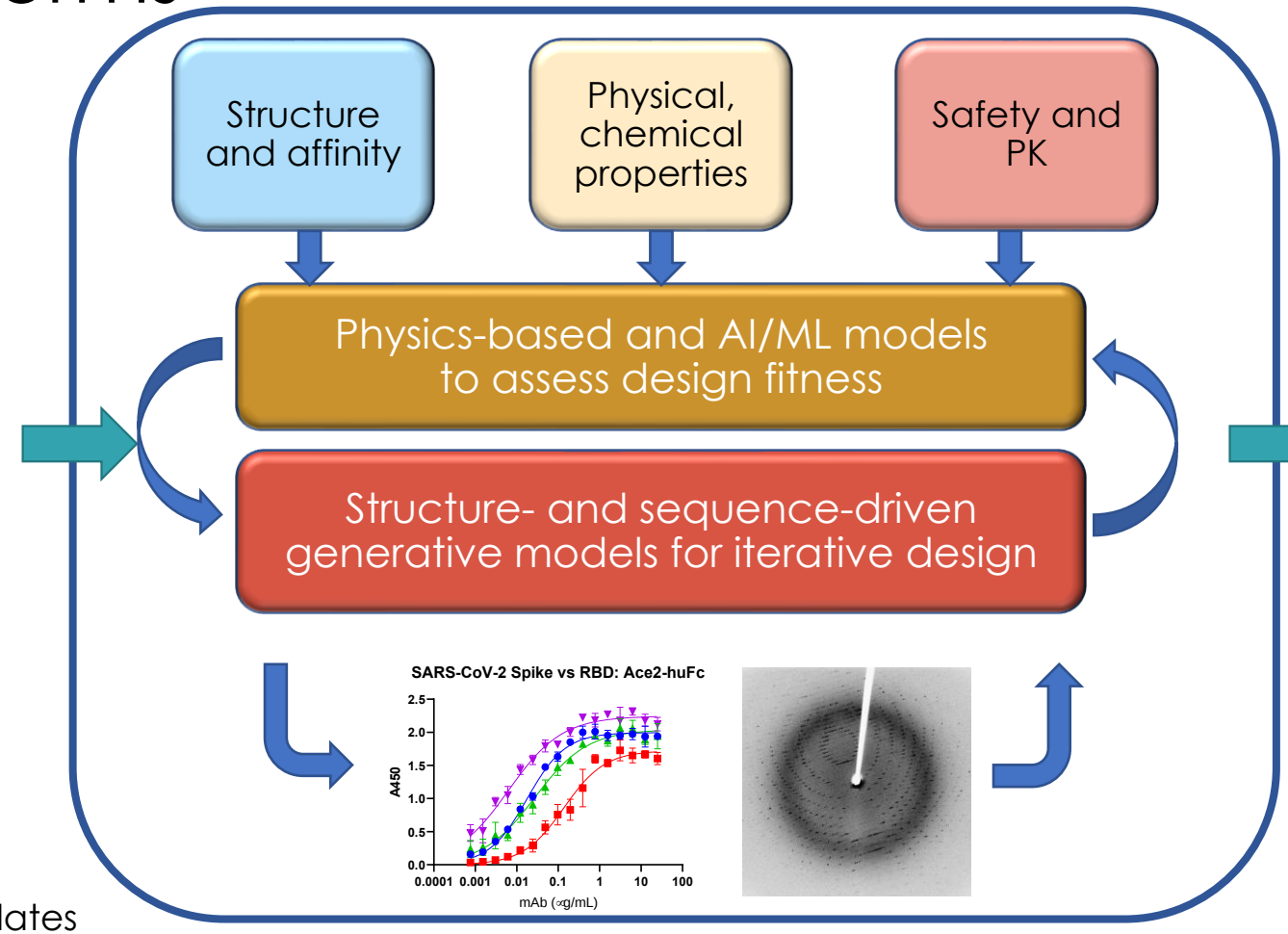
Medical Therapeutics: Computational and experimental design platforms



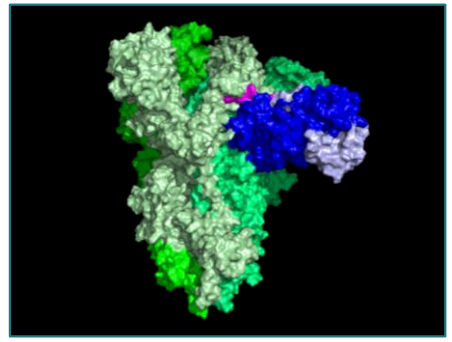


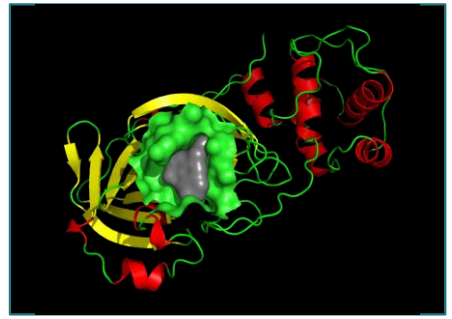
Starting points

- Crystal structures and structural models
- Multiple antibody templates
- Databases of purchasable small molecules



Platform capability funded over time through DOE, DARPA, DoD, and other funding sources





Outputs

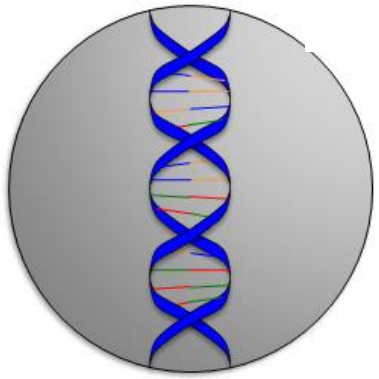
Designs with probability of:

- Desired activity
- Desired biological effect
- Good physical and safety parameters

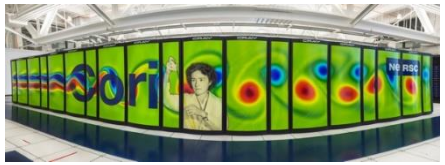
Fate and Transport: Understanding drivers impacting virus transmission

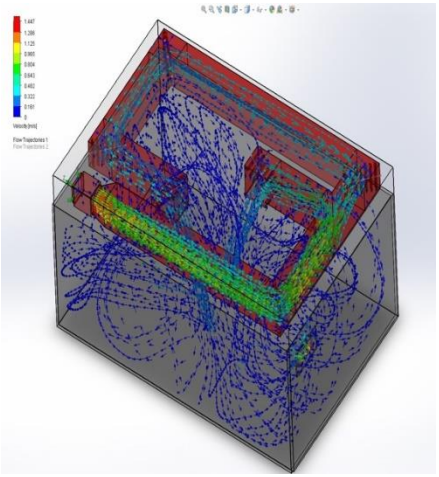
Leveraging national laboratory research facilities, aerosol processes expertise, high-performance computing (HPC) resources, and other unique capabilities

FLEXLAB Testbed	Multi-zone Research Buildings	DNATrax	HPC	Aerosol and Fluid Dynamics Expertise
LBNL	PNNL • ORNL	LLNL	SNL • ANL LBNL • ORNL	ANL • BNL • SNL LANL• PNNL



DNA barcoded bioaerosol surrogate

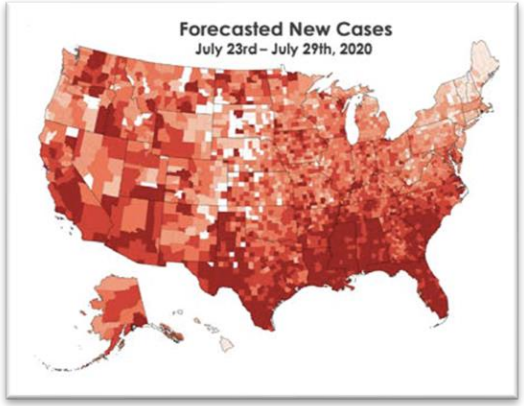




Epidemiological modeling and logistical support

Epidemiological modeling

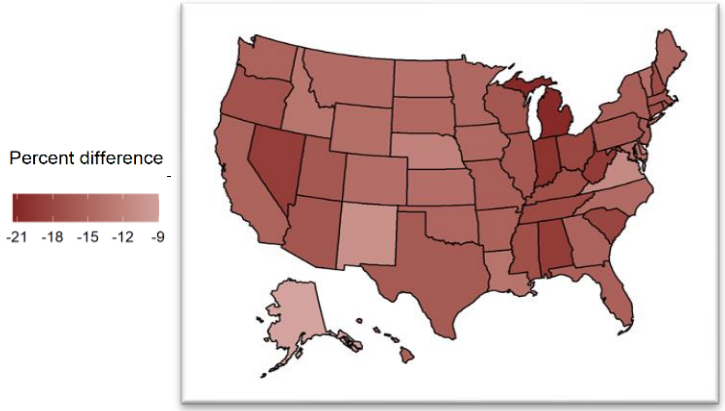
- Short-term assessments by county
- Scenario-based analysis
- Mitigation planning



7-day forecasting of disease prevalence by county

Resource, economic, and vaccine modeling

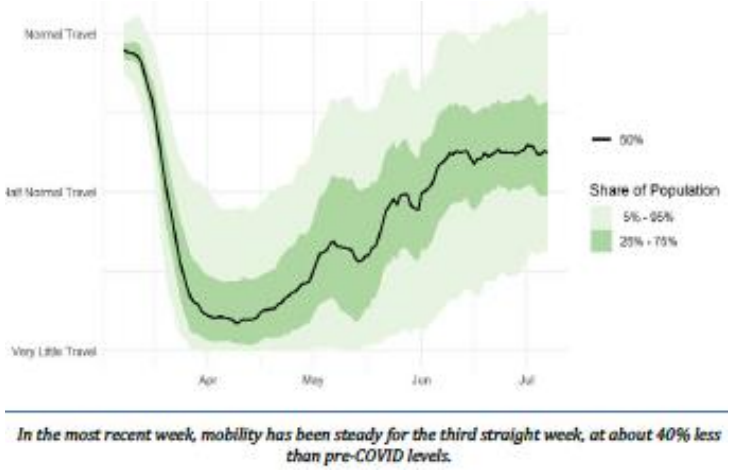
- Medical resource demand
- Economic impacts
- Vaccine distribution strategy



Manufacturing output by state in 2020

Transportation modeling

- Personal mobility
- Freight movement
- Scenario-based modeling

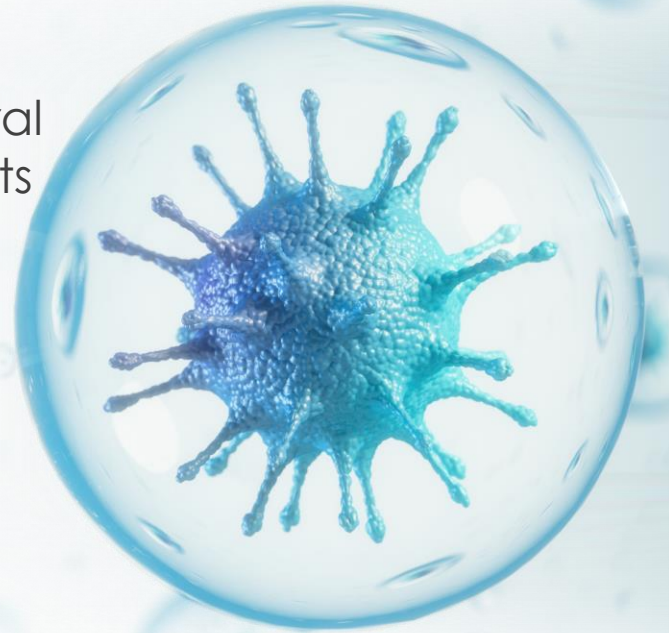


In the most recent week, mobility has been steady for the third straight week, at about 40% less than pre-COVID levels.

NVBL can provide future solutions to combat COVID and emerging diseases

This is what national labs were created to do

- Epidemiological modeling for near-real time forecasts to support decision makers as new variants emerge
- Modeling and analysis to expedite discovery of anti-viral drugs as resistance to vaccines rises due to viral variants
- New tests for rapid detection of variants and new diseases in clinical and environmental samples
- Understanding virus transport to support optimized physical and administrative protocols
- Innovations in materials and processes to address critical supply chain issues and support on-shore production of key supplies

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