Nanobiotechnology Center

A National Science Foundation supported Science and Technology Center



Integrating Nano into PreK-12 Education

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Building innovative tools to study biology at the nanometer scale

www.nbtc.cornell.edu

Mission

The educational mission of the NBTC is to foster a lifelong interest in science and technology by teaching people of all ages about the nano world.

Education Program Goals

- To implement and conduct a process through which graduate students, undergraduates and postdoctoral associates will be trained in nanobiotechnology.
- To encourage young scientists to think along interdisciplinary lines.
- To involve teachers in curriculum and professional development activities specific to the field of nanobiotechnology and aligned with state and national science education standards.
- To provide summer undergraduate research experiences with an emphasis on recruiting women and underrepresented ethnic groups.
- To create a nanobiotechnology course grounded in the changing needs of the field and the students.

Evaluation Schema

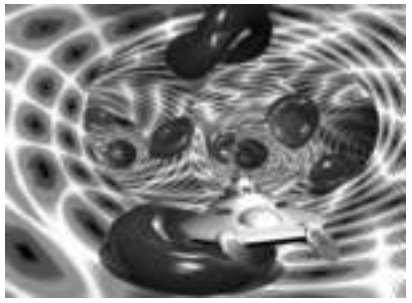
- matrix includes methodologies, data collection tools, data analysis methods and program timelines to be used in the evaluation of the education programs
- specifically aligned to the center's five-year educational program goals
- qualitative and quantitative protocol used to collect data
- outcomes derived are used as a yardstick to measure current status and to anticipate future goals

Methodology Matrix

Programs	Traveling Museum Exhibition	High School Student Internships	Research Experience for Teachers	PreK-4 Science Modules	Middle School Science Club for Girls
Program Inception	1-Jan-00	1-Jan-00	1-Jul-01	1-Nov-00	1-Jul-00
Data Sources	Questionnaires, interviews, focus groups, formal & informal observations	Informal/formal observation, interviews, pre/post surveys of students, student research notebooks and communication logs, mentor observation of student progress, student project portfolio, pre/post surveys of faculty supervisor, graduate	Pre/mid/post surveys, piloting of curriculum and laboratory modules in the classroom, interviews of teachers after piloting of material	Piloting in the classroom with teacher feedback, observation of students interacting with modules	Questionnaires, interviews, observations of project & piloting of curricular materials, teacher self-report and logs, project updates, collection of artifacts, completed projects, student/teacher driven portfolios
Subjects	ES,ET,EP,SP,EE,UF	PS,UP,ST,NS	ST,SS,NS,UF	ST,SS,NS,UF	SS,ST,UF,SA,NS
Schedule for Data Collection	September 2000-2005	June 2000-August 2005	July 2001-June 2004	October 2000-June 2005	September 2000-August 2005

Why nano in preK-12 and for the general public?

- Concepts introduced early provide a context for future learning
- Popular misconceptions
  - Good or bad nanobots
  - Genetically altered nano-organisms



- Communicate on a basic level the latest in science & engineering to those who support it (taxpayers and voters!) and who will benefit from it in the future

How do we know this?

- Pre and post surveys conducted with participants (ages 10-??) over the last two years:
  - What does nano mean? What does bio mean? What does technology mean? What, then, is nanobiotechnology?
- Interviews with ages 5-8:
  - What is the smallest thing you can think of?
  - What is a magnifying glass used for?
  - What is a meter stick used for?
  - What is a cell?

How do we meet this challenge?

- Stick to basic concepts particularly with young audiences (few adults can understand the high-end research of the field unless broken into concepts they know)
- Activities at all levels must be hands-on to engage
- Scientists and engineers need to be involved at each step: development, implementation, evaluation

Faculty member Chris Ober teaching polymers

Overview

Audience	Goals	Programs
preK-4	Introduce concepts related to nanobiotechnology	• traveling exhibition on nanobiotechnology • science modules
5-8	Develop concepts related to nanobiotechnology and introduce the field as a career option	• science lessons • science clubs
9-12	Explore innovations in nanobiotechnology	• research experiences for teachers • internships for students

PreK-4 Interviews

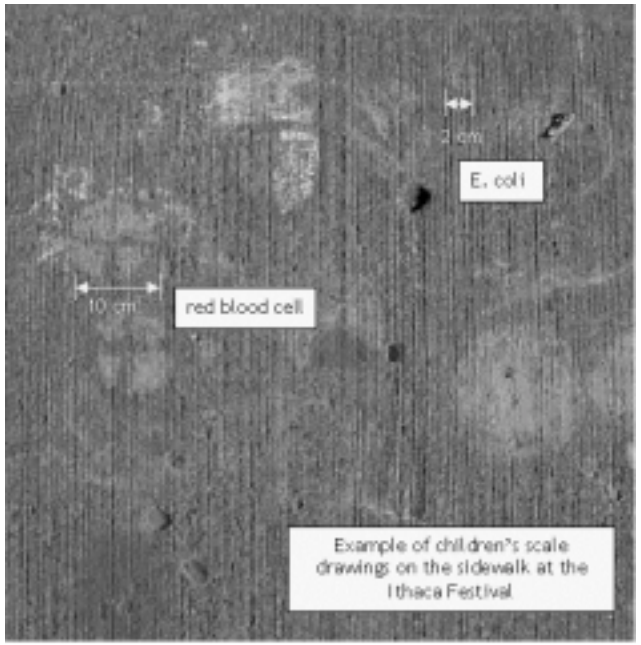
- **smallest thing** they can think of: ants, sand, etc.
- **largest number** they can think of tends to be 100 (K-1st) 1,000 (2^{nd}-3^{rd})
- **magnifying glass**: about half of K understood what it was, many (K-3rd) didn't know how to use
- **microscope**: most had never used and many confused with a telescope
- **things inside your body**: individual organs, blood, and bones, only a few got to a smaller level
- **cell**: only a small percentage of 2^{nd}-3^{rd} graders had a sense of what a cell is; no sense of how big a cell is

Realistic Concepts for Ages 5-8

- Amazing things happen that are too small to see with just your eyes.
- Scientists and kids can use tools to observe these small things.
- Small things are made up of even smaller pieces.
- There are many small things inside my body.
- Nano is really really small.
- Lay the groundwork and create a context for future learning about nanobiotechnology.

PreK-4 Science Modules

Objective: Students observe various microorganisms under three different magnifications and then draw these to scale in a one-meter box.



Nanotech Science Lessons for Grades 5-8

- Process of micro and nano-fabrication through simulation exercises
  - CAD
  - Nanosmores and Photolithography
  - Sunprinting and Photolithography

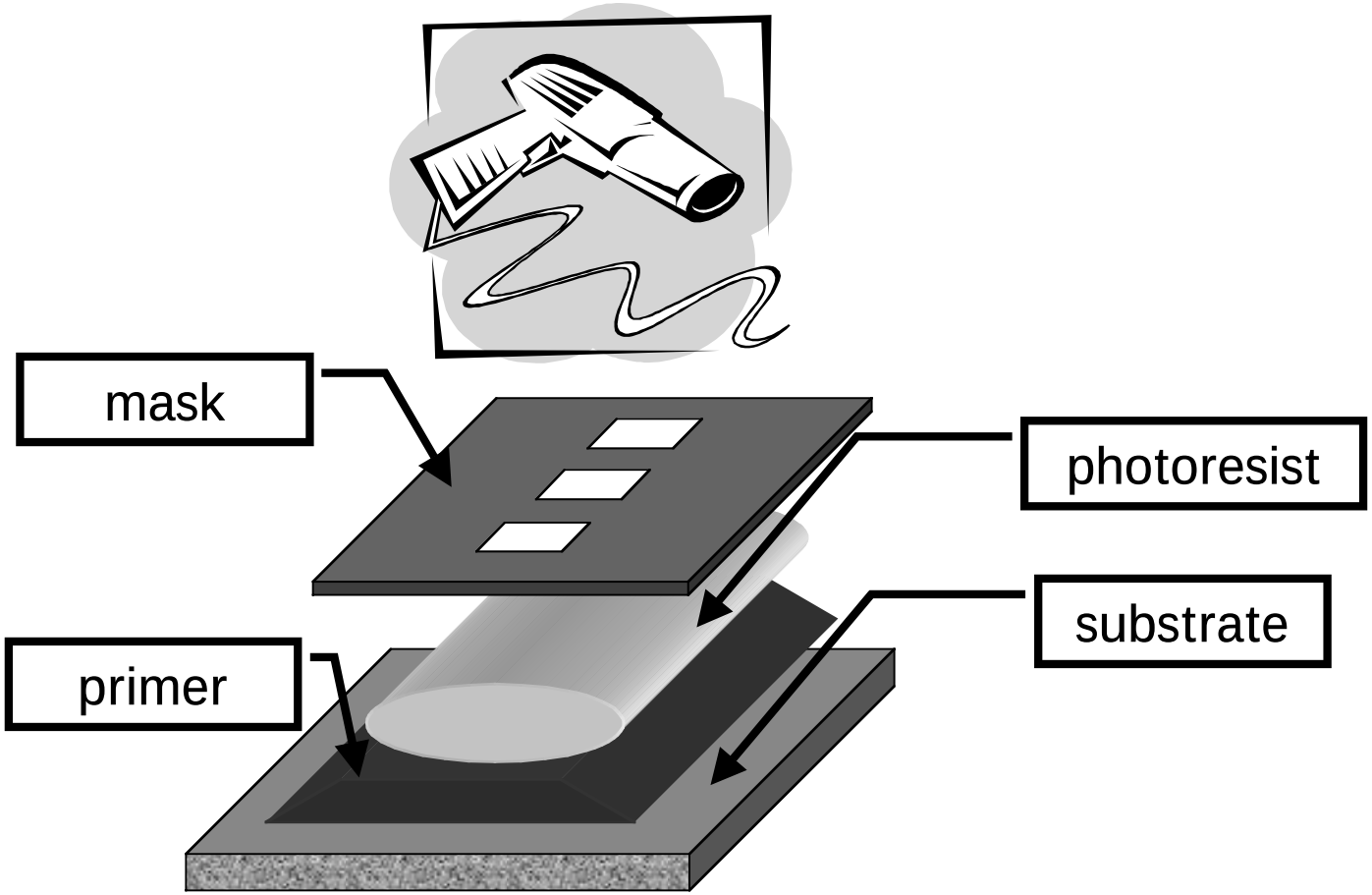
CAD

- Appropriate for middle school and up
- 20 workstations outfitted with CAD through College of Engineering
- 1 hour tutorial including an introduction on why we use CAD in nanobiotechnology

Nanosmores and Photolithography

Objective: Students create an edible, layered cookie (smore) that represents the process used to create a patterned silicon wafer using a substrate and a photoresist.

Nanosmores and Photolithography

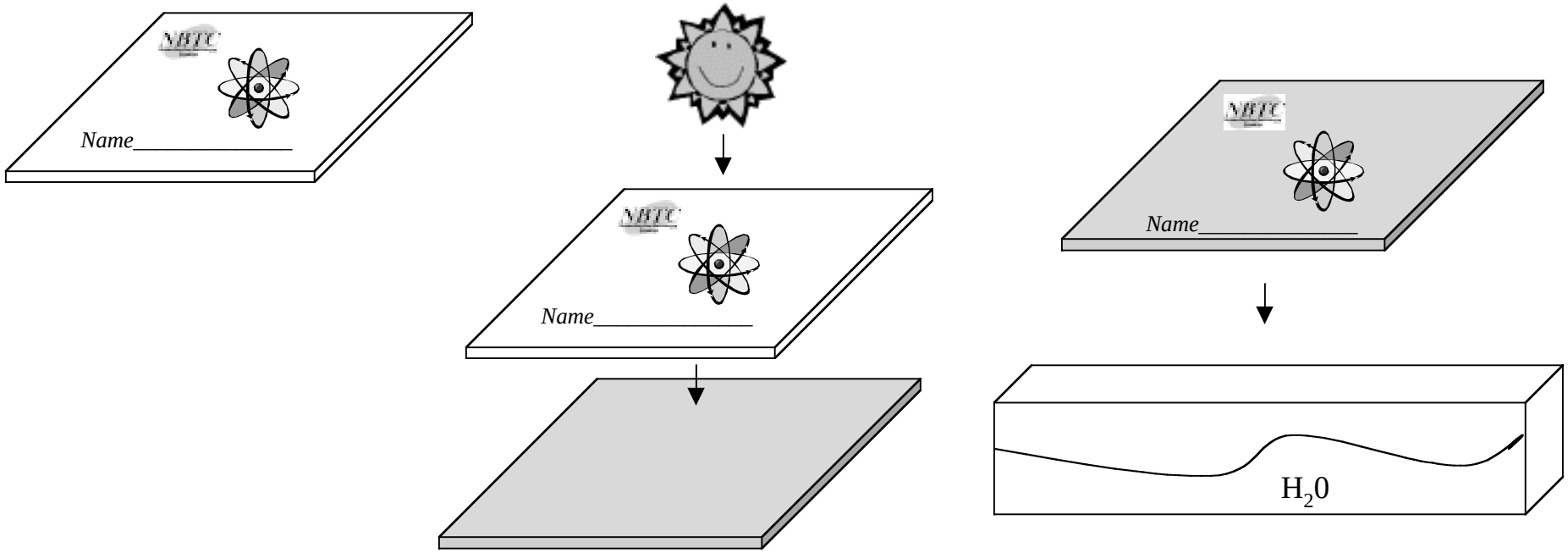


Sunprinting and Photolithography

Objective: Using the concepts of photolithography, students transfer a pattern from an acetate transparency to sun paper.

Sunprinting and Photolithography

Step 1: Choose a mask. → Step 2: Using UV light, transfer the pattern to the paper. → Step 3: Develop the pattern using H_20.



Grades 9-12

- Explore innovations in nanobiotechnology
  - internships for high school students

High School
Interns 2002

High School Student Internships 2002

- 5 week in-residence program
- Real experience designing, fabricating and testing devices at our facility

Pre-survey data

What would you like to learn through this experience?

•Through this internship I hope to realize if biotechnology or perhaps even nanobiotechnology is what I plan to make of my future. I hope to also become better acquainted with lab work and hands-on research.

•I hope to continue work on my nanoexperiment, learn about other ways to present data and decide whether I want to continue education in the material sciences.

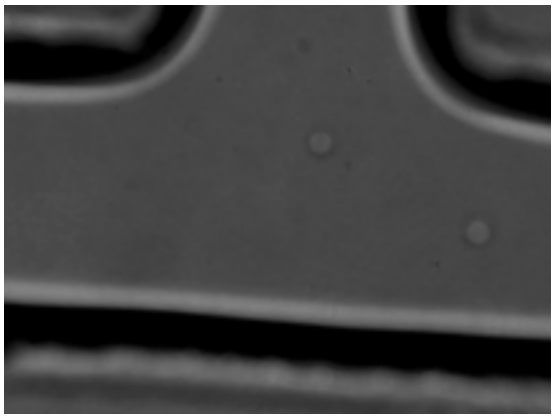
•I hope to gain a greater understanding in the nanotechnology field and get a feel for the field of biology I also would like to get an insight on life at Cornell.

Pre-survey data

- Through the participation in this program I hope to learn more about the different new applications of science, new areas of science, and how to conduct university level research, in order to be more prepared for college.
- I hope to learn about carbon nanotubes as well as experience what it is like to do authentic science research in a fully equipped lab.
- I hope to learn the new applications of this science further than what I learned last summer at OSU.

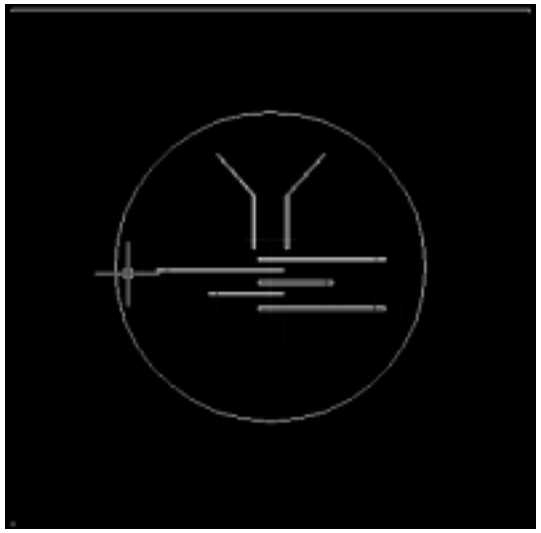
Outcomes

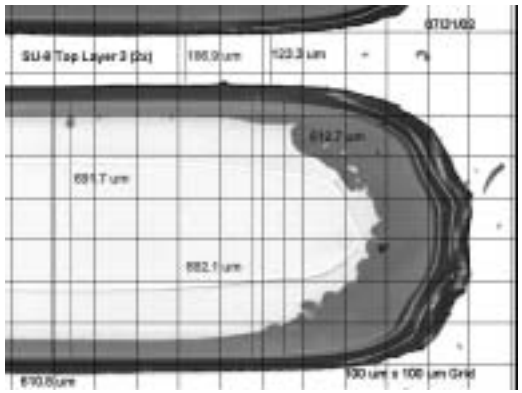
- Students worked in 2 teams to design, fabricate and test cell sorters made of PDMS



Channel viewed
under fluorescence

AutoCAD schematic
of cell sorter





PDMS channel
(measurements for
characterization purposes)

Outcomes from the post-survey

What did you learn?

• a great deal about microfabrication, DNA manipulation, microfluidics, and E. coli; also learned about teamwork.

• how a real lab works and what instruments and devices are usually used; also learned more about the behavior of bacteria; learned more effective ways to search for information such as using journals; also learned what is actually being done in nanobiotechnology.

Outcomes continued…

What did you learn?

• about the SU-8/PDMS processes (pouring, spinning, baking, developing); specific topics were cells and GFP, making cells competent, lab sterility, flourescence, microbiology, sorting, plasma treating, pumps.

• nanobiotechnology, both the theoretical science and the physical process; biology and basic lab skills; how to live in college.

In Summary

- Stick to basic concepts particularly with young audiences
- Activities at all levels must be hands-on to engage
- Scientists and engineers need to be involved at each step: development, implementation, evaluation