

Nanotechnology and Society -- STS 198

Spring 2007

Course Overview

Nanotechnology involves the development of tiny amounts of material far smaller than the human eye can detect. A nanometer is 1 billionth of a meter, and a single human hair is approximately 80,000 nanometers wide. Engineered atom by atom to give them unique properties, nanoparticles do not behave like solids, liquids or gases. Instead, they have special properties that include different colors and electronic, magnetic and mechanical properties, which can all be altered at the nanoscale. Because of these unique properties, nanotechnology is supposed to drive a “new industrial revolution,” according to U.S. government officials. One official estimates that by 2015, nanotechnology will play a key role in products that will spur the economy by \$1 trillion per year, requiring two million workers. Besides its impacts on industry, nanotechnology is projected to influence many societal factors including privacy, military and security issues, health and environmental risks, medical technologies, socioeconomic and global concerns..

This course will introduce students to both the societal and technological dimensions of nanoscale science and nanotechnology. It will explore some of the potential benefits expected from this new field including smaller but more powerful computers, internal medical monitoring, new foods, lighter and stronger materials, and new methods of cleaning up environmental pollution. It also will explore some potential risks various groups foresee including health and environmental risks, radically changed warfare because of nanotechnology-based military weapons, and repetition of costly past technological mistakes such as asbestos. Additionally it will help enhance student awareness of potential career opportunities.

Emerging applications of nanotechnology along with opportunities and challenges will be discussed weekly. Specific nano applications will include electronics, medicine and health, consumer products, and the environment. Other dimensions of nanotechnology and society will also be a focus of the course including business opportunities, entrepreneurship, intellectual property, government issues, public perceptions and the future of nanotechnology. A tour of Lehigh’s Nano-characterization Lab will be a highlight of the course activities.

Course Organization

This course is designed to be a mix of lectures and seminar discussions. **Your participation in class discussion will be an important part of this course and your grade.** You will need to be prepared by doing the assigned readings and attending class. **More than four unexcused absences will lower your final grade one letter.** Since late arrivals disrupt discussions, please try to arrive on time. Leaving and returning to the

classroom during discussions also is disruptive and should be avoided. So, please come to class prepared to stay the full time and come on time. There will be two exams and a course project resulting in a final paper.

Grading

1 st Hour Exam	25%
2 nd Hour Exam	25%
Project	35% (total)
Oral (team)	5%
Written (individual)	20%
Written (team)	10%
<u>Class Participation</u>	<u>15%</u>
Total	100%

Completion of all course work is required to pass the course.

Readings

There will be two textbooks for the course, and they will be available in the Lehigh Bookstore:

David M. Berube, *Nano-hype: The Truth behind the Nanotechnology Buzz* (New York: Prometheus Books, 2006)

Linda Willimas and Wade Adams, *Nanotechnology Demystified: A Self-Teaching Guide* (New York: McGraw Hill, 2007)

There also will be assigned readings on the Web and links for them will be embedded in your course schedule and directly available on the class Blackboard site. A few other readings will be handouts or placed directly on Blackboard.

An important nanotechnology website and a listserv you should be checking regularly are the National Nanotechnology Initiative, www.nano.gov. and the NNI's news site that will give a list of current nano news items, www.nano.gov/html/news/current.html. Another good site is the Probing Nanotechnology Project at the Woodrow Wilson International Center for Scholars, www.nanotechproject.org.

The Instructors

Stephen Cutcliffe, Professor, Department of History and Director, Science, Technology and Society Program

Sharon Friedman, Professor, Department of Journalism and Communication and Director, Science and Environmental Writing Program

Andrea Harmer, Director, Web-based Instruction, Center for Advanced Materials and Nanotechnology

Martin Harmer, Professor, Department of Materials Science and Engineering and Director, Center for Advanced Materials and Nanotechnology

Chris Kiely, Professor, Department of Materials Science and Engineering

Wei-Xian Zhang, Associate Professor, Department of Civil and Environmental Engineering

Course Coordinator: Stephen Cutcliffe, Email address—shc0@lehigh.edu.
Office Hours: MWF, 10-noon; other times by appointment.

***Accommodations for Students with Disabilities*:** If you have a disability for which you are or may be requesting accommodations, please contact Prof. Cutcliffe and the Office of Academic Support Services, University Center 212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

Academic Integrity—Students will be expected to follow the Lehigh University Undergraduate Student Senate Statement on Academic Integrity.

We, the Lehigh University Student Senate, as the standing representative body of all undergraduates, reaffirm the duty and obligation of students to meet and uphold the highest principles and values of personal, moral and ethical conduct. As partners in our educational community, both students and faculty share the responsibility for promoting and helping to ensure an environment of academic integrity. As such, each student is expected to complete all academic course work in accordance to the standards set forth by the faculty and in compliance with the University's Code of Conduct.

Tentative Final Project Instructions

Each student will participate in a team-based research project on a nanotechnology topic not covered explicitly in class. There will be both team and individual grades for this project.

There will be 4 teams consisting of 4-5 students each. Each team will focus on specific nano products or processes in both their technical and societal dimensions. No two projects can cover the same product or process. Each member of that team will be responsible for researching and writing a specific component of the larger team project—similar to a chapter in a larger report. All students on the team will be responsible for planning how the project will be researched and for contributing to and writing the executive summary, introduction, and conclusion of the project report.

Specific parts of the project might include the following:

1. technical description
2. analysis of what organizations/individuals are promoting the technology and why
3. discussion of who will likely benefit from the development and who might lose
4. economic and financial aspects
5. production and worker related issues
6. health/environmental issues
7. social/ethical/political questions
8. media coverage and public perceptions
9. other themes as appropriate

Each project will also include a team-based oral report presented during the last week of class. Students will receive an individual grade for their own specific contribution (chapter) and a shared team grade reflecting the overall quality of the project. There will be peer evaluations of individual efforts on the project by team members that could affect members' team grades.

Students will be given a chance to express topic and team preferences, but to ensure a reasonable balance of student backgrounds and majors, and a mix of different years (freshmen to seniors), the instructors will make the final team assignments. We will do our best to give you one of your top choices.

The oral report shall count for 5% of the final grade and the written paper shall count for a total of 30% of the total grade (20% individual and 10% team). Given its grading weight, this project is an important component of the course and should not be taken lightly. Getting a good head start on identifying a topic, conducting the research, and organizing your findings will be very important. All topics must be cleared with the instructors. *A few possible topics:* A nano-enhanced sports equipment item; a specific medical application; nano coatings—e.g., paint, anti-stain coating; a military application; an information technology enhancement; nano sensors.

Tentative Schedule:

- 2/1: Review information to look for possible nanotech topics for final project.
- 2/ 8: Project discussion—come prepared with questions. Turn in a list of topic preferences
- 2/15: Project team assignments; team meetings for half the class.
- 3/20: Team Project Interim Report and Questions.
- 4/24-26: Oral Team Projects Due.
- 5/2: Written Team Project Due.

TENTATIVE COURSE OUTLINE AND SCHEDULE OF READINGS

Part 1: Introduction

Week 1

Tues., Jan. 16 (Cutcliffe et al)

Introduction to course and instructors

Video: *When Things Get Small* <http://www.ucsd.tv/getsmall>

Thurs., Jan. 18 (Cutcliffe)

What is Nanotech?

Nanotechnology is often claimed to be the next great “revolution” in science and technology, one that will transform both nature’s basic building blocks—atoms and molecules—and the society that adopts its vaunted products. So, What Is Nanotechnology, and Why Should We Care about Its Societal Dimensions? Is Nanotechnology More or Less Important than Earlier Technologies, Large or Small? What economic and career opportunities are available in this rapidly evolving field?

Read:

1. Kristen Kulinowski, “Nanotechnology: From ‘Wow’ to ‘Yuck’?” *Bulletin of Science, Technology & Society* 24 (Feb. 2004): 13-20, <http://bst.sagepub.com/cgi/reprint/24/1/13>
2. *Nano... Demystified*, Ch. 1.;
3. “Promoting Economic Development Opportunities through Nano Commercialization,” David Rejeski, Director Project on Emerging Nanotechnologies, Woodrow Wilson Center, Congressional testimony, 5/4/06, [FULLTEXT5-4-06.pdf \[281.42kb\]](#)

Week 2:

Benefits and Risks, Large and Small

Nanotechnology promises many new products, processes and improvements, yet many scientists, politicians, and ethicists have begun to raise cautionary questions about possible risks associated with these projected benefits. How useful to society are sunscreens, stain resistant pants, smart paints, and improved tennis balls? Will nano-enhanced drug delivery systems and medical devices extend or improve the quality of our lives?

Tues., Jan. 23 Societal Benefits and Risks (Cutcliffe)

Read:

1. Bill Joy, “Why the Future Doesn’t Need Us,” *Wired Magazine* (August 4, 2000) http://www.wired.com/wired/archive/8.04/joy_pr.html;
2. John Seely Brown and Paul Duguid, “Response to Bill Joy and the Doom-and-Gloom Technofuturists,” *The Industry Standard* (April 13, 2000) <http://www.aaas.org/spp/rd/ch4.pdf>;
3. Ray Kurzweil, “Promise and Peril” in *Living with the Genie*, ed. by Alan Lightman. et al. (San Francisco: Island Press, 2003)

Thurs., Jan 25 Societal Benefits and Risks (Friedman)

Read:

1. *Nano-hype*, Ch’s. 1 and 2.
2. “Tiny Toxins,” Philip Ross, *Technology Review*, May/June 2006, http://www.technologyreview.com/printer_friendly_article.aspx?id=16814
3. Nanotechnologies: “Tiny Particles promise much but could pose big risk.” www.nrdc.org/health/science/nano.asp.

Week 3: Size Matters

The Developing Science of Nanotechnology—the Tools of the Trade

Tues., Jan. 30 (Kiely and M. Harmer)

How do scientists define nanotechnology? What effect does particle size have on the properties of a material? How do you make nanoparticles and carbon nanotubes with controlled size and shape? What are the different types of nanomaterials?

Lab demo on making nanoparticles

Read:

1. *Nano... Demystified*, Ch's. 2 and 3.

Thurs., Feb. 1 (Kiely and M. Harmer)

How do you see something that is much smaller than the wavelength of visible light? What would you want to know about a nanomaterial if there was some way of observing objects on the nanoscale?

Read:

1. *Nano...Demystified*, Ch. 4.
2. Look over the nanoprodut list at www.nanotechproject.org/consumerproducts. Start thinking about topics for the final team project.

Tour of electron microscopy characterization facilities

Part 2: Emerging Applications of Nanotechnology-- Opportunities and Challenges

Week 4: Faster and Smarter Electronics Using Nanotechnology

Tues., Feb. 6 (Kiely)

What types of electronic devices can we envisage making with carbon nanotubes?

Case Applications: memory, solar cells, batteries.

Read:

1. *Nano...Demystified*, Ch. 9.

Thurs., Feb. 8 (Cutcliffe, Friedman, Kiely, and M. Harmer)

Read:

1. *Nano-hype*, pp. 195-200.

Mini-Assignment: Each student should come prepared to class with one idea written out regarding a possible societal implication of enhanced electronics technologies.

In part of class we will discuss the Final Project Assignment—come prepared with questions and **turn in** a list of three topic preferences for your final term project with your favorite listed as #1.

Week 5: Better Health through Nanotechnology

Tues., Feb. 13 (M. Harmer)

How will nanoparticles improve the quality and effectiveness of our health care, or do nanoparticles or nanofibers represent a health threat?

Case applications: fighting cancer, 'lab-on-a-chip,' cosmetics

Read:

1. *Nano...Demystified*, Ch's. 5 and 6.
2. National Cancer Institute Announces Major Commitment to Nanotechnology for Cancer Research, <http://nanotechwire.com/news.asp?nid=1108>. Also read one story at <http://nano.cancer.gov>.

Thurs., Feb. 15 (Cutcliffe, Friedman, Kiely, and M. Harmer)

Mini-Assignment: Come to class prepared with one written suggestion about a likely health or ethical issue associated with nano medicine.

Part of class will be devoted to assignments of teams for the final project and brief team meetings.

Read:

1. *Nano-hype*, pp. 200-206; Ch. 9;
2. "Nano, Nano on the Wall," *Business Week*, 12/12/05, www.businessweek.com/magazine/content/05_50/b3963100.htm

Week 6: Consumer Products with Nanoengineered surfaces

Tues., Feb. 20 (M. Harmer)

What types of products would benefit from ultra strong nanocomposite materials? Why does incorporating carbon nanotubes or nanoclays into polymers improve their mechanical performance? How easy is it to fabricate nanocomposite materials? Will their use be limited to specialized products or mass-produced consumer goods?

Case applications: Lotus Effect, Gecko feet, colored and scratch resistant surfaces in autos.

Read:

1. *Nano...Demystified*, Ch. 8.
2. Clothing that makes up its own mind, Sally M. Lourenco, *Financial Times*, January 28 2006. www.ft.com

Thurs., Feb 22 (Cutcliffe, Freidman, Kiely and M. Harmer)

Mini-Assignment: Come to class prepared with one written suggestion regarding the societal implications of a likely consumer product.

Read:

1. "Nanotech Product Recalled in Germany," Rick Weiss, *Washington Post*, 4/6/06, A 02. www.washingtonpost.com/wp-dyn/content/article/2006/04/05/AR2006040502149.html

2. “This War against Germs has a Silver Lining,” Rhonda I. Runale, *Wall Street Journal*, 6/6/06, D1. Pros and cons about using silver as a bacteriacide in nanomaterials <http://online.wsj.com/article/SB114955908525572199.htm>.
3. “The first federal restrictions on nanotechnology could be coming soon,” “NANOWERK, January 3, 2007, <http://www.nanowerk.com/news/newsid=1203.php>

Week 7: Energy and Environment

Tues., Feb. 27 (Zhang)

What are the major applications of nanotechnology with regard to the environment?
How can the science of nanotechnology enhance environmental quality? What types of nanotechnologies can be used to treat hazardous and toxic wastes and to mitigate environmental changes. What are specific nanotechnology applications for energy sources?

Read:

1. Tina Masciangioli and Wei-xian Zhang, “Environmental Technologies at the Nanoscale,” *Environmental Science & Technology* (March 1, 2003): 102-108.

Thurs., Mar. 1 (Zhang)

Mini-Assignment: Come to class prepared with one written suggestion on the implications of nanotechnology for environmental and health risks?

Read:

1. *Nano-hype*, pp. 207-10;

2. *Nano..Demystified*, Ch. 7.

3. EPA Report Looks at Potential Risks, Benefits of Nanotechnology - 02/07/2006. <http://www.occupationalhazards.com/articles/14679>

March 5-9 Spring Break—No Class

Week 8

Tues., Mar. 13—Midterm Course Evaluation and Exam Review

Thurs., Mar. 15—**1st Exam**

Part 3: Nano and Society

Week 9:

The Business of Nanotechnology—Entrepreneurship, Patents and Intellectual Property

Tues., Mar. 20 (Cutcliffe)

What is the role of entrepreneurship in nanotechnology? Will it become the “new” dot.com?
How are companies involved in nanotechnology doing and what are they producing?

Read:

1. *Nano-hype*, Ch. 7
2. *Nano...Demystified*, Ch. 12.

Thurs., Mar. 22

Final Project Team Progress Reports and Discussion

Week 10:

Tues., Mar. 27 (Cutcliffe)

Social Issues

What parts of society should make decisions about what nano-products are produced? Should society assure that the benefits and costs of nanotechnology are shared equally among its members and between nations? If so, how can this be accomplished? What are the workforce needs? What issues of privacy protection are raised by nanotechnology products? What are the risks to the health and safety of those who work in the production of nano-materials? Do military applications of nanotechnology pose risks to civilian society?

Read:

1. *Nano-hype*, Ch. 10;
2. “Broader Societal Issues of Nanotechnology,” M.C. Roco, *Journal of Nanoparticle Research*, 2003, pp. 181-189. <http://www.springerlink.com/content/x7v2474uw5q7m4t0/fulltext.pdf>

Thurs., Mar. 29 (A. Harmer)

Education

What are the issues that educators face in trying to prepare for the estimated need for two million nanotechnology-related workers by 2015? At what grade level should nanoscale science and engineering be introduced and how should it be introduced for effective learning? What are the ramifications if U.S. science and technology curricula do not keep pace (or are outpaced) with those of our global competitors?

Read:

1. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineers, Institute of Medicine. (Executive Summary pp.1-9; A Disturbing Mosaic, Chp.1, pp.1-1 to 1-8; Discovery and Application, Chp.1, pp.1-14 to 1-16; Educational Challenges, Chp.3, pp. 3-25 to 3-30 top)
2. “The Value of Science,” epilogue in *What Do You Care What Other People Think?* Richard P. Feynman. Norton & Co., 1988.

Week 11: Public Perception and Understanding of Nanotech; Communication about Nano

Tues., Apr. 3 (Friedman)

Public Perceptions and Understanding of Nanotechnology

Have most people in the United States ever heard of nanotechnology and are they aware of nanotechnology's potential for extensive societal impacts? Do they know they are being exposed to nanoproducts already on the market? What are people's perceptions of nanotechnology?

Read:

1. "Informed Public Perceptions of Nanotechnology and Trust in Government," Jane Macoubrie, Project on Emerging Nanotechnologies, WWC. 1/06.

2. Hart Research Report on Nanotechnology, WWC, 9/06. www.nanotechproject.org/77/Hart.

Read the whole report.

3. "What Drives Public Acceptance of Nanotechnology," Steven Currall, et al., *Nature Nanotechnology*, December 2006, pp. 153-55.

Thurs., Apr. 5 (Friedman)

Media Coverage of Nanotechnology

Are newspapers and television providing information about nanotechnology to the public? If so, what type of information do people get and what subjects get covered? Has there been a change over time in this type of information? What about the role of the Web in communicating nanotechnology information to the public and to others in the nano community?

Read:

1. *Nano-hype*, Ch. 11;

2. "Nanotechnology: Risks and the Media," Sharon M. Friedman and Brenda P. Egolf, *IEEE Technology and Society Magazine*, Winter, 2005.

3. "Nanotechnology Doesn't Make News," PhysOrg.com, December 17, 2005,

<http://www.physorg.com/news9155.html>

Week 12: Government Support and Regulation of Risk

Tues., Apr. 10 (Friedman)

The U.S. Government's Push for Developing Nanotechnology

Why have the U.S. and other governments invested heavily in nanotechnology? What future impacts do they see that will benefit the country and the economy? What approaches exist within different nations?

1. The National Nanotechnology Initiative Supplement to the President's FY 2006 Budget, "NNI Program Overview: Interagency Coordination in Support of National Priorities," Sec. 1:55-62.

www.nano.gov/NNI-06budget.pdf.

2. *Nano-hype*, Ch's. 3-5

Thurs., Apr. 12 (Friedman)

Government Regulation and Legislation about Nanotechnology

How are government agencies dealing with issues of nanoproduct regulation? Why is regulating nano a problem?

Read:

1. *Nano-Hype*, Ch 8

2. "Chance of A Lifetime," Ann Thayer, *Chemical and Engineering Magazine*, May 1, 2006. <http://pubs.acs.org/cen/coverstory/84/8418nanotechnology.html>
3. "Nanotech: Federal safety research lacks direction -- Science Committee," Lauren Morello, September 22, 2006. <http://www.eenews.net/EEDaily/print/2006/09/22/7>
4. "Berkeley to be first city to regulate nanotechnology," Paul Elias, The Associated Press, Dec 11, 2006. http://www.examiner.com/printa-450227~Berkeley_to_be_first_city_to_regulate_nanotechnology.html

Week 13:

Tues., Apr. 17 (Cutcliffe et al)

A Summary of Where We Have Been

Where to Next? The Future of Nanotechnology

Read:

1. *Nano... Demystified*, Ch. 14.

2. "Mixed Report on U.S. Nanotechnology Effort," [Barnaby J. Feder](#), *New York Times*, September 25, 2006. http://www.nytimes.com/2006/09/25/technology/25cnd-nano.html?_r=1&oref=slogin&pagewanted=print

Thurs., Apr. 19

Second Exam

Week 14:

Tues., Apr. 24

Student Oral Team Project Reports

Thurs., Apr. 26

Student Oral Team Project Reports

Final Written Team Projects due Wednesday, May 2 in Prof. Cutcliffe's Office.