

HONORS 228J (HONR 228J)—HONORS SEMINAR
NANOTECHNOLOGY: FACT, HYPERBOLE, AND FICTION
CORE—PHYSICAL SCIENCES, NON-LABORATORY (PS)
FALL, 2008: TU TH, 2:00-3:15 P.M., MATHEMATICS (MTH) 1308

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Office hours: Mon. 2-3 p.m., Weds. 1-2 p.m., Chemistry 2500A (Bldg 091, Biochemistry = Wing 5)
Please do not drop in to my office or lab outside of office hours, but I will be happy to set up appointments if necessary.

Web and email: The course web site will be handled through ELMS (elms.umd.edu).
You should already be subscribed to the e-mail reflector for the course. To email everyone on the list, send to honr228j-0101-fall08@coursemail.umd.edu.

Course Description

Nanotechnology refers to machines or materials with dimensions on the order of nanometers, where $1 \text{ nm} = 10^{-9} \text{ m}$. Active research in materials science, molecular biology, and engineering is directed at the control of matter on this scale. As such, nanotechnology is a legitimate field supported by federal research initiatives and industry, with applications in electronics, computing, drug delivery, and other areas. We will describe some of the science behind nanotechnology, assuming high school biology, chemistry, physics, and pre-calculus. Technical topics include the design of materials, top-down vs. self-assembled synthesis, and bionanotechnology. This will be supported by a readable popular science book (Ratner and Ratner) as well as primary literature (about 6 papers altogether) from technical journals such as *Nature*, *Science*, and the *Journal of the American Chemical Society*.

Nanotechnology has captured the public imagination to an unusual extent for a technical area. This was sparked by Drexler's *Engines of Creation*, which fleshed out earlier notions of tiny semi-autonomous machinery that could transform modern life. For example, nanomachines could destroy plaque in the bloodstream, repair rusting bridges, or store energy efficiently. Less desirably, nanomachines could be agents of war or terrorism. Self-replicating nanomachines might even cause ecological disaster, turning the biosphere to so-called "gray goo." (This is highly unlikely, but there are substantive issues surrounding the health effects of nanomaterials.) We will also read some visionary essays by Feynman and Joy.

This area makes for a fascinating case study in the popularization of science: the intense hyperbole surrounding the field spawned a cadre of fabulists and then a backlash of debunkers, including many scientists active in nanotechnology research. While many proposed applications of nanotechnology will be realized, some of them violate fundamental physical principles or rely on technology indistinguishable from magic. We will attempt to distinguish among the likely, the conceivable, and the impossible applications, and to anticipate future ethical and policy issues.

Finally, the transforming potential of nanotechnology has led to some wonderful speculative fiction, from Asimov's *Fantastic Voyage* through Bear's bionanotechnology classic *Blood Music* and Stephenson's cyberpunk-flavored *The Diamond Age*. Science fiction has a history of anticipating technological developments and the consequent societal dislocations, and we want to be prepared!

The class will include lectures, discussions of assigned reading, movies, student presentations on technical, hyperbolic, or fictional material, and guest lectures or site visits with campus nanotechnologists. There is a substantial amount of reading, though almost all of it should be entertaining as well as informative. Students will cap off the semester by writing their own short pieces of speculative fiction.

Procedures, Assignments, and Grading

This course is a seminar, requiring substantial student participation to be successful. I hope that we all have a lot of fun, but that doesn't mean there's no work involved! You are expected to complete the assigned reading before each class in order to be able to understand or discuss the topic at hand. There is a substantial amount of reading and writing required. The assignments comprise (1) three reality checks (quizzes) on the science or other reading that we cover (30 % of your grade), (2) class participation in discussions of the literature (10 %), (3) a 20-minute PowerPoint presentation on a current nanotechnology application, delving into the primary literature and other sources to parse reality vs. hype vs. promise; also your evaluations of others' presentations (30 %), and (4) a 5-page short fiction on the human impact of nanotechnology (30 %). In lieu of a final, we may have a literary reading to enjoy each other's fiction.

Grading: Many of you are accustomed to sailing through classes and getting all A's. Real life is not like that: if you are doing something difficult and worthwhile, success is not guaranteed. No one scores 100% on a grant proposal or a novel, and college is supposed to introduce you to life. In this class, I anticipate a distribution of roughly 45:45:10 A:B:C. I am hoping to be pleasantly surprised by the overall class performance, resulting in mostly A's; I am hoping not to be disappointed, resulting in more B's and C's. I do not enjoy giving D's or F's, but I will give them without hesitation if necessary. Grading will be curved in that there will be no cutoffs—on some exams, 80 % may be an A—but you are not competing with your classmates for a set number of A's. Plus/minus final grades will be given. In the past, my classes have been considered challenging, but I have rarely had a complaint about an unfair final grade.

If you absolutely must miss a quiz or turn in an assignment late, you must contact me in advance or within 24 hours after the event, and you must also present a valid University excuse (a note from Health Services if possible). You can then make up the quiz or turn in a late assignment. Recognize that missing your assigned presentation slot will dislocate everyone's schedule. If you fail to give a presentation or turn in the final assignment, you will receive a failing grade. I expect and enforce adherence to the University's Code of Academic Integrity, found at <http://www.studenthonorcouncil.umd.edu/code.html>. I expect you to write out and sign the University honor pledge on each quiz: **"I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination."** I encourage you to form study groups as needed, but **any written work that you turn in must be done independently of anyone else**. Also, "plagiarism" will be interpreted in its broadest sense: ideas from others must be referenced, words from others must be in quotation marks and referenced. Paraphrasing without referencing will be considered plagiarism. Extensive paraphrasing from a single source is unacceptable, referenced or not. As a condition of remaining in the class, you are specifically directed to read my own web page on this: <http://www.biochem.umd.edu/biochem/kahn/plagiarism.html>.

Please be on time for class. Please make sure that your cell phone does not ring. Cell phones must be stored out of reach and sight during quizzes. If you bring a laptop to class, I expect you to make sure that it will not be a source of distraction to other students.

Reading

Required texts:

Engines of Creation (Eric Drexler, 1986, 1990), ISBN 978-0385199735. Popularization of the idea of nanotechnology and the concept of a molecular assembler. Widely derided as part fantasy.

Fantastic Voyage (Isaac Asimov, 1966), ISBN 978-0553275728. Novel about miniaturization and the experience of the micro-world. Much better than the movie of which it is a novelization!

Nanotechnology: A Gentle Introduction to the Next Big Idea (Mark and David Ratner, 2003), ISBN 978-0131014008. Accessible introduction to conventional (reality-based) nanotechnology, by which they mean mainly materials science. *(required reading continued on next page)*

Blood Music (Greg Bear, 1985, 2002), ISBN 978-1596871069. Novella and later a novel setting out a dystopian (?) view of bionanotechnology and DNA-based computing.

The Diamond Age (Neal Stephenson, 1995) ISBN 978-0553380965. Cyberpunk-flavored novel exploring the consequences of widespread nanotechnology, drawing heavily on Drexler's ideas.

Required shorter articles will be provided via ELMS or web links.

Recommended text:

Nano-Hype: The Truth Behind the Nanotechnology Buzz (David Berube, 2006), ISBN 978-1591023517. Sourcebook on exactly what the title suggests. Covers personalities and conflicts in great detail.

Tentative Course Schedule

Some dates are likely to change, but dates for quizzes and student presentations are firm. Please submit a paragraph on your proposed topic at least two weeks before your scheduled presentation.

1. Introduction to nanotechnology fact, hyperbole and fiction 9/2/08
Intro and course organization. Start reading: *Fantastic Voyage; Nanotechnology, the Next Big Idea*
 2. Chemistry, physics, biology, and technology background 9/4/08
Materials science. Chemical principles. Biological nanomachines. Top-down vs. bottom up synthesis.
 3. Movie, Part I: *Fantastic Voyage* (1966) 9/9/08
Early science fiction film, great special effects for its day. Gives you time to rev up your reading!
 4. Movie, Part II: *Fantastic Voyage*, discussion [Finish reading *Fantastic Voyage*] 9/11/08
We will discuss living in the nano-world and the differences between the film and the novelization
 5. Introduction to nanotechnology [Finish *Nanotechnology, the Next Big Idea*] 9/16/08
Lithography, MEMS, AFM, quantum dots. [Start reading assigned nanoscience articles.]
 6. Introduction to vision and hype: the molecular assembler [Start reading *Engines of Creation*] 9/18/08
Feynman, Drexler, the Foresight Institute
 7. Close reading of assigned nanoscience articles 9/23/08
Papers by Whitesides, Lieber, Mirkin
 8. Introduction to bionanotechnology 9/25/08
DNA/RNA polymerases, ribosomes, polyketide synthetases, DNA assembly, protein design
 9. Discussion of *Engines of Creation* [Finish reading *Engines of Creation*] 9/30/08
 10. Introduction to Industrial Nanotechnology 10/2/08
How industry works, commercial nano products, drug delivery [Read DeShong material, other articles]
- Quiz I (30 minutes) ← Covers through Session 9. 10/2/08**
11. Guest Lecture: Phil DeShong on nanoparticles and drug delivery 10/7/08
Dr. DeShong is an organic chemist on campus [Start reading *Blood Music*]
 12. Discussion of hype vs. reality 10/9/08
Smalley and Whitesides vs. Drexler [Start reading *Joy*]
 13. **Student presentations:** 10/14/08
Three presentations on nanoscience developments in the research literature
 14. Dystopian visions 10/16/08
Discussion of *Joy* article; lecture on nanotoxicology
 15. **Student presentations:** 10/21/08
Three presentations on nanoscience developments in the research literature

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| 16. Discussion of Blood Music Start reading The Diamond Age | 10/23/08 |
| 17. Overview of actors in Nanotech (Berube) Academics, government, industry, and what each one wants. | 10/28/08 |
| 18. Student Presentations Three presentations on nano-companies or technologies [Start bionanotech articles] | 10/30/08 |
| 19. Discussion of nano-politics Interactions among scientists, fabulists, investors, and the public sphere. | 11/4/08 |
| → Quiz II (30 minutes) ← Covers through Session 17. | 11/4/08 |
| 20. Guest Lecture: John Fourkas on 3-D nanosynthesis Dr. Fourkas is a physical chemist here who specializes in light-driven synthesis of soft materials | 11/6/08 |
| 21. Student Presentations Three presentations on nano-companies or technologies | 11/11/08 |
| 22. Close reading of articles in bionanotechnology Seeman, Adelman, Baker | 11/13/08 |
| 23. Student Presentations Three presentations on nano-hype or industry | 11/18/08 |
| 24. Discussion of The Diamond Age What makes a good story? Connections to Drexler. Reality vs. fantasy. | 11/25/08 |
| 25. Student Presentations Three presentations on nano-fictions | 11/25/08 |
| → Thanksgiving Break← | 11/27/08 |
| 26. Review/catch-up day on topics left from earlier in the semester Whatever we felt had not been fully explored | 12/2/08 |
| 27. Student Presentation Last presentation on nano-something | 12/4/08 |
| → Quiz II (50 minutes) ← Covers through Session 24. | 12/4/08 |
| 28. Discussion: Where are we going? Predictions for 5, 50, 500 years from now. | 12/9/08 |
| 29. Open discussion and review | 12/11/08 |
| → Short Story due ← | 12/11/08 |
| → FINAL EXAM TIME← | Thursday, 12/18/08, 10:30-12:30 a.m., MTH 1308 |

We will not have a final, but we may decide as a group to use the time for reviewing the semester, handing back final assignments, etc. We may decide to meet as a group for a literary reading, to be arranged.