SMALL SCALE FOR A LARGE AUDIENCE

Outreach Projects on Microfabrication and Microfluidics

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Extrinsic Motivation

Why go outside your classroom?

- NSF Broader Impacts
- Institutional service learning requirements
- Institutional mission at religious, land grant, or other types of institutions

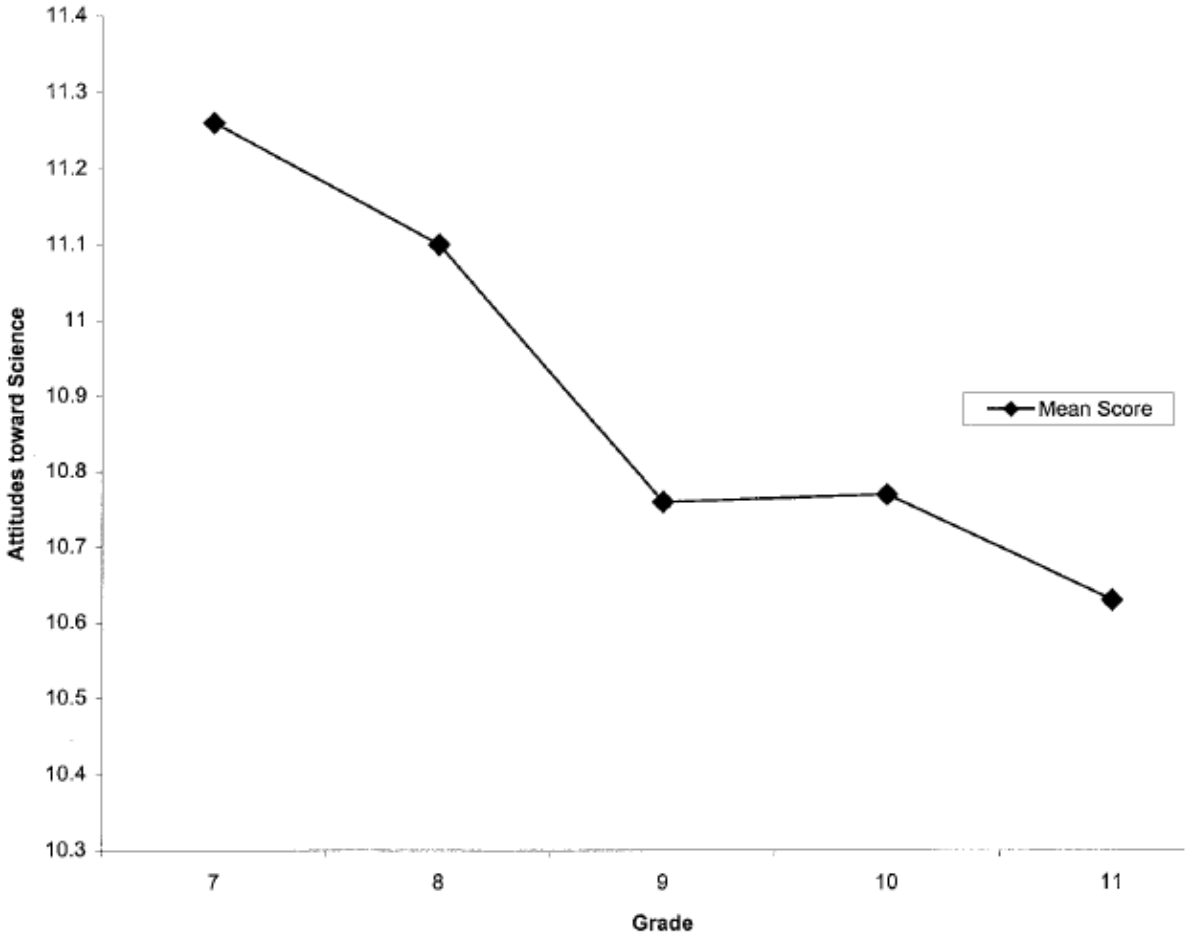
Intrinsic Motivation (for me)

Why go outside your classroom?

- Only 18% of Americans say they know a scientist personally.[1]
- 44% of Americans cannot name a scientist role model. Those that can name Bill Gates, Al Gore, and Albert Einstein most frequently.[2]

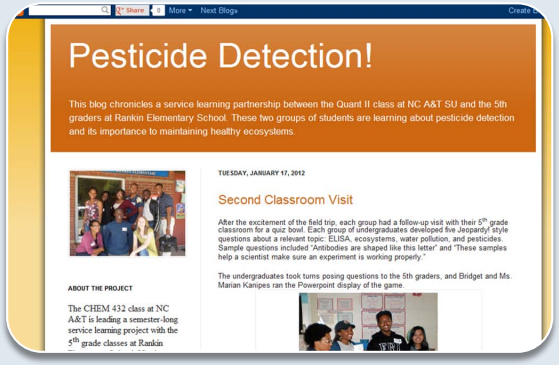
[1]M. Woolley and S.M. Propst, *JAMA*. **2005**, *294*,1380-1384.
[2]Survey on the State of Science in America conducted for the Museum of Science and Industry in Chicago by Harris Interactive (2008).

Motivation for K-12 Outreach



R. George, *J. Sci. Ed. Technol.* **2000**, *9*, 213-225.

Audiences & Venues



Students

- K-12 classrooms
- Colleges
- After-school programs

Families

- Museums
- Festivals and fairs

Communities

- Science Café
- Blogs
- Retirement communities

Today's Talk

Activities

- Microcontact Printing
- Gold Nanoparticles
- Jell-O Microfluidics
- "Macro"-rafts

Considerations

- Science
- Safety
- Supplies
- "Secrets"/Fail-Safes

Microcontact Printing

Reference: Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems, University of Illinois at Urbana-Champaign, https://nano-cemms.illinois.edu/materials/microcontact_printing_full

Microcontact Printing

The Science

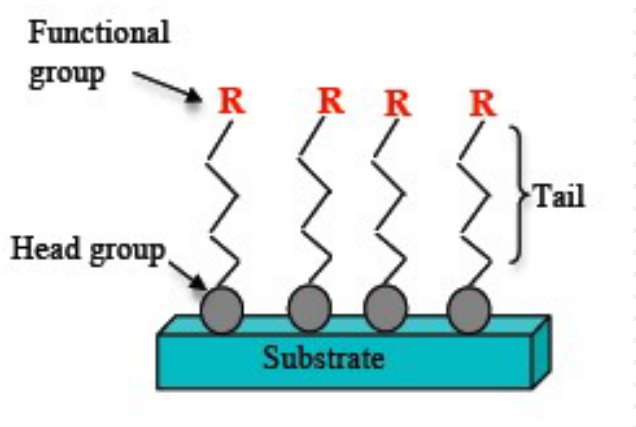
Soft lithography

Thin film deposition

Microcontact printing

Self-assembled monolayers

Isotropic chemical etching



Microcontact Printing

Safety Considerations

- Students should wear gloves, goggles, and lab coats or aprons
  - Silver nitrate stains skin and clothing
- Avoid contact with Tollens' reagent and hexadecanethiol
  - Wash skin thoroughly if exposed
  - Use an eyewash for 10 min if eyes are exposed
- Tollens' reagent is prepared using concentrated ammonia, which requires a fume hood

Microcontact Printing

$367 total up front
enough for 250+

Supplies and Costs

- Polydimethylsiloxane ($61/500 g, Ellsworth)
- Transparency master ($13/50, Staples)
- Glass slides ($14/288, S17466A, Fisher)
- Silver nitrate ($102/25 g, 209139, Sigma-Aldrich)
- Conc. ammonia ($36/500 mL, 320145, Sigma-Aldrich)
- Dextrose ($11/500 g, S25296, Fisher)
- 1-hexadecanethiol ($50/100 mL, 50-014-35933, Fisher)
- Ethanol ($6/500 mL, S25310, Fisher)
- Sodium thiosulfate pentahydrate ($7/100 g, S25574, Fisher)
- Potassium hexacyanoferrate(II) trihydrate ($25/100 g, S25489, Fisher)
- Potassium hexacyanoferrate(III) ($27/100 g, AC19678, Fisher)
- Tin (II) chloride ($12/25 g, S25578, Fisher)
- Hairdryer
- Plastic cups and droppers

Microcontact Printing

Fail-Safe the Activity

- Slides need to be cleaned and rinsed very well to get good adhesion
- Practice ahead of time – you may want to adjust the concentration of hexadecanethiol
- Silver etching solution should be prepared no more than a few hours in advance and kept in a refrigerator protected from light. It should be yellow, not blue.
- Color-code cups of reagents, droppers, and instructions to minimize confusion
- Bring containers to collect liquid waste and rinses

Gold Nanoparticle Synthesis

Adapted from: McFarland, Haynes, Mirkin, Van Duyne and Godwin, "Color My Nanoworld," *J. Chem. Educ.*, **2004**, *81*, 544A.

Photo credit: Joe Harpring, *The Republic* (Columbus, IN)

Gold Nanoparticles

The Science

Oxidation and reduction

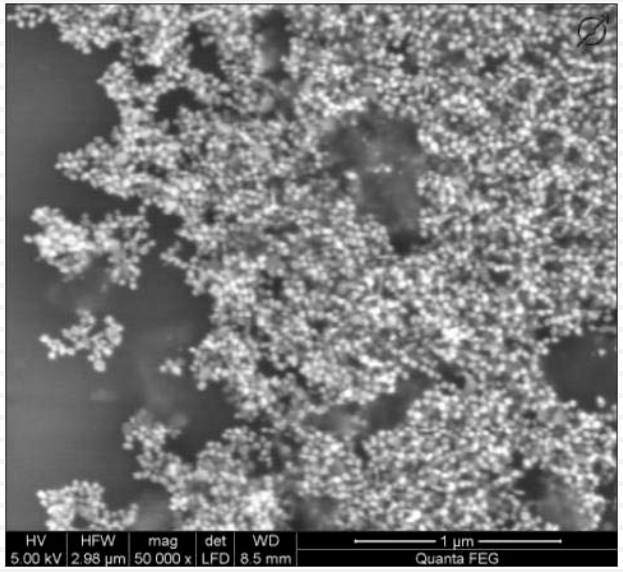
Capping agents

Quantum effects

Absorbance spectroscopy

Scanning electron microscopy

Atomic force microscopy



Gold Nanoparticles

Safety Considerations

- Students should wear gloves, goggles, and lab coats or aprons
  - Hydrogen tetrachloroaurate trihydrate is corrosive
  - Care should be taken to avoid burns from boiling solutions

Gold Nanoparticles

$113 total up front
enough for 250

Supplies and Costs

Hydrogen tetrachloroaurate trihydrate

$99/1 g, G4022, Sigma-Aldrich

Sodium citrate

$14/500 g, S25545, Fisher

Hotplates, stir bars, droppers, glassware

Optional: salt, sugar, access to a UV-Vis spectrophotometer, AFM, SEM and/or other analytical tools

Gold Nanoparticles

Fail-Safe the Activity

- Prepare some gold nanoparticle solutions ahead of time in case some syntheses fail
- Check students' stoichiometry and calculations before distributing their gold solution
- It is very important to add the citrate solution quickly
- If using SEM or AFM, ensure that your instrument can detect the particles of interest ahead of time

Gelatin Microfluidics

Reference: Yang, Ouellet, and Lagally, "Using Inexpensive Jell-O Chips for Hands-On Microfluidics Education," *Analytical Chemistry*, **2010**, *82*, 5408–5414.

Photo Credit: WRAL Raleigh

Gelatin Microfluidics

The Science

Soft lithography

Microfluidics

Laminar flow

Gelatin Microfluidics

Safety Considerations

- Minimal hazards, just a bit messy

Gelatin Microfluidics

$184 total up front
enough for ~200

Supplies and Costs

Jell-O ($30/72oz, B000E1FYHY, Amazon, buy 4)

Knox gelatine ($22/lb, B001UOW7D8, Amazon)

Wooden coffee stirrers ($8/1000, B005GQR6JQ, Amazon)

6-7” disposable plates ($7/250, 9996PWQ, Webstaurant)

1 gal. Ziploc bags ($22/204, B0025W9AKC, Amazon)

2”x 3” resealable bags ($5/500, B002EDH2U2, Amazon)

Optional: My First Lab Microscope
($53, B000NOU54O, Amazon)

Gelatin Microfluidics

Fail-Safe the Activity

- Prepare plenty of Jell-O chips in advance
  - Allow at least 2 days for the chips to "cure" in the fridge
  - For kids, budget about 4 chips/hour
  - Consider bringing "macro" PDMS chips as back-up
- Assembling 200 kits takes 4 people about 4 hours
- Bring a plastic table cloth and baby wipes
- Demonstrate the laminar flow for younger kids

"Macro"-rafts

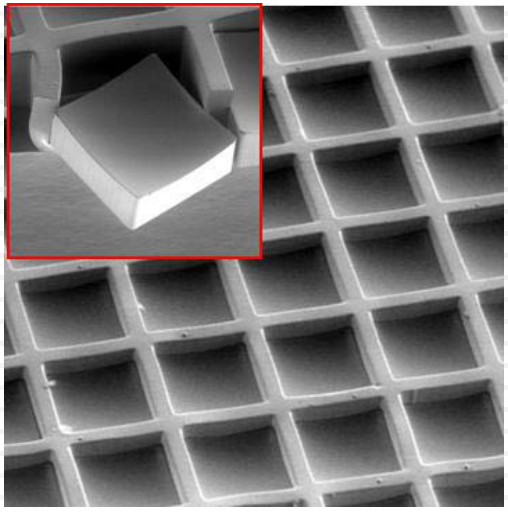
Based on research from the Allbritton lab at UNC: Wang, *et al.*, "Micromolded arrays for separation of adherent cells," *Lab on a Chip*, **2010**, *10*, 2917-2924.

“Macro”-rafts

The Science

Microfabrication

Cell sorting



Your Science

People respond to *"real"* research.

How would you explain your science to a family member?

How can you make your work interactive for a non-specialist?

Safety Considerations

- Minimize hazards whenever possible
  - Avoid concentrated acids/bases/oxidizers
  - Avoid most volatile solvents
- Provide personal protective equipment for all participants
  - Be prepared for worst-case scenario
- If you don't have access to a sink, provide a way for participants to clean up

benchmark:
$1-2/student

Supplies and Costs

- Check out Fisher Scientific Education Grade and Carolina Biological
- Search for local partners and funding sources
  - School of Education, Office of Admissions, etc.
  - Local science museums and festivals
  - Local businesses (talk to your Development Office)
  - Community programs (e.g., Communities in Schools)
  - American Chemical Society and other professional organizations

Fail-Safe the Activity

- Get input from non-scientists
- Know your venue
  - Get screened or trained in advance as needed
  - Align content to state standards when working with K-12 classrooms
  - Obtain safety and photo waivers if necessary
- Prepare a poster and handouts
- Practice, and act like a kid when you do it

Homework

Brainstorm:

- In the next session you attend, ask yourself how each talk could be transformed into an outreach activity
- Sketch out a plan to turn your research into an activity or demo suitable for the public

Research:

- Look up the state standards for your state's K-12 science curriculum
- Browse a website mentioned in this talk, *J. Chem Ed.*, JASDL, the ERIC database, or another resource

Network:

- Identify a potential contact at a local school or museum and get in touch

WITH **MANY** THANKS

Collaborators

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Venues

Louisville Science Center
Columbus New Tech High School
Indiana University Nanoscience Center
Rankin Elementary School
North Carolina A&T State University
University of North Carolina Science Expo
North Carolina Science Festival
Raleigh Museum of Natural Sciences

And thanks for your attention!

Want More Information?

Contact me:
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Slides posted at
mkovarik.web.unc.edu

- http://www.servicelearning.org/
- http://nano-cemms.illinois.edu/education
- http://education.mrsec.wisc.edu/Edetc/nanolab/gold/index.html
- McFarland, Haynes, Mirkin, Van Duyne and Godwin, "Color My Nanoworld," *J. Chem. Educ.*, **2004**, *81*, 544A.
- Yang, Ouellet, and Lagally, "Using Inexpensive Jell-O Chips for Hands-On Microfluidics Education," *Analytical Chemistry*, **2010**, *82*, 5408–5414.