

Project Title:

Democratizing Nanoscopy: Deploying Low-Cost Single-Molecule Localization Microscopy in High School STEM Classrooms

Project Leaders & Key Personnel:

Name: Iby Madup, PhD

Role: Project Leader

Affiliation: Red Rocks National Laboratory

Contact: imadup@rrnl.gov | (555) 019-2831

Role in Proposal & Implementation: Principal conceptualizer of the educational adaptation of single-molecule localization microscopy (SMLM). Dr. Madup led the drafting of this proposal and will oversee general project management, scientific oversight, and inter-institutional coordination between industry partners and school districts.

Name: Dr. Ayam Knott-Real

Role: Project Co-leader

Affiliation: Leeuwenhoek University

Contact: aknottreal@leeuwenhoek.edu | (555) 019-5842

Role in Proposal & Implementation: Co-developed the pedagogical framework and quantitative assessment metrics for high school curriculum integration. Dr. Knott-Real will direct teacher training workshops, oversee sample/reagent distribution logistics, and lead the program's quantitative outcomes evaluation.

Key Personnel

Name: Licht B. Bright, PhD

Affiliation: Fauxton Nanoworks Inc.

Contact: lb.bright@fauxtonnano.com

Role in Proposal & Implementation: Serves as technical liaison. Provided specifications for equipment compatibility and hardware donations. Will coordinate hardware delivery, warranty support, and technical maintenance across target school sites.

Name: Marcus Aurelius

Affiliation: Gotham City Public Schools (GCPS) STEM Office

Contact: maurelius@gothamcityschools.org

Role in Proposal & Implementation: Assisted in identifying target high schools and establishing safety compliance protocols. Will manage district-level logistics, teacher scheduling, and facility access.

Executive Summary

Advanced optical microscopy techniques—specifically Single-Molecule Localization Microscopy (SMLM)—have revolutionized modern biological inquiry by breaking the diffraction limit of light. However, exposure to super-resolution nanoscopy remains confined to top-tier research institutions, creating an equity gap in early STEM education.

This project, "**Democratizing Nanoscopy**," addresses this gap by establishing an outreach initiative across all 15 public high schools in Gotham City. Partnering with **Fauxton Nanoworks Inc.**, which is fully donating 15 desktop SMLM systems (valued at \$375,000), the initiative requests **\$30,000 over two years** from the Microscopy Society of America (MSA) Strategic Initiatives program. MSA funding will directly support essential ancillary optical tools, chemical reagents, standardized calibration samples, and workshop logistics required for sustainable classroom integration.

The project aims to train 30 high school educators, directly engage over 1,500 students in hands-on nanoscopy experiments, and establish a open-access library of high-school-compatible SMLM lesson plans. By bringing diffraction-unlimited imaging into K-12 classrooms, this initiative advances MSA's strategic goals of expanding microscopy education, broadening public engagement, and cultivating the next generation of microscopists.

PROJECT NARRATIVE

Strategic Area Being Addressed and Justification

The Microscopy Society of America (MSA) Council has prioritized expanding microscopy education, fostering public outreach, and broadening access to advanced imaging technologies among underrepresented and early-career cohorts. Advanced imaging modalities—particularly Super-Resolution Microscopy (SRM) techniques such as Photoactivated Localization Microscopy (PALM) and Stochastic Optical Reconstruction Microscopy (STORM)—are currently restricted to research-intensive universities and specialized facilities due to cost and complexity. Consequently, high school students rarely encounter modern optical physical principles beyond basic widefield brightfield imaging.

This initiative directly addresses two **MSA Strategic Priorities Education and Professional Development** and **Community Outreach and Inclusion** by introducing Single-Molecule Localization Microscopy (SMLM) directly into secondary school curricula. By leveraging hardware donations from Fauxton Nanoworks Inc., this program eliminates traditional financial barriers to entry, enabling secondary students in Gotham City to directly interact with single-molecule emitters, observe optical photoswitching dynamics, and calculate nanoscale spatial resolutions.

Project Plan & Implementation Steps

The project will unfold across two distinct phases over 24 months across 15 public high schools in Gotham City:

- **Phase 1: Procurement, Standardization, & Educator Training (Months 1–6)**

Fauxton Nanoworks Inc. will deliver 15 benchtop SMLM units. Project leaders will assemble standardized ancillary hardware kits (optical alignment tools, safety eyewear, precision pipettes) and chemical reagent packs (blinking buffers, dye-labeled biological test slides). In Month 5, a 3-day professional development workshop will be hosted at Leeuwenhoek University for 30 Gotham City STEM educators.

- **Phase 2: Classroom Deployment & Super-Resolution Modules (Months 7–18)**

SMLM systems will be deployed in 15 schools. Teachers will implement three dedicated laboratory modules:

1. *The Diffraction Limit vs. Nanoscopy* (comparing conventional diffraction-limited images with SMLM reconstructions).
2. *Single-Molecule Kinetics* (measuring photoswitching rates of Alexa Fluor 647 in varying buffer compositions).
3. *Cellular Nanostructures* (imaging fluorescently labeled actin filaments and microtubules in fixed cells).

• **Phase 3: Assessment, Dissemination, & Fair Competition (Months 19–24)**

Hosting the inaugural *Gotham City High School Super-Resolution Imaging Competition* during the annual District Science Fair. Program evaluation, data analysis, and open-source publication of classroom modules will be finalized.

Feasibility & Prior Experience

The leadership team possesses extensive experience in nanoscopy and educational outreach:

- **Dr. Iby Madup** has over 12 years of experience developing low-noise SMLM instrumentation and localization algorithms at Red Rocks National Laboratory.
- **Dr. Ayam Knott-Real** has directed university-level optics outreach programs for over eight years and previously established a successful regional microscopy workshop network for middle school teachers.
- **Fauxton Nanoworks Inc.** has validated their robust benchtop SMLM design in pilot university undergraduate labs, demonstrating a mean drift of less than 5 nm/min without active thermal enclosure.

Measurement of Outcomes & Success Standards

To evaluate implementation fidelity and educational outcome, quantitative metrics are defined for both project years:

Metric	Target / Benchmark	Minimum Standard for Success
Educator Training	30 teachers trained across 15 schools	Year 1: ≥ 24 teachers across ≥ 12 schools passing technical competency assessment
Student Reach	1,500 students participating in SMLM labs	Year 1: ≥ 500 students Year 2: $\geq 1,000$ cumulative students
Image Resolution Realized	Lateral spatial resolution < 35 nm on test grids	Year 1 & 2: $\geq 80\%$ of participating student groups successfully resolve < 50 nm features
Educational Impact	Pre- vs. post-module assessment scores	Year 1 & 2: Statistically significant improvement ($p < 0.05$) with $\geq 25\%$ increase in conceptual optics understanding

Short-Term and Long-Term Accomplishments

- **Short-Term Impact:** Immediate modernization of high school physics and biology laboratory exercises across Gotham City. Over 1,500 students will gain practical experience in fluorescence optics, single-molecule detection, stochastic modeling, and digital image processing.
- **Long-Term Impact:** Establishing a replicable, scalable model for K-12 advanced microscopy education. The open-access curriculum and standardized kit lists developed under this proposal will serve as a national blueprint for other MSA-sponsored regional chapters and school districts.

Innovation

1. **First-in-Class Secondary Nanoscopy Curriculum:** While conventional K-12 outreach relies on low-cost fold-scope or brightfield microscopes, this project introduces *true single-molecule super-resolution nanoscopy* into secondary education.
2. **Open-Source Data & Analysis Pipeline:** Students will utilize open-source image analysis software (e.g., ThunderSTORM / ImageJ) to process their raw photo-switching movies into reconstructed super-resolution maps, bridging physical optics with computational scientific data processing.

Alignment with MSA Strategic Goals

This initiative directly furthers MSA's mission by building public appreciation for the microscopic sciences and creating a pipeline of diverse talent entering the field. Quantitative tracking of student demographics, self-reported interest in STEM careers, and participation in MSA student chapters will track long-term societal impact.

Plan for Long-Term Support

The initial hardware deployment is fully sustained by the initial equipment grant from Fauxton Nanoworks Inc., which includes a 3-year full hardware warranty.

Following the conclusion of the two-year MSA Strategic Initiative grant period, ongoing operational expenses (primarily consumable replacement reagents and fluorescent dye kits, estimated at ~\$300 per school per year) will be transitioned to the **Gotham City Public Schools Science Department annual budget line item**, as formally agreed in the attached Memorandum of Understanding with the GCPS STEM Office. Reagent kit refills will be distributed through a central district distribution repository, ensuring this program requires **no ongoing financial support from the MSA after the conclusion of Strategic Initiative funding**.

BUDGET JUSTIFICATION

Total Amount Requested: \$30,000 (\$15,000 in Year 1; \$15,000 in Year 2)

As specified by MSA Strategic Initiative guidelines, **no salary or stipend support** is requested for project leaders, key personnel, or participating school staff. All instrument hardware costs (\$375,000 equivalent retail value) are provided as in-kind contributions by Fauxton Nanoworks Inc.

Breakdown by Expense Category

1. Ancillary Tools & Optical Safety Hardware

- **Year 1: \$4,500 | Year 2: \$1,000**
- *Justification:* Each of the 15 school sites requires ancillary hardware to support the SMLM systems. This includes laser safety goggles certified for 405 nm and 647 nm wavelengths (4 pairs per school × 15 schools = 60 pairs @ \$50/pair = \$3,000), set of optical cleaning kits and precision mechanical pipettes (15 kits @ \$100/school = \$1,500). Year 2 allocation (\$1,000) covers replacement pipettes, lens cleaning consumables, and optical hardware maintenance.

2. Reagents, Fluorophores, & Buffers

- **Year 1: \$4,000 | Year 2: \$5,500**
- *Justification:* SMLM requires specialized chemical buffers (e.g., MEA/GLOX oxygen-scavenging systems) to induce stable photoblinking of fluorophores (Alexa Fluor 647, Atto 488). Year 1 funds purchase bulk chemical components and dye-conjugated antibodies for kit preparation (\$4,000). Year 2 funds support increased consumable usage as student throughput expands (\$5,500).

3. Calibration Kits & Biological Test Samples

- **Year 1: \$3,000 | Year 2: \$3,500**
- *Justification:* Standardized fluorescent bead arrays (100 nm and 40 nm tetraspeck beads) and prefabricated DNA-PAINT / GATTA-SIM calibration slides are required for system alignment and resolution validation across all 15 sites. Year 1 provides initial calibration sets (\$3,000). Year 2 provides replacement test slides and biological samples (fixed cell lines labeled for actin/tubulin) (\$3,500).

4. Educator Training Workshops & Logistics

- **Year 1: \$3,500 | Year 2: \$500**
- *Justification:* Year 1 covers room rental, printed training workbooks, lab supplies, and lunch for 30 educators during the 3-day summer training institute at Leeuwenhoek University (\$3,500). Year 2 covers logistics for a half-day refresher course and sample exchange meeting (\$500).

5. Imaging Competition & Dissemination

- **Year 1: \$0 | Year 2: \$4,500**
- *Justification:* Year 2 supports the Gotham City High School Super-Resolution Imaging Competition held at the annual District Science Fair. Includes printing of scientific posters, student award plaques/certificates, travel support for winning student teams to present at the regional MSA affiliate meeting (\$3,500), and open-access publication fees for curriculum documentation (\$1,000).

MSA Strategic Initiatives Budget Proposal Submission Form

Please fill out this budget proposal template with the proposed budget for your Strategic Initiatives Proposal. Add additional line items as needed.

DO NOT MODIFY THE FORMAT OF THIS BUDGET TEMPLATE.

Proposal Title: Democratizing Nanoscopy: Deploying Low-Cost Single-Molecule Localization Microscopy in High School STEM Classrooms

Proposal Title MUST be the same as listed on your submission form & project proposal package.

Proposed Budget:

Line Item #	Line Item	Year 1 Cost	Year 2 Cost	Total
1	Ancillary Tools & Optical Safety Hardware	\$4,500.00	\$1,000.00	\$5500
2	Reagents, Fluorophores, & Blinking Buffers	\$4,000.00	\$5,500.00	\$9500
3	Calibration Kits & Biological Test Samples	\$3,000.00	\$3,500.00	\$6500
4	Educator Training Workshops & Logistics	\$3,500.00	\$500.00	\$4000
5	Student Imaging Competition & Dissemination	\$-	\$4,500.00	\$4500
TOTAL	Requested Strategic Initiative Funding	\$15,000.00	\$15,000.00	\$30000