Global Good and IV Lab
Inventing for Impact

Translating scientific research into technological solutions for some of the world’s toughest problems
Global Good brings new technologies to life in the ideal invention workspace of the Intellectual Ventures Lab. Collaborating across Lab-based platforms teams, we perform the translational work that applies research-proven science to deliver real-world solutions.

ABOUT GLOBAL GOOD

Every year, millions of people suffer and die in poor countries from causes that humanity has the scientific and technical ability to solve. Funded by Bill Gates and focused on a shared vision with Nathan Myhrvold, Global Good invents technology to solve some of humanity’s most daunting problems.

Pursuing this core purpose of inventing for humanitarian impact, we envision a world where no one suffers from conditions or issues that science has the power to prevent or treat, regardless of where they live.

We do this by collaborating with like-minded organizations, forward-looking governments, research institutions, and corporate and private sector partners that can help to bring our inventions to market.

Pioneering ideas are typically developed to serve affluent markets. In contrast, we seek to create and commercialize breakthrough products for launch into low-income economies, serving the people with the greatest needs first. Thereafter, they may eventually be deployed to more developed economies in a “reverse innovation” approach.

THE IV LAB ADVANTAGE

Global Good’s collaboration with the IV Lab provides several unique advantages that help to accelerate the invention process.

Collaborative Inventing. We generate novel solutions via cross-team brainstorming and “Invention Sessions” with leading inventors.

Risk and Agility. Our inventors, scientists, and engineers have creative freedom to take risks, fail fast, and adapt quickly for more rapid development of refined solutions.

Smart Partnerships. Working together with partners worldwide throughout the process, we’re able to provide more effective solutions.
While many organizations seek opportunities to apply existing technical solutions, Global Good’s problem-first approach begins by looking at existing gaps and then seeking to develop new technologies in response to the needs.

**Global Development Technologies**

Our global development work focuses on practical solutions to address gaps in nutrition, food security, and food safety; to mitigate smallholder farm risks from pests, pathogens, and other environmental factors; and to sustainably improve agribusiness value chains with an emphasis on benefitting smallholder farmers and their families.

**Global Health Technologies**

In the area of health, we focus heavily on improving Primary Health Care with an emphasis on strengthening local clinics and their capability to provide more effective care to the community. Our broader concerns include developing solutions for the prevention, management, and elimination of high-burden diseases as well as addressing general health-related risk factors in the home and workplace.

More detail is available via www.globalgood.com.
Our Vision and Big Bets

Center for In-vitro DIAGNOSTICS

Biotechnology
NAAT Products
Flow DX, Microfluidics
Rapid Culture

Integrating leading technologies into solutions for global health and development

Center for Intelligent DEVICES

Optics and Sensors
Machine Learning
Fluid and Respiratory Systems
Thermal Control

DIAGNOSTICS AND DEVICES

Advances in global development and healthcare are enabled by improved decision support—accurate assessment of current conditions leading to well-informed remedial actions.

In healthcare, low-income nations are generally unable to provide clinics with sufficient decision support. Medical diagnostics usually require professionally skilled analysis, performed at distant lab facilities that are insufficiently resourced to serve the neighboring populations. Our vision for primary care seeks to enable localized decision support with diagnostic systems that deliver immediate professional-quality test results at the point of care, empowering health workers to provide more effective interventions when needed.

Similarly, in the global development realm, we see how smallholder farmers will greatly benefit from new technologies enabling easier assessment of soil nutrients, grain storage moisture, milk cleanliness, and other key factors for productivity and food safety.

To realize this vision for improved decision support, we are investing heavily in developing new diagnostics, delivered via smart devices, providing automated analysis and results at the local level.

PRINCIPAL INVESTIGATORS & PLATFORMS

Principal Investigators (PIs) are senior research engineers or scientists with deep expertise in specialized fields. They co-mingle in the Lab environment and form collaborations to tackle problems. Each PI heads a specifically focused team that can develop and offer “platform” solutions applying a reusable technology capable of being repurposed for multiple practical uses.

While each team will tend to focus on either diagnostics or devices, project activities are often highly integrated across all scientific and technical disciplines in the IV Lab.
The Center for In-vitro Diagnostics develops biological testing technologies to meet the needs of low-income communities who lack access to professionally staffed diagnostic labs. They apply leading techniques such as nucleic acid amplification and detection, microfluidic device design, and digital assay methods. Their solutions seek to provide timely, point-of-care diagnoses for challenging diseases, such as tuberculosis and cervical cancer risk, and also address unsafe water supplies and other broader community concerns.
Biotechnology

The Biotechnology team harnesses advances in nucleic acid detection, protein engineering, and signal amplification. They work on developing next-generation, point-of-care diagnostics that are inexpensive, accurate, and easy to use. Applications include diagnosing cervical cancer risk, tuberculosis, and hepatitis C; determining bacterial load in food products; and removing food toxins.

This group translates advances in the life sciences to develop technologies that improve healthcare and food supply. In its tenure as one of the longest running “platforms” at IV Lab, this team has successfully developed diagnostic approaches that have since launched as new platform groups to take those technologies further. Meanwhile, this core group continues to seek new diagnostic possibilities aligned with Global Good’s focus on meeting the needs of low- and middle-income countries.

While developing new diagnostics is sufficiently challenging in itself, the task is further complicated by the constraints of inventing for low-resource environments. Ideally, solutions should meet World Health Organization criteria for suitability known as ASSURED: Affordable, Sensitive, Specific, User-friendly, Rapid and Robust, Equipment-free, and Deliverable.

Damian Madan, Principal Investigator

Before joining IV Lab, Damian was a senior scientist at Echelon Biosciences where he developed a suite of products that primarily serve oncology drug discovery and in vivo imaging markets. Damian received a B.A. from Willamette University in biology and philosophy and a Ph.D. in molecular biology from Princeton University where he studied cellular machines involved in protein folding. Damian was also a post-doctoral fellow at the University of British Columbia, where he studied the molecular causes of Huntington’s disease.

Advanced DNA-based methods are playing a key role in the development of next-generation diagnostics.
NAAT Products

This group is primarily focused on applications of Nucleic Acid Amplification Tests (NAAT) to determine the existence of specific DNA sequences in biological samples. Whereas our NAAT diagnostics platform and initial project concepts were pioneered by the Biotechnology PI team, this group is now doing late-stage development work to bring those projects to full implementation.

The NAAT team is furthering the development of low-cost tools to rapidly detect pathogen DNA, working in conjunction with platform technologies that can potentially diagnose multiple infectious diseases.

One of the first tests in development will detect human papillomavirus (HPV), which causes 99% of cervical cancer cases and is responsible for 200,000 deaths every year in poor countries. In developed nations, the Pap smear has drastically reduced cervical cancer mortality. It is performed at routine intervals in the woman’s life, monitoring for slowly progressing cellular changes. However, the Pap smear is not suited for low-resource settings where women are rarely tested and are unlikely to return for test results or treatment. The new HPV test aims to immediately identify the disease-causing virus, decreasing the need for frequent testing. With results provided in one hour, women could receive same-day screening and treatment.

DNA is extracted and amplified for the detection of HPV.

John Connelly, Principal Investigator

John is a bioengineer by training with a focus on diagnostic technologies and assay development. Prior to joining IV Lab, he was a senior scientist at Diagnostics For All where he led the development of a novel, non-instrumented, disposable NAAT device and associated assays for use in developing countries. John holds a BS, MS, and PhD from Cornell University, all in Biological and Environmental Engineering. He was also a post-doctoral fellow at Cornell University, where he led technology transfer to integrate a highly sensitivity NAAT assay for the detection of Cryptosporidium parvum in drinking water.
FlowDx, Microfluidics

This team’s research in microfluidics and related material sciences focuses on next-generation rapid diagnostics with enhanced sensitivity. Their work combines robotic assay optimization, paper microfluidics, digital assays, nanoparticle optimization, signal amplification, and antibody discovery and optimization. Application areas include malaria, tuberculosis, other major infectious diseases, and environmental pathogens.

This team specializes in new applications and improved sensitivity for disease-targeted microfluidic systems in which a drop of sample fluid is utilized to generate a signal that is easily interpretable using simple instrumentation (or even none). To facilitate this process, the microfluidics group created robotic assay optimization methods to speed the optimization of diagnostic tests. The new tool helps accelerate progress toward more rapid and accurate diagnosis of several diseases.

Microfluidic assay development tools, such as robotic LFA optimization, may also be used by others in the global health community. Innovations in microfluidic assay types, such as our low-cost digital assays, will be broadly applicable across many diagnostic use cases.

Kevin Nichols, Principal Investigator

Kevin P. Nichols, Ph.D., is a bioengineer with a broad background in assay development. Besides heading the FlowDx work, he has also led several lateral flow assay development efforts at IV Lab. Previously, Kevin was a staff scientist at Argonne National Laboratory, working on microfluidic analytical chemistry systems. His educational background includes a postdoctoral appointment in the chemistry department at the University of Chicago, a Ph.D. from the MESA+ Institute for Nanotechnology, and an undergraduate degree in bioengineering from Cornell University.
The Rapid Bacterial Viability Detection group invents and integrates techniques for quickly determining the viability of microorganisms. In performing this work, they apply the use of cell culture, staining, phage-based detection, metabolite detection, and microfluidic device design.

Current application focus areas include tuberculosis, sepsis, and water quality.

Whether tests are being developed for medical diagnosis or environmental safety, obtaining immediate results is critically important. This group develops practical technology applications that can detect specific harmful bacteria strains in far less time than previous diagnostics.

Methods for detecting *E. coli* in water supply samples typically require a day or more to obtain results via specialized lab processes and professional expertise. This group’s *E. coli* detection project aims to provide test results in just a few hours without the need for any specialized workspace or personnel.

The process is accomplished through a lab-on-a-chip system that automates laboratory steps to detect *E. coli* in environmental samples using genetically modified viruses that induce the expression of a visible signal in the target bacteria. The stepwise procedure is performed in a microfluidic system, wherein tiny channels direct the flow of liquids, such as a test sample and additives, through the entire diagnostic sequence.

**Anne-Laure M. Le Ny, Principal Investigator**

Anne-Laure has extensive experience in molecular biology, biochemistry, and assay development. Prior to joining the team at Intellectual Ventures Laboratory, she worked at Nantworks on vaccine development and drug discovery research against influenza. She received her Ph.D. and a M.S. from the University of Southern California in Chemical Engineering where she studied the interaction between DNA and small molecules. She also holds an undergraduate degree in Applied Chemistry from the University of Orléans in France.
The Center for Intelligent Devices focuses on creating smart systems to solve for gaps in global development and healthcare. Their diverse range of innovations is helping improve diagnostic capabilities at village health posts while also increasing food productivity for smallholder farm families. Designed to be technically effective, these devices must also be engineered to survive the challenges of low-resource health posts and farm environments, such as extreme temperatures, moisture, dust, pests, and unreliable power supply.

Benjamin Wilson
Director, Center for Intelligent Devices

Ben Wilson’s work at Intellectual Ventures Laboratory is primarily focused on optical devices and advanced algorithms as well as machine learning for image and spectral interpretation. As an IV Lab scientist, he has been a key contributor to more than thirty scientific articles and conference papers covering a wide range of optics-related topics. Prior to joining IV, he worked on research teams at the University of Washington and Pacific Northwest National Laboratory. He received his Ph.D., M.S., and B.S. degrees in Electrical Engineering from the University of Washington.
Optics and Sensors

This team creates intelligent sensors to perform diagnostics for global health and agricultural applications. Their core capabilities include spectroscopy, chemometrics, machine learning, signal and image processing, and optical and electronic hardware design. Much of their work involves coupling novel, low-cost sensors with smart algorithms to evaluate materials ranging from medicines to soils.

Optical spectroscopy provides instant evaluation of a material’s properties via non-destructive reflection of Near Infrared (NIR) light by the object.

This group has developed an NIR-based system for detecting falsified and poor-quality medicines in the developing world. At the heart of this solution is a new type of low-cost portable NIR device that is suitable for use in low-resource settings. The process begins with creating a baseline library of NIR measurements obtained from known good samples. Then the NIR scan data from a tested pill is compared with the library data to evaluate authenticity.

This extremely portable process is done with the data library and the comparison processing app entirely contained on a mobile phone.

Other projects for this team include using NIR spectroscopy to analyze the quality of soils for smallholder farmers and developing wearable sensors to monitor the health of premature infants.

Matt Keller, Principal Investigator
Matt Keller Ph.D. specializes in optical and electronic sensor systems for detection and diagnostics with a primary focus on low-cost spectroscopy solutions for health and agriculture applications. Previously, he headed optimization of laser parameters for the Lab’s Photonic Fence system. Before joining IV, he was a Research Scientist at Lockheed Martin Laser and Sensor Systems where he led R&D on novel surgical lasers and laser-based neural interfaces. He earned his BE and PhD in Biomedical Engineering from Vanderbilt University where his dissertation examined the use of Raman spectroscopy and fluorescence imaging for surgical applications.
Machine Learning

The scientists and developers in this group apply the latest advances in Artificial Intelligence (AI) and Machine Learning (ML) to improve automated analysis of medical images and agricultural data. Their innovations help to deliver more accurate and reliable decision support to improve lives in resource-constrained populations.

This team applies machine learning towards a variety of healthcare solutions. They created automated microscope image-analysis software that can detect malaria parasites on blood smears. The system was “trained” using thousands of slides of both healthy and malaria-infected blood, the largest slide collection of its kind. The software is capable of diagnosing and quantifying malaria as accurately as a trained medical professional. The team is also developing an AI-powered system to analyze lung ultrasound video, supporting improved diagnosis and treatment of lung pathologies— including childhood pneumonia, a leading cause of illness and death in the developing world.

Another project applies ML to the detection of precancerous cervical lesions via images that can be acquired with a mobile device in remote health clinics that lack trained medical personnel.

Deep-learning AI algorithms were applied to create a program that can visually identify malaria-infected blood cells.

**Courosh Mehanian, Principal Investigator**

After earning a Ph.D. in physics from Cornell University, Courosh Mehanian changed course to pursue a career doing research in the areas of machine learning and computer vision. He has made significant contributions in neural networks for early visual processing, automatic target recognition, semiconductor quality control, automated pap-smear interpretation, and computer-aided diagnosis in digital pathology for drug safety testing. Prior to joining Intellectual Ventures Laboratory, he held positions at Boston University, MIT Lincoln Laboratory, Cytyc, KLA-Tencor, and Charles River Laboratories....
The Fluid and Respiratory Systems group provides expertise in fluid dynamics, transport phenomena, mechanical engineering, chemical kinetics, and multi-phase material behavior. Areas of focus include prevention and treatment of respiratory diseases such as pneumonia through an efficient therapeutic oxygen mask and an oxygen delivery system that mitigates otherwise unreliable oxygen supply.

This team primarily focuses on innovative and appropriate systems and devices that can bridge logistic and infrastructure gaps in low-resource settings.

One of their key focus areas is the improvement of clinical delivery of oxygen to infants – seeking to significantly reduce deaths caused by pediatric pneumonia. To support oxygen delivery mask studies, they created scale models of a wide range of infant face shapes and sizes based on measurements of actual children. They then modeled and studied mask designs using a lung simulator and specialized sensors to record concentrations of oxygen and carbon dioxide as well as pressures and flows. This work led to the development of an improved oxygen delivery cannula (nose mask) with more than double the efficiency of other masks.

Other projects include irrigation systems for smallholder farms, improved cookstoves, and cryogenic cold-chain innovations.

**Daniel Lieberman, Principal Investigator**

Dan is a mechanical engineer by training with 20+ years experience investigating thermo-fluid systems in many areas including cryogenics, respiratory systems, chemically reacting flows, and propulsion devices. Prior to IV Labs, he managed a post-failure-analysis team at an engineering consulting firm. He has held part-time faculty positions at the University of Southern California and École des Métiers de l’Aérospatiale de Montréal. He holds a Ph.D. and M.S. in Aeronautics from California Institute of Technology, a bachelor’s degree in engineering from McGill University, and is a registered Professional Engineer (PE).
Thermal Control

The Thermal Control group creates technical solutions for projects requiring precision temperature control. Their work focuses on developing and maintaining a knowledge base of physics, thermodynamics, thermal design, thermal control, and mechanical, electrical, and systems engineering as applied to topics such as the vaccine cold chain, agricultural dry chain, biospecimen transport, and related logistics.

This team works on projects addressing the need to maintain cold temperature conditions in warm climates, such as for storage and transport of certain medical supplies or perishable foods. However, maintaining higher temperatures may also be needed, as seen in the microbial culture incubator to provide stable incubation temperatures in low resource settings with unreliable power. Additional projects seek improved methods to appropriately dry and measure dryness in agricultural products to reduce post harvest loss and increase smallholder farmer income.

To test device prototypes, this group uses IV Lab environmental chambers. These room-size spaces can replicate ambient conditions from 5 to 70 degrees Celsius and 5 to 95 percent relative humidity. For example to simulate sub-Saharan climates, they can provide an ongoing daily cycle of 43 °C daytime and 25 °C at night.

Michael Friend, Principal Investigator

Michael’s work includes the development of the Arktek passive vaccine storage device and the solar-powered Arktek SDD. Other work includes the affordable microbial culture incubator, milk chilling solutions for smallholder farmers, livestock vaccine cold chain solutions, and agricultural crop drying and moisture measurement. With more than 30 years’ experience spanning nuclear fusion, optical sensors, lasers, medical equipment, and aerospace, Michael has worked for companies large and small. He received a B.A. in mechanical engineering from Cornell and an M.S. in biomedical engineering from the University of Virginia.
Our Invention Environment

CORE FACILITIES
The 87,000 square-foot IV Lab building houses several specialized workspaces, ready and available to support all phases of development work – from exploratory experimentation to prototype fabrication and eventual testing of devices and processes. Focused areas in the Lab include • an advanced physics lab • an instrument fabrication shop • a biotechnology lab • a photonics lab • an electronics lab • a mechanical and micromechanical engineering lab • a mosquito insectary • and other science and engineering workspaces.

PRECISION FABRICATION
The Scientific Instrument Manufacturing and Testing Group (SIMTG) brings several decades of collective engineering and manufacturing experience to IV Lab’s fully equipped shop. With advanced capabilities, such as 3D printing, water-jet cutting, electrical discharge machining, and multi-axis NC milling, they are able to design and fabricate complex customized research instruments and quickly produce new device-design prototypes. This is particularly valuable for Global Good’s agile approach to iterative design.

PROFESSIONAL STAFF
More than 100 Intellectual Ventures employees work in the IV Lab space. A majority of the team members hold advanced degrees and have previous research experience in educational or commercial settings. IV Lab staff also often collaborate with external partners in industry, government, and academia. Our Lab-and-Global-Good teamwork is well served by the flexibility to shift staff and priorities among projects at various stages of development according to evolving needs.
IV Lab often provides foundational research and development for the incubation of new stand-alone companies. Spinouts built on internally developed technologies include TerraPower (nuclear energy), Kymeta (satellite communications), Evolv (security scanning), Echodyne (compact radar), Modern Electron (electrical power), and Pivotal Commware (holographic broadband). A few of these companies continue to reside in the IV Lab building – separately defined entities in the Lab space and customers of available Lab services. Additionally, some IV business units have their own dedicated spaces in the Lab, outfitted with specialized equipment according to their needs.

Here are a few examples of groups who have been located in the building:

**TerraPower**, one of the first ventures launched with Lab support, employing specialized fabrication capabilities of the Lab’s precision instrumentation group

**Modern Electron**, pioneers in new energy technology, dedicated to generating affordable, modular, and reliable electricity

**Modernist Cuisine**, a food-science focused group with the world’s most advanced culinary research kitchen

The Advanced Physics Laboratory leads research in partnership with private and public institutions to push the boundaries of science. Projects include high-current cold-electron sources, new classes of X-ray sources and detectors, and SiC-based MEMS devices for microfluidics and biosensing applications. They also work on the synthesis and growth of large-area chalcogenide semiconductors and are creating devices to apply the unique properties of this class of materials. Future research work may include direct thermal energy conversion and storage.
“The tech industry has almost entirely been about making tools and toys for rich people. We sat down and thought, what are some of the ways we could direct technology to the poorest people on Earth... to transform the lives of people who need their lives transformed?”

— Nathan P. Myhrvold