

## BioBus – Driving Community Science & Education

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Community science terms the active participation of the community in the entirety of the scientific process. Community science emphasises that everyone in the community is encouraged to collaborate with science to perform research and monitoring, whether it's learning how to survey for wildlife and biodiversity, managing and analysing data or carrying out original research. A prominent example is BioBus, which serves the whole New York City Metropolitan area and focuses on creating deep collaborative networks guided by the questions and goals of all people involved in a project.

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## 1. BioBus - A Mobile Infrastructure

The BioBus, Inc. mission is to help minority, female and low-income K-12 and college students in New York City, New York, United States of America, discover, explore and pursue science [1]. BioBus works toward building inclusive and accessible scientific communities in which all people have the opportunity to reach their full potential. Our programs incorporate the best aspects of informal science education and employ resources formal classrooms could never feasibly offer. Two BioBus mobile science laboratories and multiple community science labs are equipped with research-grade tools, from 3D printed optical kits to optical microscopes, that are expertly designed for inquiry-based science education and community science projects.

Since 2008, over 300,000 students in more than 800 schools have discovered the thrill of scientific discovery in BioBus programs. BioBus full-time community scientists with advanced degrees spark, cultivate, and sustain student's scientific interests, identities, and careers. Over 70% of the schools that BioBus visits serve low-income communities, and 80% of our students identify as Black or Latino, groups that are underrepresented in science. 80% of our staff are from groups underrepresented in STEM fields, an important factor in inspiring the primarily Black, Latino, and female students we serve. BioBus' data-driven program evaluations ensure quality, consistency and constant improvements. The results demonstrate statistically significant shifts in student's attitudes and identities related to science, and the overall success of BioBus's programs [2]. Moreover, BioBus programs are informed by student voice - one of the most recent examples is *Going Viral-The card game*. Developed by creative high school interns Desiree Obaji and Ruby Gumenick, and BioBus staff, this free educational card game helps students to understand how viruses work! While a desktop version is under development, a printer friendly version can be found at a dedicated microsite [3].

To further broaden our impact, BioBus is part of the Mobile Laboratory Coalition (Coalition), a partnership of traveling laboratory programs, institutions of higher education, and K-12 schools [4]. The unifying goal of the Coalition is to provide hands-on relevant science experiences for students and teachers that will lead to meaningful, measurable improvements in science proficiency, and encourage scientific career exploration. Through these programs participants are provided the opportunity to master the use of cutting edge laboratory equipment found in today's research facilities while learning key life science concepts and techniques. Mobile laboratories literally roll onto a school campus, providing the same exciting and enriching experiences to all students regardless of socioeconomic status, geography, or school facilities.

### 1.1 Community Science in an Urban Setting

How does BioBus bring science to the people? BioBus supports the local community to explore science and answer the research questions that matter to them. One example is the Sunday Science program around analysing soil from students' neighborhoods and included a search for lead contamination in Harlem Soils, which took place in December 2019. Participating students sampled soil at a local church and community center in upper Manhattan, and conducted a

chemical analysis to alert local neighbors about possible contamination in the soil. Community Scientist's findings were confirmed by Columbia University's Lamont-Dotherty Earth Observatory.

The entire BioBus community also contributed to the health of the East River through the Urban Ecosystems program. Students, scientists, and whole families cataloged the river's diversity of life, taking the first step toward ensuring the river remains healthy and its organisms survive. Students helped design effective and reliable sampling devices to collect organisms for study, and used molecular biology techniques to sequence DNA and identify the invertebrates inhabiting Lower Manhattan's East River Shoreline. They created novel scientific data, contributed that data to a citywide database, learned to use research-grade microscopes, engaged in near-peer mentorship, and acquired new skills in scientific illustration, water quality measurement and species identification. A professional STEM evaluator invited to observe called the program, "the best in informal science...From start to finish, students were engaged in using authentic inquiry practices as a scientist would." The evaluator, with thirty years of experience, wrote, "I've never seen any other class which was so student-directed."

Novel scientific data generated by our students and community scientists contributes to several databases and initiatives, increasing public understanding of environmental issues across the city. Examples include the Global Learning and Observation to Benefit the Environment (GLOBE) program [5], Cornell University's Celebrate Urban Birds (CUBs) [6], and the NYC Street Tree Map [7].

## 1.2 The Power of Community

BioBus also supports development of open-source community projects, such as the BioBus "Do-It-Yourself" (DIY) microscope [8]. This hands-on and modular optical platform guides anyone who is interested through experimenting with designing and building their own 3-D printed microscope. Its modular nature allows for many different optical configurations. Simple modifications even allow for building a cost-efficient fluorescent microscope! All the optical mounts for the DIY microscopes have been custom designed and printed on a 3D platform. In addition to saving money on the structural components themselves, this allows using surplus lenses, instead of standard size ones, allowing for both high quality and low cost. The microscope can be flexibly aligned for 40X or 200X magnification, in order to see small organisms and cells. Co-developed with Joshua Sanders of Sanworks, all files are available online at [build.biobus.org](http://build.biobus.org) [8].

## 1.3 COVID-19 Pivot and Future Directions

With schools closed by COVID-19, BioBus launched *BioBus at Home*, a series of virtual lab programs which transport BioBus from physical labs to online labs [8]. This remote laboratory infrastructure has temporarily replaced grounded mobile labs and shuttered community labs. Recently, BioBus staff also designed and built high-tech, self-contained science stations as a flexible tool for STEM research and education. The Stations can now provide an impactful

alternative during the transition to full in-person programs as the COVID-19 pandemic subsides. BioBus scientists recently designed a new generation of stand-alone Science Stations to reshape underfunded schools and open spaces into accessible, high-tech labs. Adjustable workbenches, powerful microscopes, rotating monitors, and HD eyepiece cameras make Science Stations incredible tools for collaborative exploration. Even a single Science Station can transform well-ventilated indoor and outdoor spaces into working laboratories, and facilitate a rapid and safe return to in-person programs following the pandemic. With the ability to engage an entire class with a single Science Station, BioBus can offer programs in schools and non-traditional spaces without a mobile lab visit. BioBus has successfully used the Stations to lead hands-on, inquiry-based lessons on neuroscience, ecology, and engineering at public schools and community centers around New York. We will continue to use them to promote safety, physical distancing, and hands-on science education while the country fights COVID-19.

#### 1.4 Acknowledgements

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