06: **Research funding; proposals (part I)**

March 9, 2012

Announcements

- Will return background reports by Friday, March 16.
- Proposal assignment now on ctools, due Friday March 30.
- Elsevier RSS feeds are finally working.

Revised schedule

Schedule (subject to change)

#	Date	Theme	Pre-class task (Thurs 2pm)	Assignment (Fri 2pm)
0	Jan/6	Course overview; recap of ME RFE/candidacy process		
1	Jan/13	Defining "research"; learning styles	Research words	
2	Jan/20	Searching and analyzing the literature	Research theme	
3	Jan/27	Creativity and impact; choosing a research topic		
4	Feb/3	Planning and time management		Literature search
5	Feb/10	Advisor-student relations; mentorship and collaboration	Discussion topics	
6	Feb/17	Responsible conduct of research		
	Feb/24	No class		Background report
	Mar/2	No class (spring break)		
7	Mar/9	Formulating and writing a proposal		
8	Mar/16	Evaluating proposals	Proposal exercise	
9	Mar/23	Graphics and visual aids	Proposal aims	
10	Mar/30	Giving and evaluating presentations		Proposal
11	Apr/6	Research administration and commercialization	Proposal peer-review	
12	Apr/13	Student presentations (extended session)		Presentation

Our survey results

	good	improve
creativity	5	4
communication	8	5
time mgmt, organization, efficiency	5	6
fundamentals, theory, analysis	1	5
searching/retaining information	3	6
perseverence, confidence	3	3

Our survey results

Rank the following 1-5: 1=strongly disagree; 3; neutral; 5=strongly agree.

1. I am committed to a research career. **3.2**
2. Nothing else is more important than the research aspect of my career. **1.9**
3. I would be happy working in a position that doesn't emphasize research. **3.1**
4. I have a great desire to contribute to knowledge about how things work. **4.4**
5. I want work that has a strong research orientation. **3.8**

Rank the following 0-10: 0 = not at all confident; 5 = neutral; 10 = very confident

"I can…" (based on your current capabilities, regardless of your research results)

1. Be an effective contributor to a research project. **7.7**
2. Successfully conduct a research project by myself. **6.1**
3. Submit a first-author paper to a conference, and the paper has a high likelihood of acceptance. **5.5**
4. Submit a first-author paper to a journal that will be accepted. **5.1**
5. Be an effective co-author (collaborator, not first author) on a paper. **8.1**
6. Effectively conduct data analyses. **7.9**
7. Identify and pose research questions that are worthy of study. **6.2**
8. Complete a literature review and summarize the important issues. **6.7**
9. Design and conduct effective research. **6.5**
10. Be an effective and successful scientist. **7.2**

Rank the following 1-5: 1=to a very slight extent; 5 = to a very large extent.

1. My advisor shares history of his/her career with me. **2.6**
2. My advisor encourages me to prepare for advancement in this program. **3.2**
3. My advisor encourages me to try new ways of behaving in my role as a graduate student. **2.5**
4. I try to imitate the work behavior of my advisor. **2.6**
5. I agree with my advisor's attitudes and values regarding education. **3.8**
6. I respect and admire my advisor. **4.3**
7. I will try to be like my advisor when I reach a similar position in my career. **3.6**
8. My advisor demonstrates good listening skills in our conversations. **4.0**
9. My advisor discusses my questions or concerns regarding feelings of competence, commitment to advancement, relationships with peers and faculty or school/family conflicts. **2.7**
10. My advisor shares personal experiences as an alternative perspective to my problems. **2.1**
11. My advisor encourages me to talk openly about anxieties and fears that detract from my work. **2.1**
12. My advisor conveys empathy for the concerns and feelings I have discussed with him/her. **2.9**
13. My advisor keeps feelings and doubts I share with him/her in strict confidence. **3.6**
14. My advisor conveys feelings of respect for me as an individual. **3.9**

Rank the following 1-5: 1=to a very slight extent; 5 = to a very large extent.

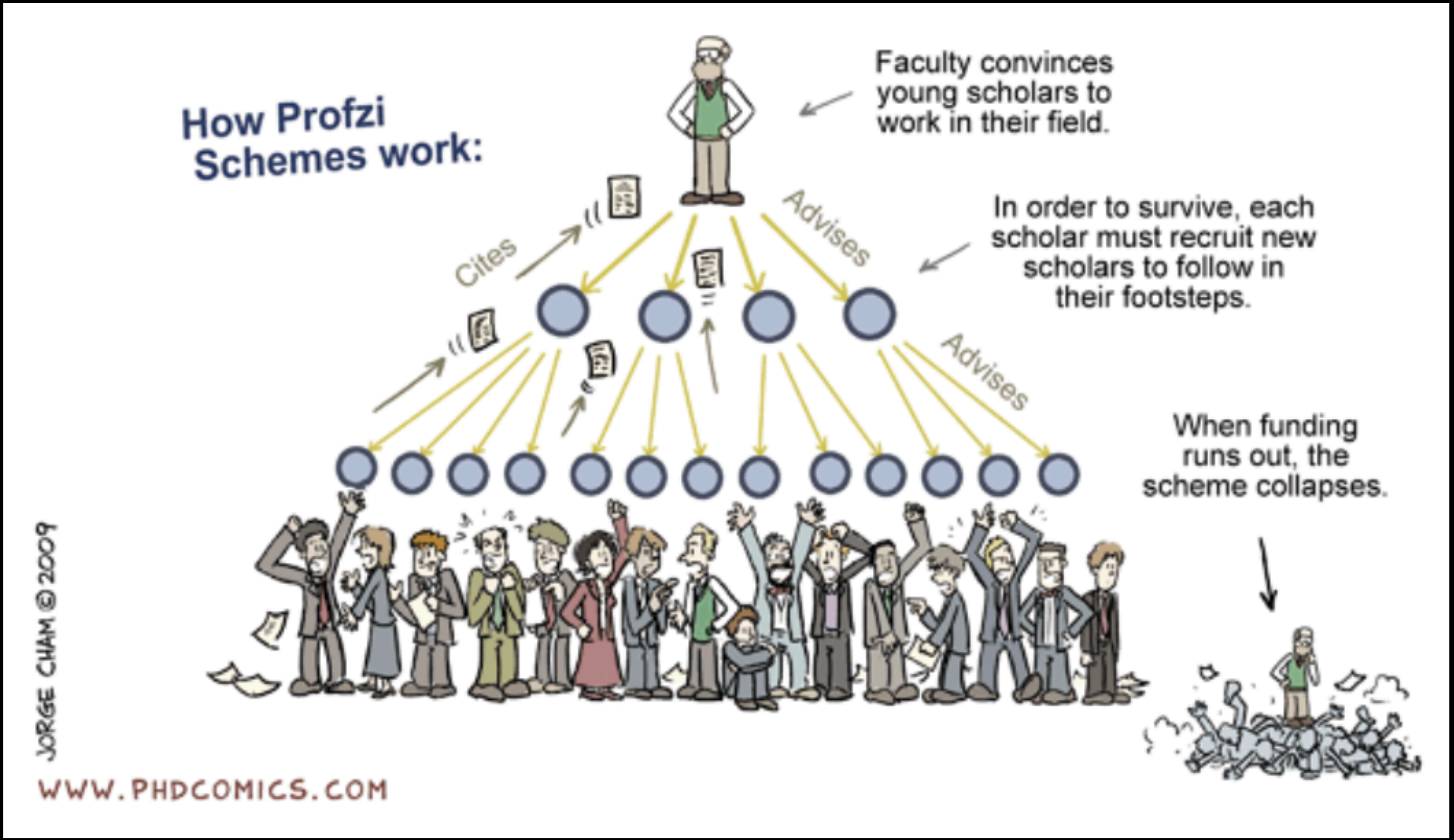
1. My advisor reduces unnecessary risks that could threaten the possibility of my advancing in my program. **3.1**
2. My advisor helps me finish assignments/tasks or meet deadlines that otherwise would have been difficult to complete. **3.0**
3. My advisor helps me to meet new colleagues. **3.5**
4. My advisor gives me assignments that increase my written and personal contact with influential faculty in the school. **2.5**
5. My advisor gives me assignments or tasks that prepare me for a research position after I graduate. **3.1**
6. My advisor gives me assignments that present opportunities to learn new skills. **4.2**

Today: research proposals

- Discuss research funding from a faculty perspective
- Explain how proposals are designed, both from a faculty (grant) and student (RFE, fellowship) perspective
- View proposal writing as a means of planning and organizing research
- Plan an exercise to catalyze thoughts for your proposal

References on ctools:

- Sample of student fellowship and faculty grant proposals
- UMich "Proposal Writer's Guide"; other advice articles
- *Nature* guidelines for a "first paragraph"
- Slides (anonymous) on NSF GRFP applications – good advice
- List of **action words**



But seriously, the cycle of funding is an essential (and sometimes limiting) part of the research process. Ideally, it is the starting point for long-term innovation.

The Research Enterprise at U-M

3rd largest segment at U-M

- Health System: ~ $2.4 B
- Education: ~ $1.3 B
- Research: ~$1.2 B

http://research.umich.edu/content/2012/01/2012-regents-report-slides.pdf

TABLE 5. Twenty institutions reporting the largest FY 2009 R&D expenditures in S&E fields, ranked by FY 2009 amount: FY 2007–09

(Millions of current dollars)

Rank	Institution	2007	2008	2009
	All S&E R&D expenditures	49,493	51,934	54,935
	Leading 20 institutions	14,497	15,244	16,424
1	Johns Hopkins U., The[a]	1,554	1,681	1,856
2	U. MI all campuses	809	876	1,007
3	U. WI Madison	841	882	952
4	U. CA, San Francisco	843	885	948
5	U. CA, Los Angeles	823	871	890
6	U. CA, San Diego	799	842	879
7	Duke U.	782	767	805
8	U. WA	757	765	778
9	PA State U. all campuses	652	701	753
10	U. MN all campuses	624	683	741
11	MA Institute of Technology	614	660	736
12	U. PA	648	708	727
13	OH State U. all campuses	720	703	716
14	Stanford U.	688	688	704
15	U. CA, Davis	601	643	682
16	Cornell U. all campuses	642	654	671
17	U. CA, Berkeley	552	592	652
18	U. CO all campuses	528	536	648
19	U. NC Chapel Hill	477	526	646
20	TX A&M U.	544	582	631
	All other institutions	34,996	36,690	38,511

S&E = science and engineering.

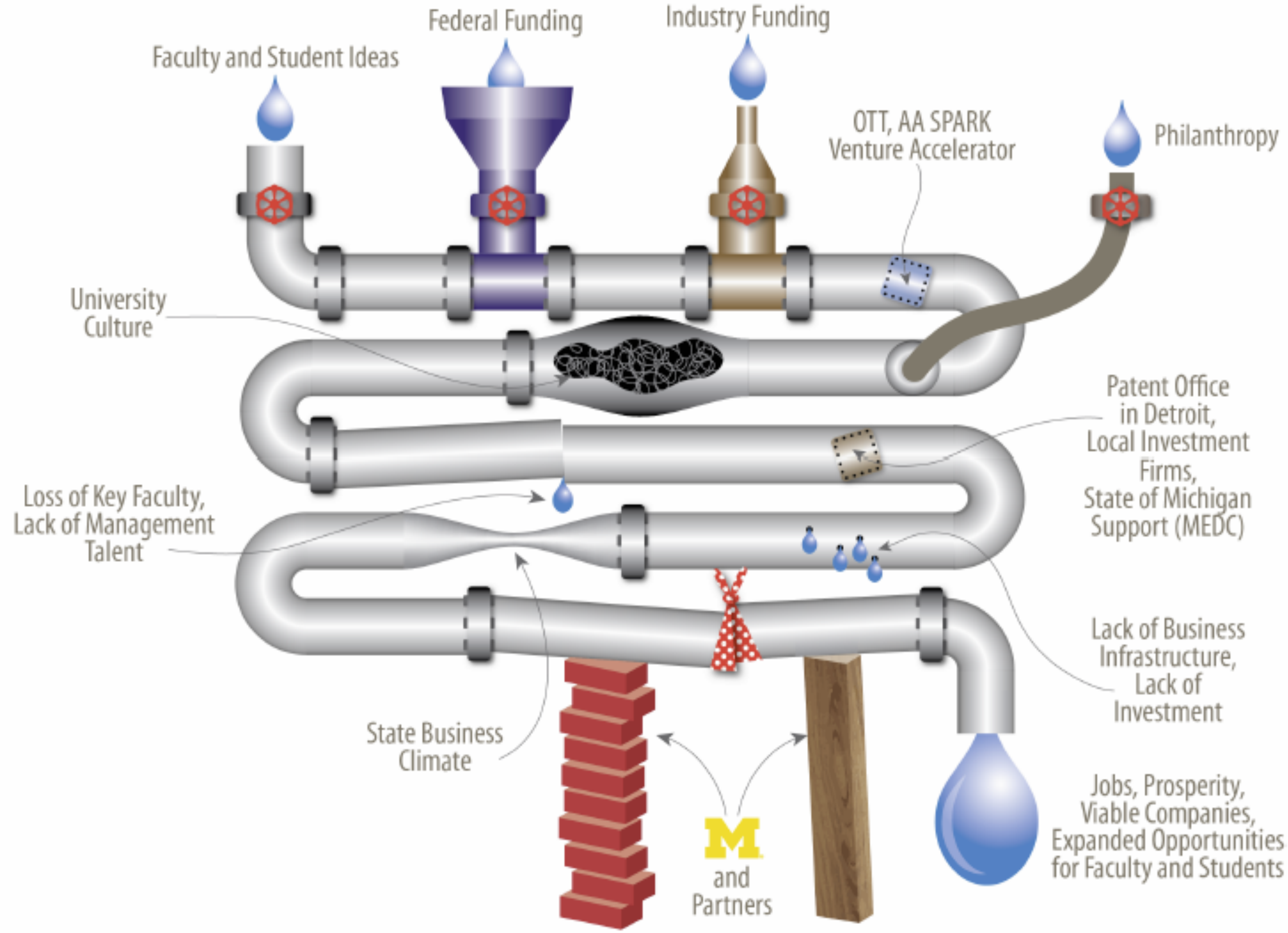
[a] The Johns Hopkins University includes the Applied Physics Laboratory, with $778 million, $845 million, and $978 million in total R&D expenditures in FY 2007–09, respectively.

What rank is UM's research budget among all US universities?

As a single entity, UM is #1

http://www.nsf.gov/statistics/infbrief/nsf10329/nsf10329.pdf

Innovation Pipeline



Who funds university research?

- External funding agencies (public and private), for example:
  - National Science Foundation (NSF)
  - National Institutes of Health (NIH), National Cancer Institute (NCI)
  - DoD: Defense Advanced Research Projects Agency (DARPA), Office of Naval Research (ONR), Air Force Office of Scientific Research (AFOSR), Army Research Office (ARO)
  - Foundations: Gates, Keck, Howard Hughes

  → Projects aligned with the agency **mission,** e.g., defense, health care, education – fundamental and/or applied.

  → Foundation funding generally has less specific objectives.

- Internal sources
  - Vary widely by university, usually depending on endowment size and amount of discretionary giving.
  - Often geared toward exploratory collaboration (interdisciplinary), high-risk ideas, formation of large teams (e.g., for center proposals), or technology transition (startups). There's not much though.

Figure 1: Research Expenditures by Major Sponsor Group FY2001-2011

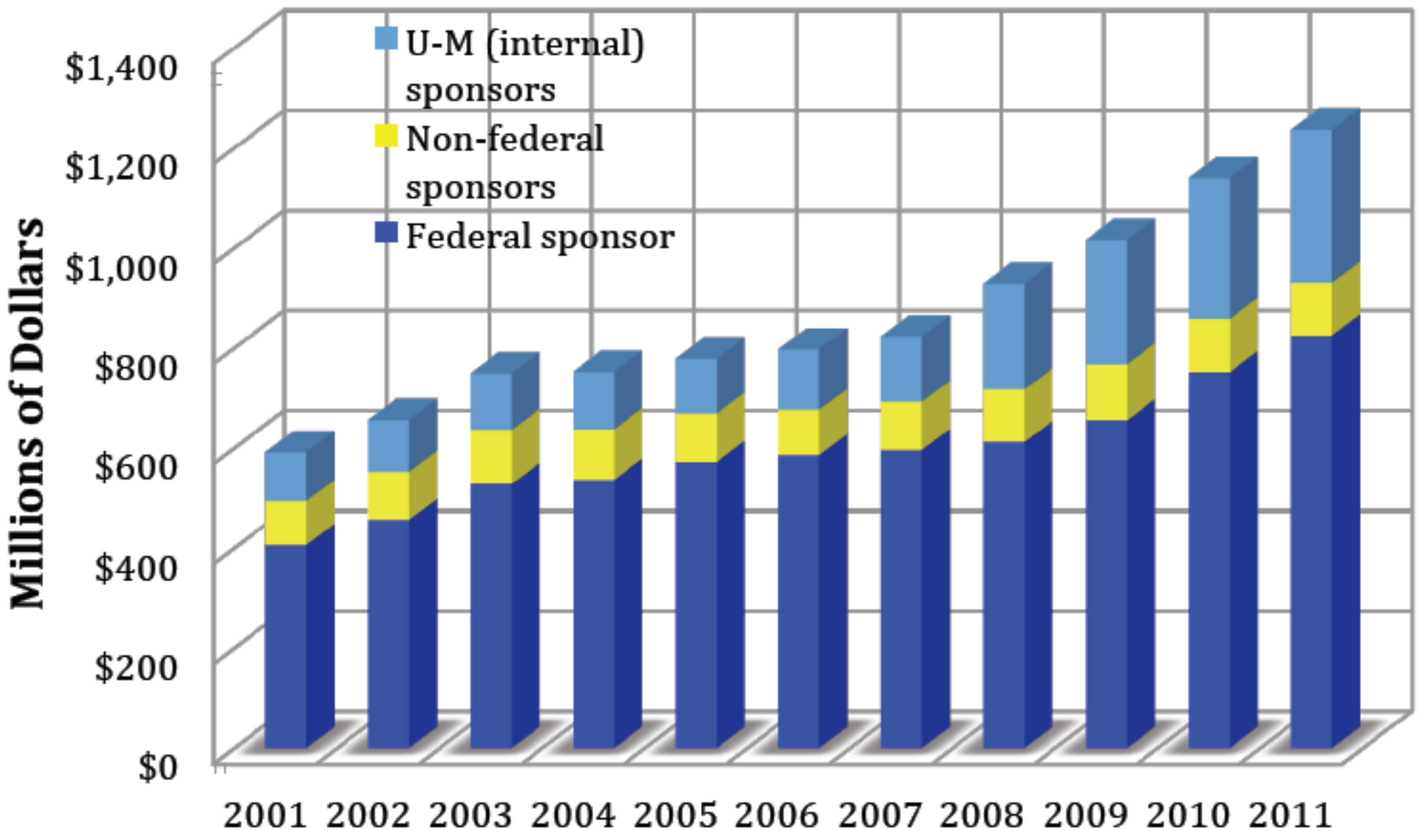


Table 1: U-M Research Expenditures by Major Sponsor Group, FY2011

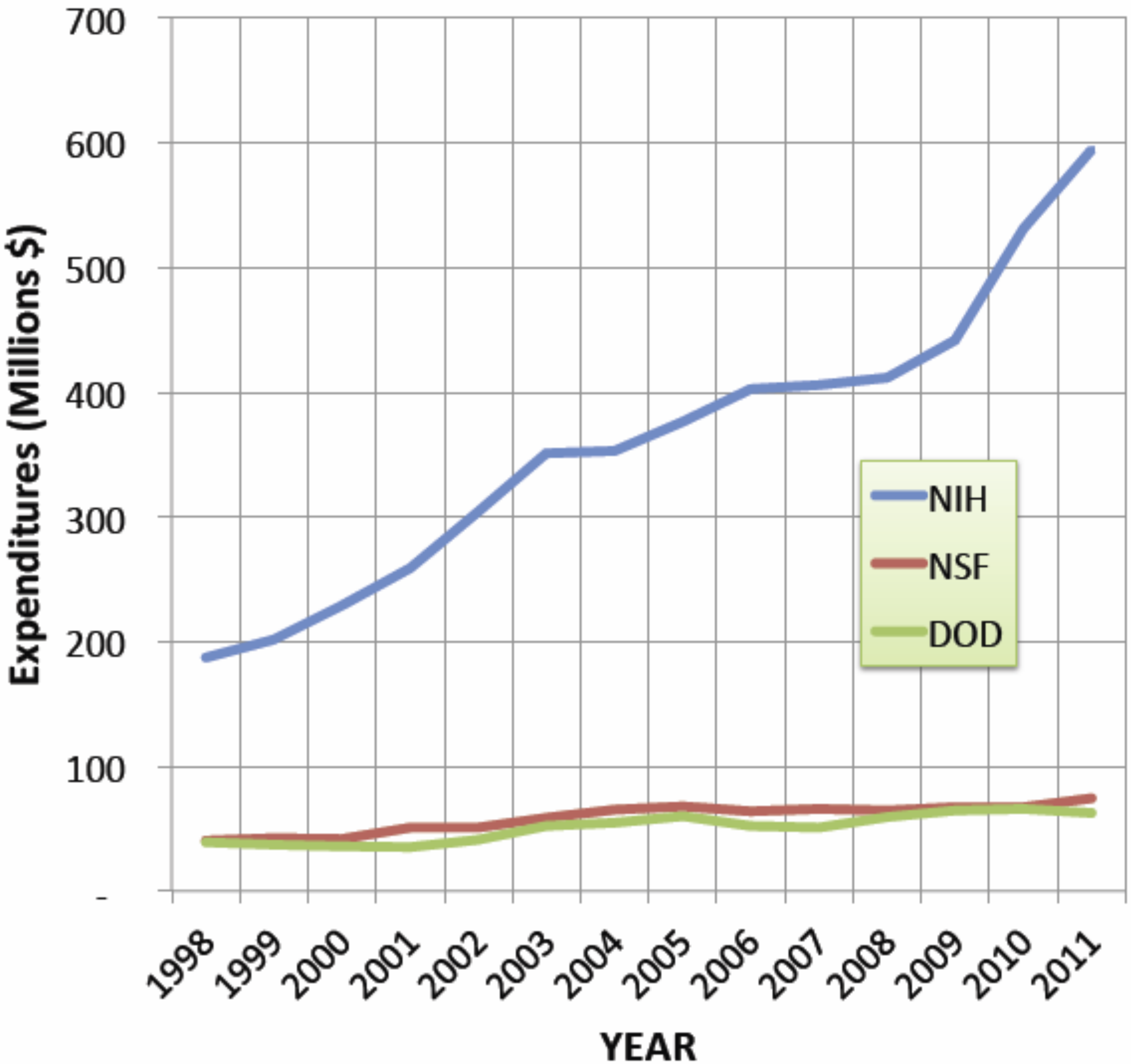
Sponsor Group	Expenditures	% of total
Total Federal Government	$824,752,621	66.7%
Total Non-Federal Sponsors	$105,629,030	8.5%
*Industry (direct)***	*$40,839,950*	*3.3%*
Foundations	*$21,487,269*	*1.7%*
State of Michigan/Counties/Cities	*$1,838,644*	*0.1%*
Total U-M Funds	$306,128,972	24.8%
Total Research Expenditures	$1,236,510,624	

***subcontracts from industry under federal government as the prime sponsor are not included in this number; seeTable 3.*

Table 2: U-M Research Expenditures
Percent Change by Major Sponsor Group, FY2010-2011

Sponsor Group	FY10	% of total	FY11	% of total	$ Chg.	% Chg.
Total Federal	$750,937,273	65.9%	$824,752,621	66.7%	$73,815,348	9.8%
NIH	*$507,485,540*	*44.5%*	*$571,188,536*	*46.2%*	*$63,702,996*	*12.6%*
NSF	*$67,331,716*	*5.9%*	*$74,246,980*	*6.0%*	*$6,915,264*	*10.3%*
DOD	*$65,970,563*	*5.8%*	*$62,738,099*	*5.1%*	*$3,232,464*	*-4.9%*
Energy	*$27,145,008*	*2.4%*	*$35,409,948*	*2.9%*	*$8,264,940*	*30.4%*
N.A.S.A.	*$16,412,115*	*1.4%*	*$15,339,972*	*1.2%*	*-$1,072,143*	*-6.5%*
Transportation	*$10,456,674*	*0.9%*	*$7,782,251*	*0.6%*	*-$2,674,423*	*-25.6%*
Commerce	*$9,489,189*	*0.8%*	*$10,788,559*	*0.9%*	*$1,299,370*	*13.7%*
Total Non-Federal	$106,762,901	9.4%	$105,629,030	8.5%	-$1,133,871	-1.1%
Industry	*$39,269,613*	*3.4%*	*$40,839,950*	*3.3%*	*$1,570,337*	*4.0%*
Foundations	*$24,881,157*	*2.2%*	*$21,487,269*	*1.7%*	*-$3,393,888*	*-13.6%*
State of Mi./Local Govt.	*$3,792,924*	*0.3%*	*$1,838,644*	*0.1%*	*-$1,954280*	*-51.5%*
Total U-M	$249,658,394	24.6%	$281,793,811	24.7%	$32,135,417	12.9%
Total Expenditures	$1,139,493,986		$1,236,510,624		$97,016,638	8.5%

U-M Research Expenditures by Agency

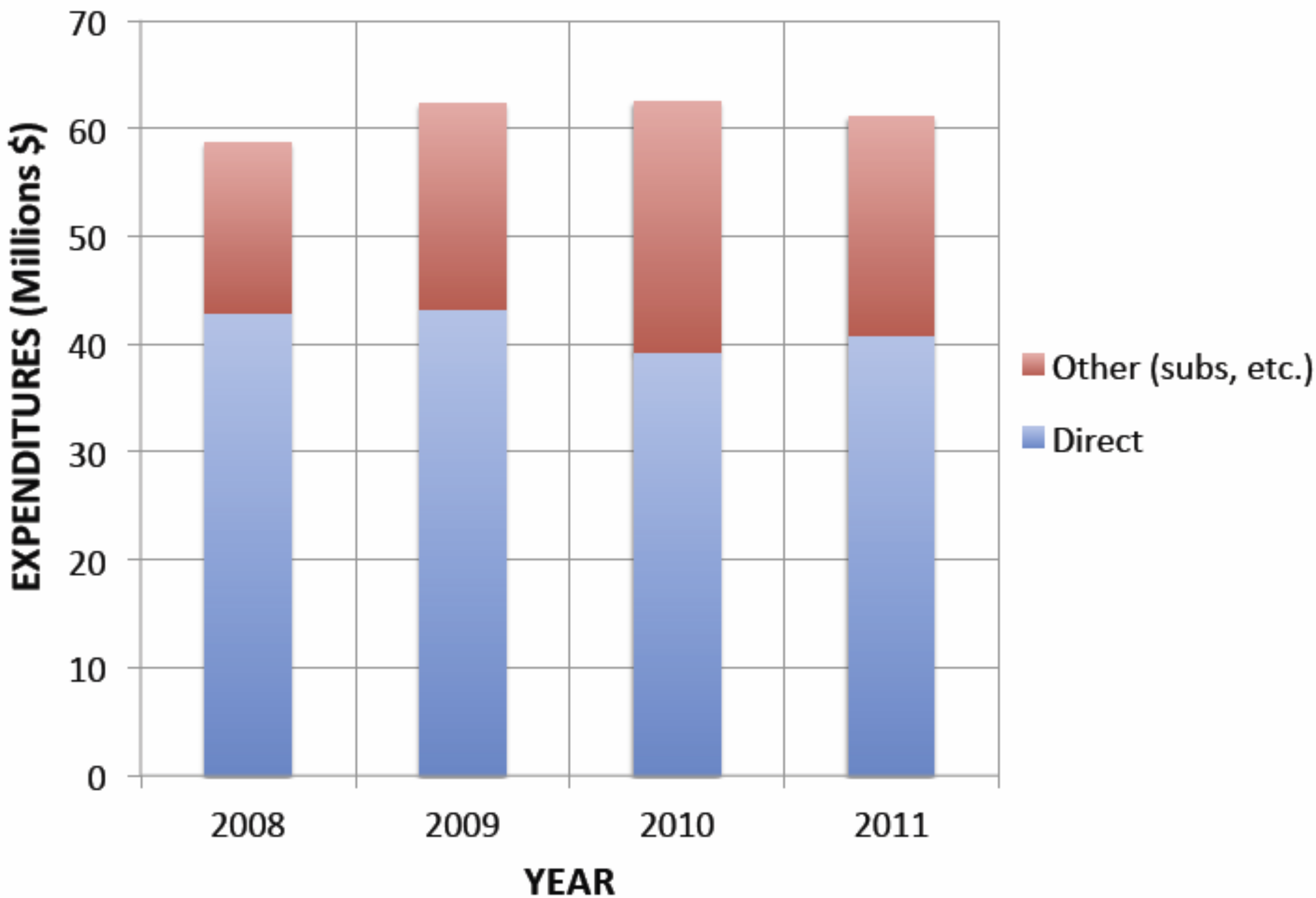


Notable Growth: 2011

- NIH: +12.6%
- NSF: +10.3%
- DOD: -4.9%
- Energy: +44%
- NASA: -6.5%

http://research.umich.edu/content/2012/01/2012-regents-report-slides.pdf

The Role of Industry



A small, but important segment: **A catalyst**

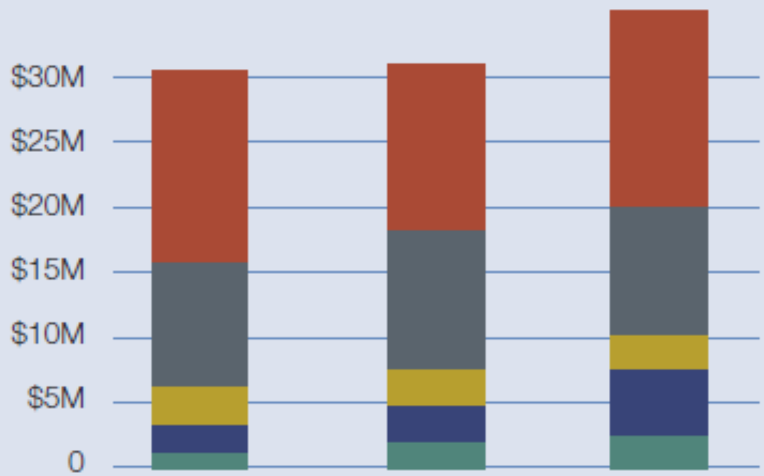
http://research.umich.edu/content/2012/01/2012-regents-report-slides.pdf

Table 4: Research Expenditures by Unit, FY2011

Unit	FY11	Change	Unit	FY11	Change
Medical School	$544.9M	9.3%	Rackham	$6.1M	1.4%
Engineering	$178.8M	-0.7%	Social Work	$5.6M	4.0%
LSA	$138.7M	24.6%	Nursing	$4.9M	-0.1%
ISR	$114.1M	13.7%	Kinesiology	$4.5M	4.3%
Public Health	$83.0M	35.6%	Information	$4.3M	12.8%
OVPR Units	$29.9M	-5.1%	Law	$3.7M	8.4%
Dentistry	$19.9M	1.1%	Public Policy	$3.6M	29.8%
SNRE	$15.3M	13.6%	Arch. & Urban Pl.	$1.1M	27.2%
Education	$12.0	15.2%	UM-Flint	$672K	16.0%
Pharmacy	$8.4M	3.6%	Music	$259K	-19.7%
Business	$7.4M	-4.9%	Art and Design	$101K	-26.5%
UM-Dearborn	$7.2M	16.1%	Other Units	$35.0M	4.4%

ME department only

ANNUAL RESEARCH EXPENDITURES



	08–09	09–10	10-11
NIH	1,403,643	1,996,237	2,168,238
DoE	1,773,858	2,390,860	5,407,039
NSF	2,460,177	2,701,330	3,104,779
DoD	10,195,017	10,992,316	9,796,979
All Other	14,608,221	13,792,756	14,092,339
Total	**$30,440,916**	**$31,873,498**	**$34,569,374**

	FA09	FA10	FA11
Assistant	**11**	**12**	**14**
Associate	**12**	**12**	**11**
Professor	**35**	**36**	**37**
Total Faculty	**58**	**60**	**62**

http://me.engin.umich.edu/sites/default/files/attachments/ME2010AnnualReport.pdf

Where does the money go?

- Students/postdocs
  - 50% GSRA = approx. $65,000/yr (!?)
- Faculty summer salary
  - Faculty are paid a "9 month" salary for their teaching, so their summer pay comes from research grants
- Research expenses
  - Equipment
  - Material/supplies
  - Facility usage fees
  - Travel
- Overhead ("indirect cost")
  - At UM, add 55.5% of everything except equipment and tuition

- If doing experiments, estimate $100K per GSRA-yr

Generally, what does a proposal say?

I want to do X, so please give me money! Specifically,

		fellowships
▪ Why are you doing the project?	• Motivation and background • Why it's important to everyone who should care, AND specifically to the funding agency	★
▪ What will you be doing?	• Aims/tasks	★
▪ How will you be doing it?	• Methods (detail depends on proposal format/length)	
▪ Who will be doing it?	• You and your background/expertise (why you?) • Collaborators (strategy important)	★
▪ Where will it be done?	• Location and facilities	
▪ How long will it take?	• Timeline, milestones, and deliverables	★
▪ How much will it cost?	• Budget with justification	

Typical format of a grant proposal

- Summary (0.5-1 page)
  - MUST catch the reviewer's attention!
- Background (what)
- Novelty and rationale (why)
- Description of research (how)
- Expected outcomes
  - Impact that's important to the audience
- Timeline
- Qualifications and supporting documents

The proposal in our context

- A bridge from the background report to your research plans
- An opportunity to sharpen your outlook, perhaps for the RFE or for longer-term objectives

From background report to proposal

- you've identified general question(s)
- you may need to make the questions more specific
- you need a "mission statement", my research will xxxx
  - → ONE clear (though maybe long) sentence
- you need to identify specific aims/tasks that you will do to complete the mission -to break it down into measurable chunks
- you need to decide which background/motivation is most relevant to what you propose
  - identify the aims first (I used to do the opposite, and realized that was wrong)

Choosing what proposals to write is like choosing a research problem

- Feasibility: "whether a problem is hard or easy, in units such as the expected time to complete a project". [Alon]
- Importance: how important is the topic within the research community and beyond?
- Interest: both internal and external…
- Competence: why are you qualified? Do you have an advantage (secret weapon)?

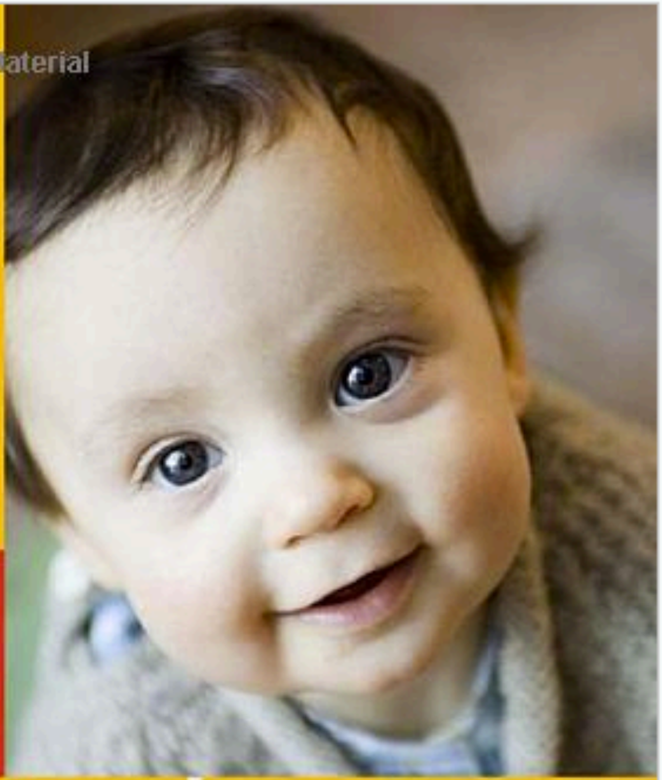
A proposal requires a different kind of writing

A proposal's overt function is to persuade a committee of scholars that the project shines with the three kinds of merit all disciplines value, namely, conceptual innovation, methodological rigor, and rich, substantive content. But to make these points stick, a proposal writer needs a feel for the unspoken customs, norms, and needs that govern the selection process itself. These are not really as arcane or ritualistic as one might suspect. For the most part, these customs arise from the committee's efforts to deal in good faith with its own problems: incomprehension among disciplines, work overload, and the problem of equitably judging proposals that reflect unlike social and academic circumstances.

Writing for committee competition is an art quite different from research work itself. After long deliberation, a committee usually has to choose among proposals that all possess the three virtues mentioned above. Other things being equal, the proposal that is awarded funding is the one that gets its merits across more forcefully because it addresses these unspoken needs and norms as well as the overt rules.

Przeworski and Salomon, "On the Art of Writing Proposals"

BABY'S FIRST WORDS IN SPANISH



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Civil, Mechanical and Manufacturing Innovation

NanoManufacturing (NM)

CONTACTS

Name	Email	Phone	Room
Charalabos Doumanidis	cdoumani@nsf.gov	(703) 292-7557	550 S

PROGRAM GUIDELINES

SYNOPSIS

The NM program supports research and education on manufacturing at the nanoscale, and the transfer of research results in nanoscience and nanotechnology to industrial applications. The program emphasizes a systems approach to the scale-up of nanotechnology for high rate production, reliability, robustness, yield, and cost, and promotes integration of nanostructures to functional micro devices and meso/macroscale systems. Special emphases are on environmental, health, and societal aspects of nanotechnology and nanomanufacturing.

Display additional information

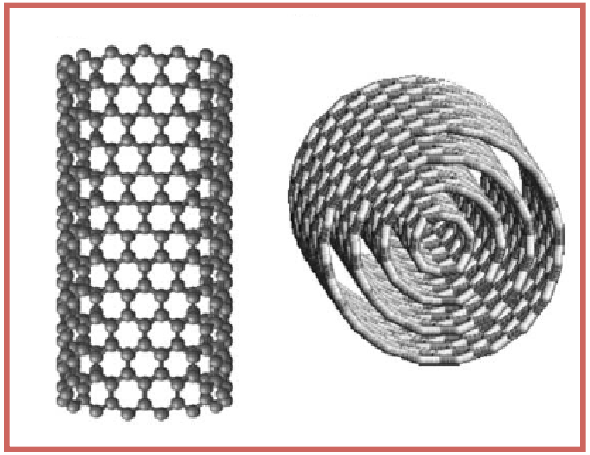
THIS PROGRAM IS PART OF

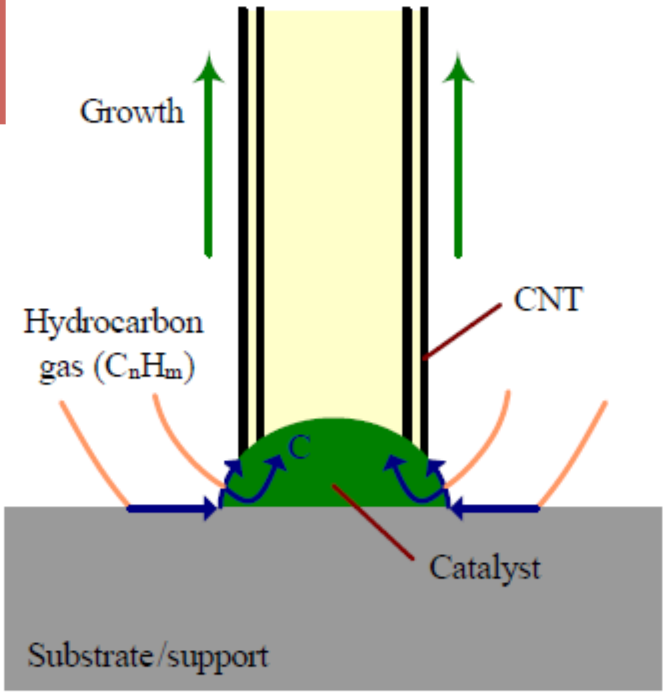
Advanced Manufacturing

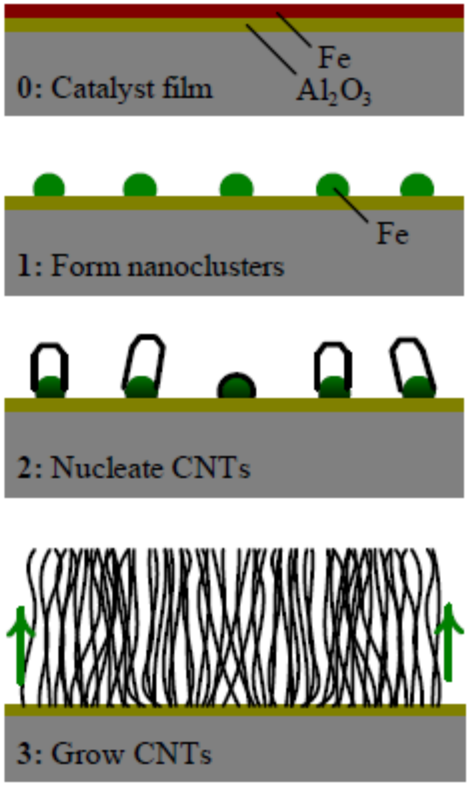
What Has Been Funded (Recent Awards Made Through This Program, with Abstracts)

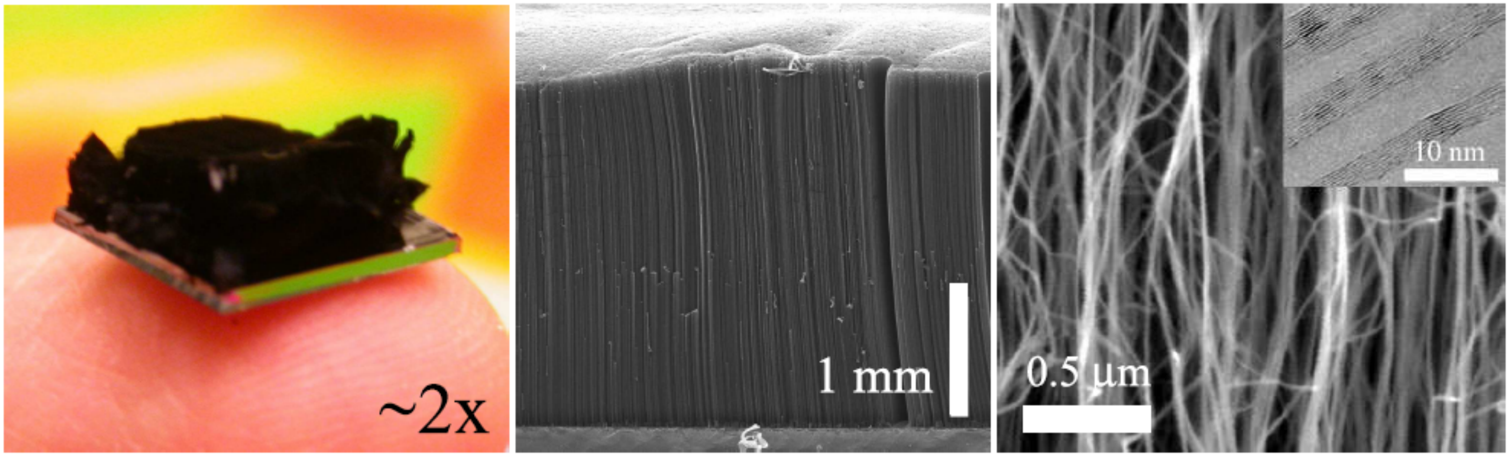
My first proposal

Carbon Nanotubes (CNTs)

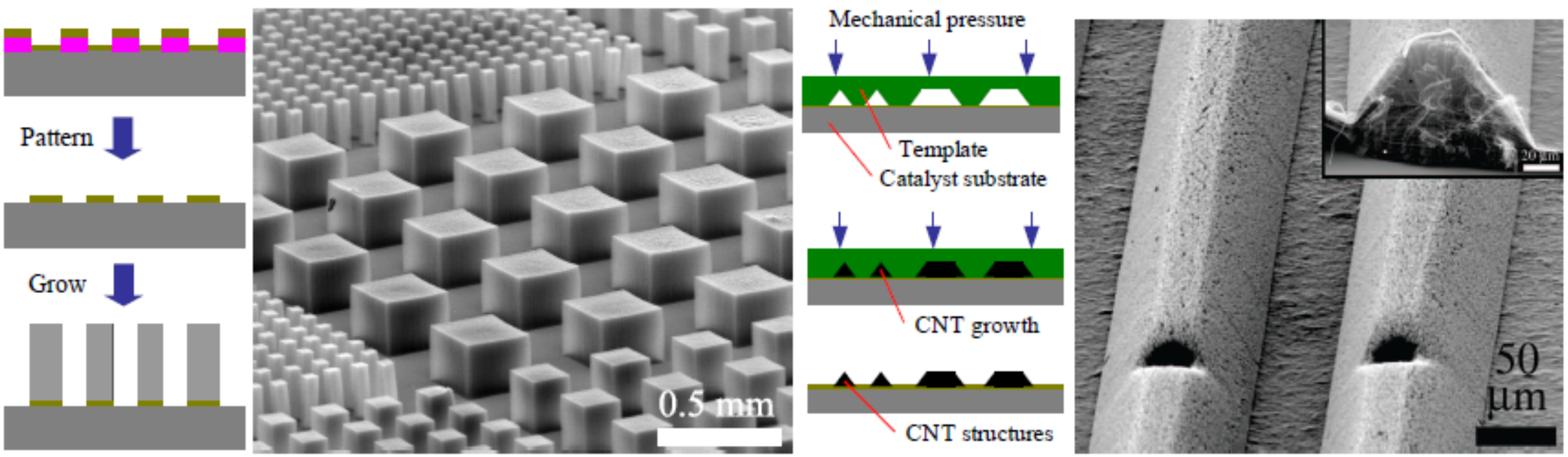







~2x
1 mm
0.5 µm
10 nm

(a) (b) (c)


Pattern
Grow
0.5 mm
Mechanical pressure
Template
Catalyst substrate
CNT growth
CNT structures
50 µm

(a) (b) (c) (d)

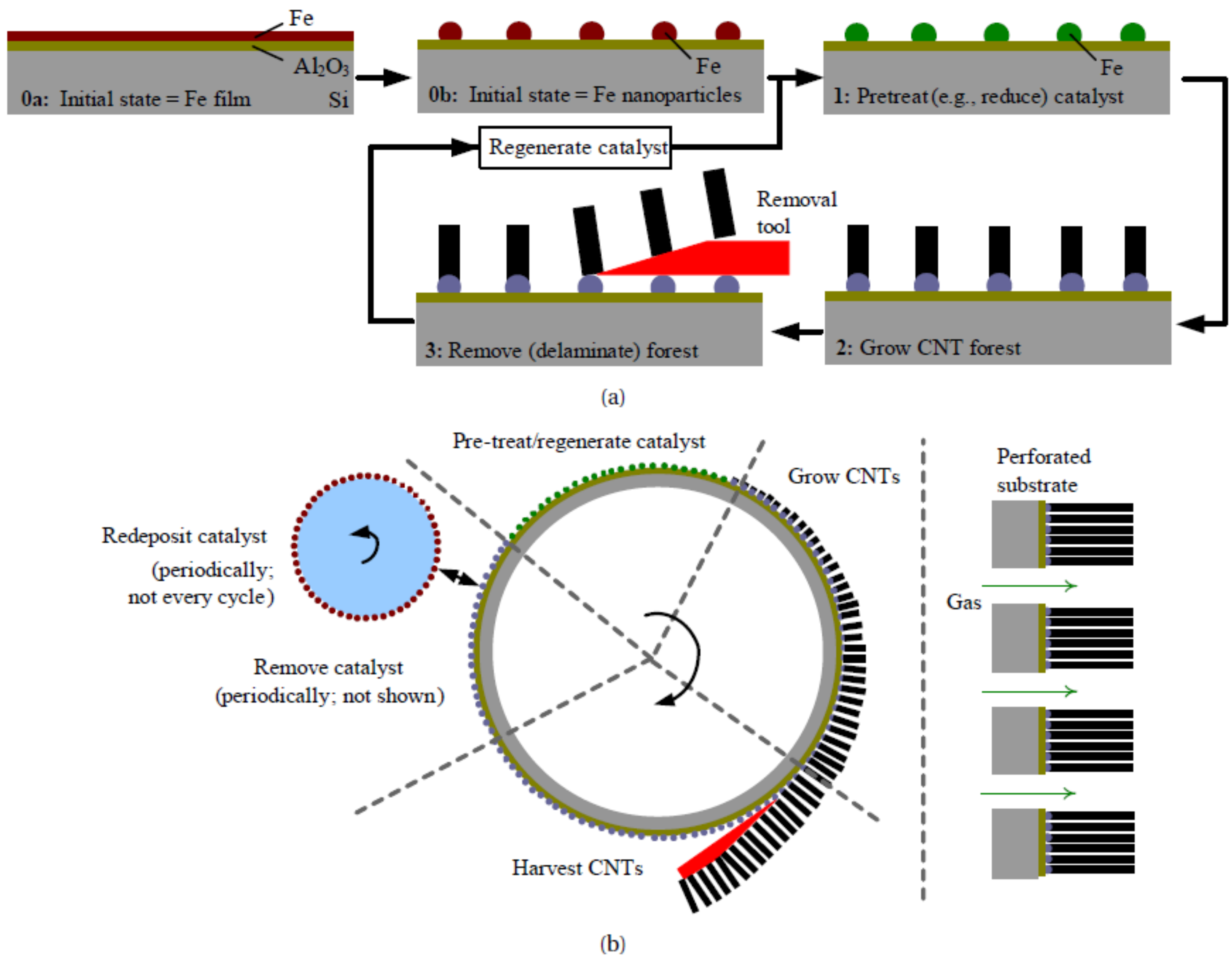


Figure 1. Proposed investigation of continuous manufacturing of CNT films: (a) schematic of batch-style study of consecutive catalyst treatment, CNT growth, CNT removal, and catalyst regeneration experiments; (b) schematic of ring apparatus with recirculating substrate, and perforated substrate concept.

Objectives

1. Study the limiting mechanisms of CNT forest growth on small substrates, for example:
   - Why does the forest stop growing?
   - Do the CNT diameter and catalyst size change during growth?
   - How can we "revive" growth after it stops?

2. Make a small machine for continuous CNT growth
   - Study the machine design aspects
   - Demonstrate growth by linear translation
   - Recirculating ring machine

3. Implement "continuous made" CNT forests in reinforced composites (=application)

Initial results to validate the concept

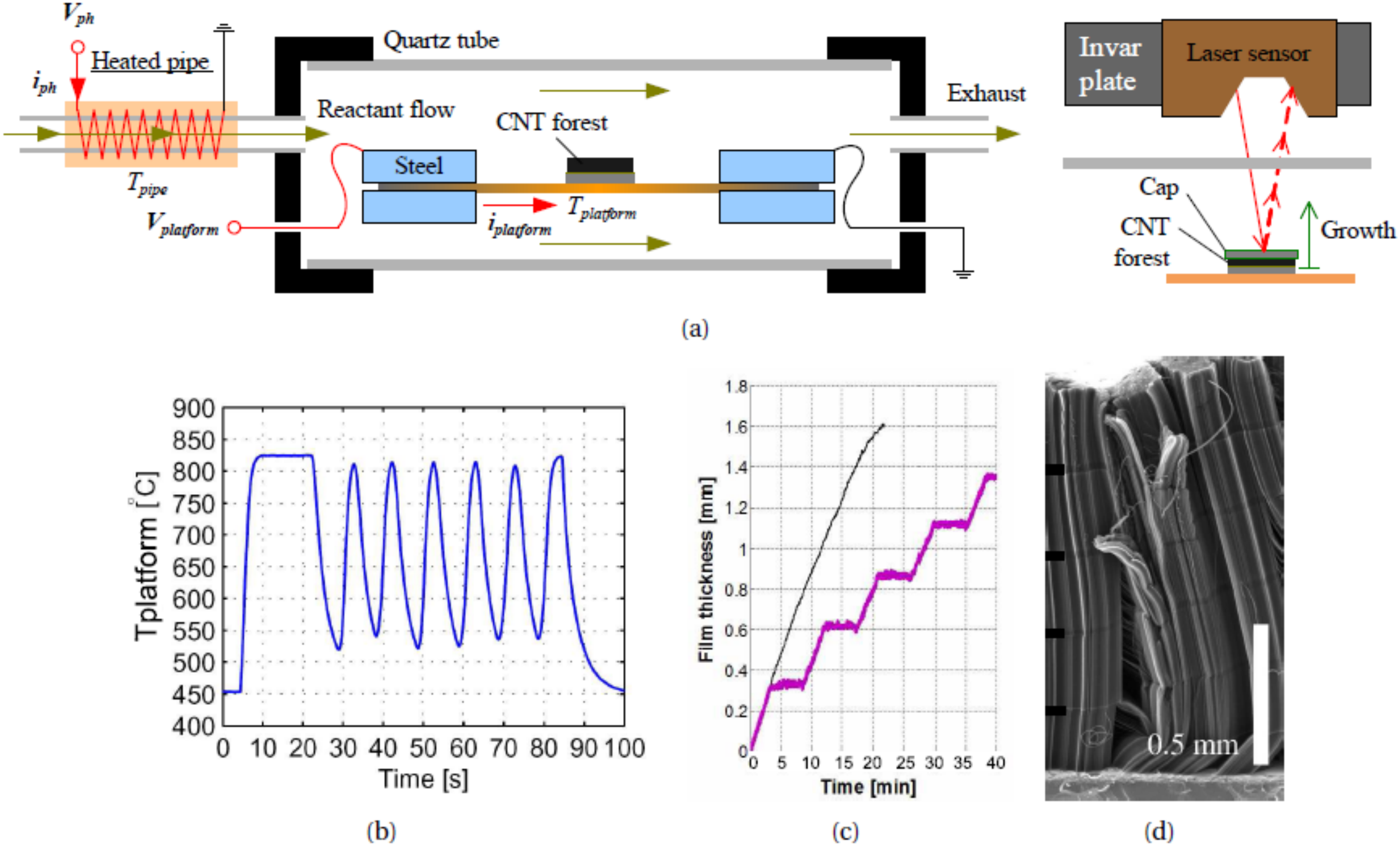
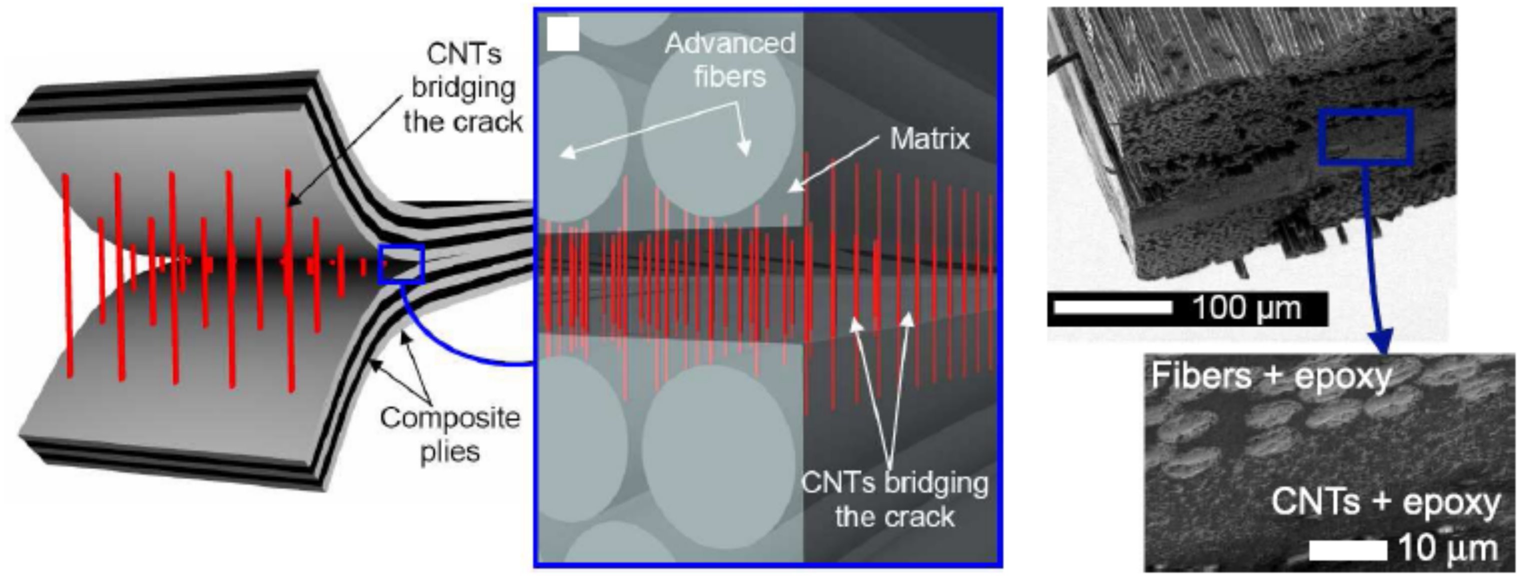


Figure 4. Desktop reactor apparatus for CNT growth on a suspended resistively-heated silicon platform [42, 43]: (a) schematic of substrate in sealed quartz tube with heated inlet pipe for thermal pretreatment of reaction gases and laser sensor for measuring growth kinetics; (b) rapid heating and subsequent cycling of platform temperature by oscillating supply current; (d) multi-layer forest grown on heated platform by cycling hydrocarbon supply; (c) real-time kinetics of multi-layer forest growth.

Proposed application



(a) (b)

Figure 6. Nanostitched fiber composite architecture [78, 79]: (a) schematic of CNT forest layer toughening interface between consecutive fiber layers; (b) SEM images of nanostitched interface between unidirectional carbon fiber layers.

	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Study of limiting growth mechanisms								
Modification of heated platform for *in situ* Raman spectroscopy (UM)	■							
Full study: 4 substrate-catalyst combinations (UM)	■	■	■	■	■			
RBS and SAXS studies of selected samples (UM)			■	■	■	■		
Predictive modeling based on *in situ* and *ex situ* data (UM)					■	■		
Model verification using best process conditions, publication (UM)						■	■	■
Machine design elements for continuous growth								
Design and testing of gas isolation system (MIT)	■	■						
Ring materials selection and batch-style testing (MIT)		■	■					
Design and testing of *in situ* catalyst application (MIT)			■	■				
Recirculating ring substrate growth apparatus								
Design (MIT/UM)		■	■	■				
Fabrication (MIT)			■	■	■			
Testing (MIT; UM student visits MIT)					■	■	■	
Growth of large forests for aerospace component tests (MIT)								■
Fabrication/testing of nanostitched composites (MIT w/NECST funding)					■	■	■	■
Outreach: teaching, high school lectures, nanobliss (UM/MIT)	■	■	■	■	■	■	■	■
Industry interaction and tech transfer via NECST (UM/MIT)	■	■	■	■	■	■	■	■
Documention (UM/MIT)				■				■

NSF proposal format

- Project summary (1 page)
- Project description (15 pages)
- References (no limit)
- Supporting documents
  - PI biosketch (short CV)
  - Budget and justification
  - Letters of support/collaboration (optional)

NSF criteria

Criterion 1: What is the intellectual merit of the proposed activity?

How important is the proposed activity to advancing *knowledge* and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

Criterion 2: What are the broader impacts of the proposed activity?

How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? **Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?**

http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf

What were the intellectual merit and broader impact of my proposal?

- …

NSF Proposal Notification - Proposal No.-0728052 - Message (HTML)

This message has been replied to or forwarded.

From: aakay@nsf.gov
To: Hart, Anastasios
Cc: fastlane-admin@umich.edu
Subject: NSF Proposal Notification - Proposal No.-0728052

Sent: Wed 8/29/2007 10:04 PM

The day after I came to Ann Arbor

Proposal Number: 0728052
Title: Limiting Growth Mechanisms and Continuous Manufacturing of Carbon Nanotube Films

Dear Dr. Hart:

I regret to inform you that the National Science Foundation is unable to support your proposal referenced above.

Your proposal was reviewed in accordance with the general merit review criteria established by the National Science Board that address the intellectual merit of the proposed activity and its broader impacts. These criteria permit an evaluation of the proposal's technical merit, creativity, educational impact and its potential benefits to society. If your proposal was submitted in response to a specific solicitation, additional review criteria may have been used to review your proposal as described in the solicitation.

The full text of the two merit review criteria and supporting explanations are available in Chapter III.A of the NSF *Grant Proposal Guide* <http://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp>.

You may access the reviews of your proposal, a description of the context in which your proposal was reviewed, and any further analysis or statements at the FastLane URL referenced below. This information may be helpful to you in understanding the Foundation's action and also in preparing any future submissions. If you would like further information concerning the review of your proposal, please contact the cognizant program officer whose name, email address, and telephone number are provided below. Information about NSF's reconsideration process is described in Chapter IV.D of the NSF *Grant Proposal Guide* <http://www.nsf.gov/publications/pub_summ.jsp?ods_key=papp>[1].

Although we are unable to support this proposal, we would be pleased to consider any future proposal you may wish to submit.

Sincerely,

Adnan Akay
Division Director
Division of Civil, Mechanical, and Manufacturing Innovation

Cognizant Program Officer: Mary Lynn Realff, mlrealff@nsf.gov, (703)292-0000

Review panel summary

Proposal Number: 0728052

Panel Summary:
Panel Summary

What is the intellectual merit of the proposed activity?

The project will develop a "ring" apparatus for continuous large-scale production of aligned carbon nanotube (CNT) films.

-- Strength: The large-scale production of nanostructure is a critical aspect of nanomanufacturing. The proposed manufacturing scheme is very interesting and novel. The PIs have solid background and preliminary results related to the proposed area.

-- Weakness: Harvesting of the CNTs could be an issue. The research plan is too ambitious for the proposed timeline. The PI mentioned the industry support through NECST. But no industry support letter is provided. If these issues were addressed, the proposal could be more competitive.

What are the broader impacts of the proposed activity?

If successful, the project might generate big impact on nanomanufacturing industry. Undergraduate course and senior design project will be developed.

Summary Statement
Panel's recommendation: FUND IF POSSIBLE

Reviewer #2

Review #2

Proposal Number:	0728052
NSF Program:	Nanomanufacturing
Principal Investigator:	Hart, Anastasios John
Proposal Title:	Limiting Growth Mechanisms and Continuous Manufacturing of Carbon Nanotube Films
Rating:	Multiple Rating: (Very Good/Good)

REVIEW:

What is the intellectual merit of the proposed activity?

The project aims to develop a "ring" apparatus for continuous large-scale production of aligned carbon nanotube (CNT) films by CVD and to integrate CNT films in hybrid material architectures. The PIs will first study the limiting aspects of catalyst performance using a desktop reactor with heated platform (already developed by the PIs). Then a ring apparatus will be developed for continuous production of CNT.

Strength: The large-scale production of nanostructure is a critical aspect of nanomanufacturing. The proposed manufacturing scheme is very interesting and novel. The PI will extend his dissertation research and continue to collaborate with his former advisors. The preliminary work sets a good foundation for the proposed activities.

Weakness: The PIs will transfer the knowledge obtained from heated platform to the ring apparatus. Is it a reasonable assumption that the knowledge can be directly transferable? Under the two growth environments, the conditions for achieving desired diameters, quality of CNTs, and uniformity are most likely different. Therefore, the "rigorous design of experiments" (p.9) and predictive model development are crucial to the smooth knowledge transfer from heated platform to the ring apparatus. However, neither details of designed experiments nor predictive modeling are not provided. In situ CNT removal can be very challenging as well.

The PI will relocate the equipment built at MIT and develop his lab at UM. This takes time. Is the proposed goal too ambitious for the PI at this stage?

The PI mentioned the industry support through NECST. But no industry support letter is provided.

What are the broader impacts of the proposed activity?

If successful, the project might generate big impact on nanomanufacturing industry. The education impact seems to be the routine course development.

Summary Statement

The disclaimer

Context Statement

Unsolicited Proposals Context Statement: DIRECTORATE FOR ENGINEERING
Division of Civil, Mechanical, and Manufacturing Innovation

General Information for Applicants

This year the Division of Civil, Mechanical, and Manufacturing Innovation expects to review about 2,300 competitive research proposals, and expects to make awards to between 10% and 15%.

The Division's practice is for programs to seek the advice of several independent external (to NSF) reviewers for each proposal, and these reviewers and reviewers for other proposals submitted to the programs, comprise panels to compare and assess the merit of related proposals. For each proposal, the panel prepares a summary of its discussion. Your proposal was recently considered by the Nanomanufacturing Unsolicited Proposal Review Panel.

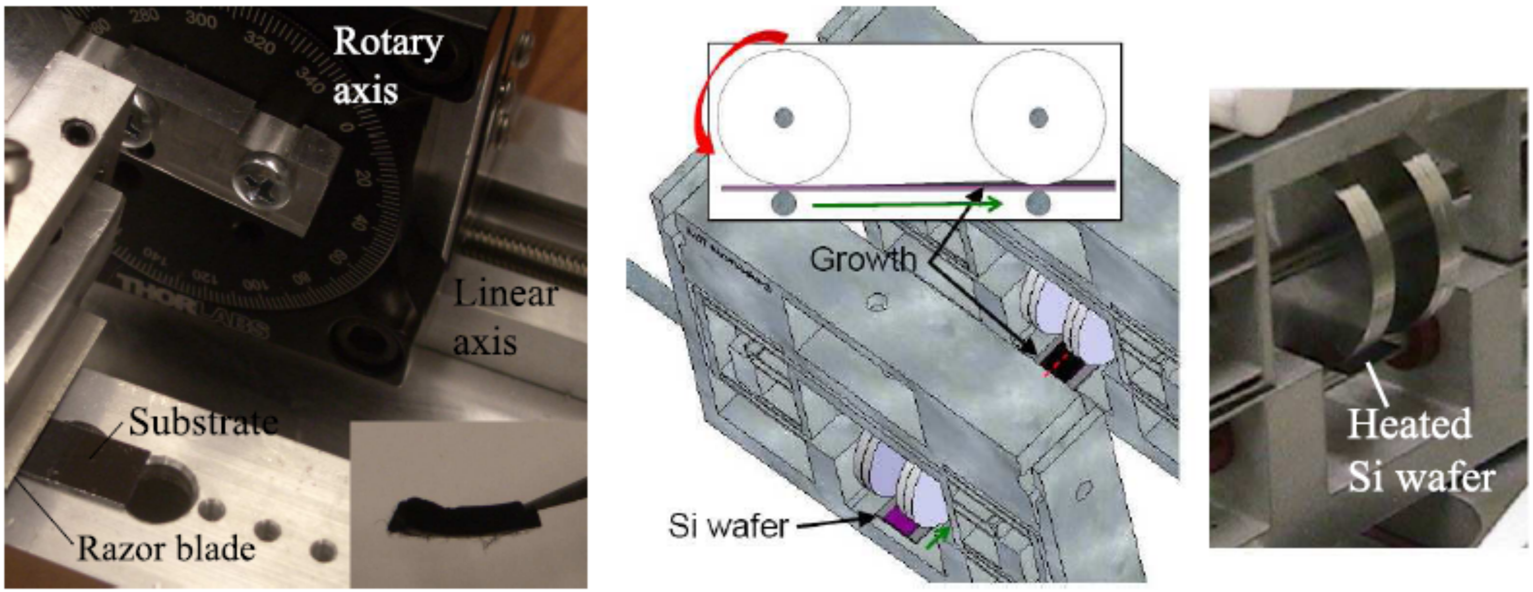
The Panel Summary and verbatim copies of all completed reviews are available via FastLane. In reading them, please keep in mind that reviewers are addressing their comments primarily to the NSF, not necessarily to you. They sometimes make remarks without giving detailed references or providing specific suggestions for improvement, although many reviewers do provide such helpful information. Some reviews may contain non-substantive, irrelevant or erroneous statements that the Program Director did not use in making a recommmendation.

A decision about a particular proposal is often very difficult, and factors other than reviewer comments and ratings enter into consideration. Comments by a reviewer must sometimes be considered in the context of other reviews by the same person. A Program Director often has additional information not available to reviewers (such as progress reports on recent projects). Maintaining appropriate balance among subfields, the availability of other funding, the total amount of funds available to the program, and general Foundation policies are also important decision factors.

If you would like more information regarding the review process or the review of your proposal, please contact the cognizant Program Director.

Information about reconsideration of declined proposals is found in NSF's Grant Policy Manual http://www.nsf.gov./publications/pub_summ.jsp?ods_key=gpm, Section 900.

New objective: learn how to remove the forest



(a) (b)

Figure 5. (a) Apparatus for cleanly delaminating CNT forests using a razor blade, with inset showing delaminated ≈1.5 mm thick forest on tweezer tip; (b) linear translation growth apparatus with planar silicon substrate which is resistively heated using rolling electrical contacts.

SAINT-GOBAIN
ABRASIVES

Industrial SuperAbrasives R&D
Saint-Gobain High Performance Materials
One New Bond St.
Worcester, MA 01606
September 26, 2007

Dr. John Hart
University of Michigan
2278 G.G. Brown
2350 Hayward
Ann Arbor, MI 48109-2125

Dear Dr. John Hart,

Saint-Gobain has evaluated your proposed research "Limiting Growth Mechanisms and Continuous Manufacturing of Aligned Carbon Nanotube Films", for submission to National Science Foundation (NSF). For applications which utilize aligned carbon nanotubes for mechanical, thermal, and electrical properties, manufacturing of large-area films will be an essential technology. Accordingly, the proposed manufacturing system could have broad and significant impact on the commercial feasibility of these materials and related industries. Building on the proposed investigation of a continuous growth process for carbon nanotubes, this platform would be useful for a wide variety of other materials which also have attractive properties, as well as for preparation of hybrid materials and composites using the aligned nanostructures as scaffolds.

In our relationship with Dr. Hart's research activities at the University of Michigan, we have complementary expertise in preparation and characterization of advanced ceramic and abrasive materials. We envision possible opportunities for collaboration both within the proposed activity, and for application development in the future, and therefore strongly support the proposed research.

Sincerely,

Richard Hall
Technology Director

pending NSF proposal 0800213 - Message (HTML)

Message | Adobe PDF

Reply | Reply to All | Forward | Delete | Move to Folder | Create Rule | Other Actions | Block Sender | Safe Lists | Not Junk | Categorize | Follow Up | Mark as Unread | Find | Related | Select | Add to Evernote 4 | Send to OneNote

Respond | Actions | Junk E-mail | Options | Find | Evernote | OneNote

You forwarded this message on 3/2/2008 11:06 AM.

From: Jorn Larsen basse [jornlb@verizon.net]
Sent: Fri 2/29/2008 1:55 PM
To: Hart, Anastasios John
Cc: ghazelri@nsf.gov; Jorn L-B
Subject: pending NSF proposal 0800213

Dear Dr. Hart:
I am writing in regards to your pending NSF proposal 0800213, "Limiting growth mechanisms ..."
My name is Jorn Larsen-Basse. I am a retired NSF program director and am currently serving as a consultant to the CMMI Division. In that capacity I am assisting Dr. George Hazelrigg, Deputy Division Director in his temporary additional role as acting program director for nanomanufacturing.
Your proposal has been reviewed and did quite well. I am pleased to report that Dr. Hazelrigg intends to recommend an award at a budget of $ 350,000. Congratulations!!
You realize, of course, that the award is not final until the recommendation has been approved.
At this point we need from you:
An abstract, suitable for posting on the NSF Website - can be e-mail or Word attachment,
A statement - e-mail is OK - that some of the travel funds in the budget will be used to attend the (required) CMMI grantees meetings, which take place each 18 months, I believe.
Any questions - please contact Dr. Hazelrigg, ghazelri@nsf.gov, 703-292-7068 or, secondarily, myself, jornlb@verizon.net, 301-530-3274.
Again - congratulations!
Jorn Larsen-Basse

http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0800213

Review #4

Proposal Number:	0800213
NSF Program:	Nanomanufacturing
Principal Investigator:	Hart, Anastasios John
Proposal Title:	Limiting Growth Mechanisms and Continuous Manufacturing of Aligned Carbon Nanotube Films
Rating:	Excellent

REVIEW:

What is the intellectual merit of the proposed activity?

This proposal describes a method of producing continuous large-scale production of aligned CNT films, efficiently collecting them, and integrating them into composite materials. Since the PI describes documented experiments that proves the feasibility of each separate phase of this process, the primary task will be to demonstrate a nanomanufacturing method consisting of a rotating drum that can continuously receive deposited Fe catalyst particles, grow the nanotube mats using CVD, efficiently harvest them with a doctor blade, and then prepare the equipment for the next cycle. Publications from the all of the proposal PI's demonstrate a detailed understanding of each phase of the process and I think this project has a high probability of success.

What are the broader impacts of the proposed activity?

The amount of potential industry interest is quite high as demonstrated by five letters of interest from Nantero, Hewlett Packard, Boeing, Saint-Gobain Abrasive, and Spirit Aerosystems.

Summary Statement

This proposal provides a clear path to nanomanufacturing in its strictest definition and should be funded.

NIH review criteria (equally weighted)

1. **Significance.** Does the project address an important problem or a critical barrier to progress in the field? If the aims of the project are achieved, how will scientific knowledge, technical capability, and/or clinical practice be improved? How will successful completion of the aims change the concepts, methods, technologies, treatments, services, or preventative interventions that drive this field?

2. **Investigator(s).** Are the PD/PIs, collaborators, and other researchers well suited to the project?...

3. **Innovation.** Does the application challenge and seek to shift current research or clinical practice paradigms by utilizing novel theoretical concepts, approaches or methodologies, instrumentation, or interventions?...

4. **Approach.** Are the overall strategy, methodology, and analyses well-reasoned and appropriate to accomplish the specific aims of the project? Are potential problems, alternative strategies, and benchmarks for success presented?...

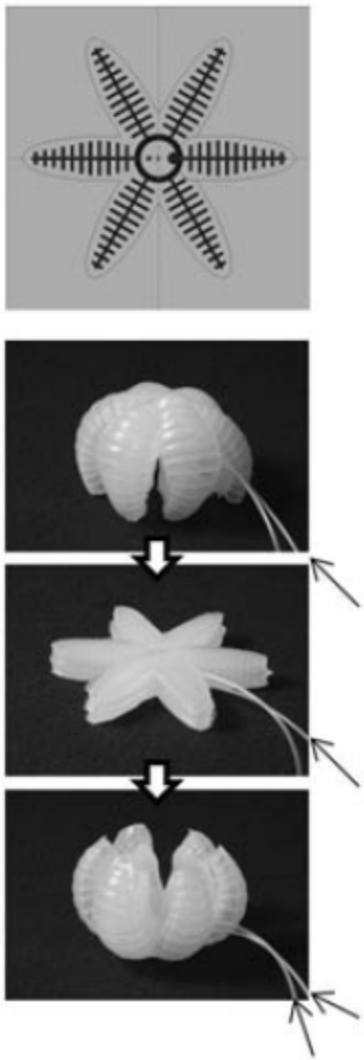
5. **Environment.** Will the scientific environment in which the work will be done contribute to the probability of success? Are the institutional support, equipment and other physical resources available to the investigators adequate for the project proposed?...

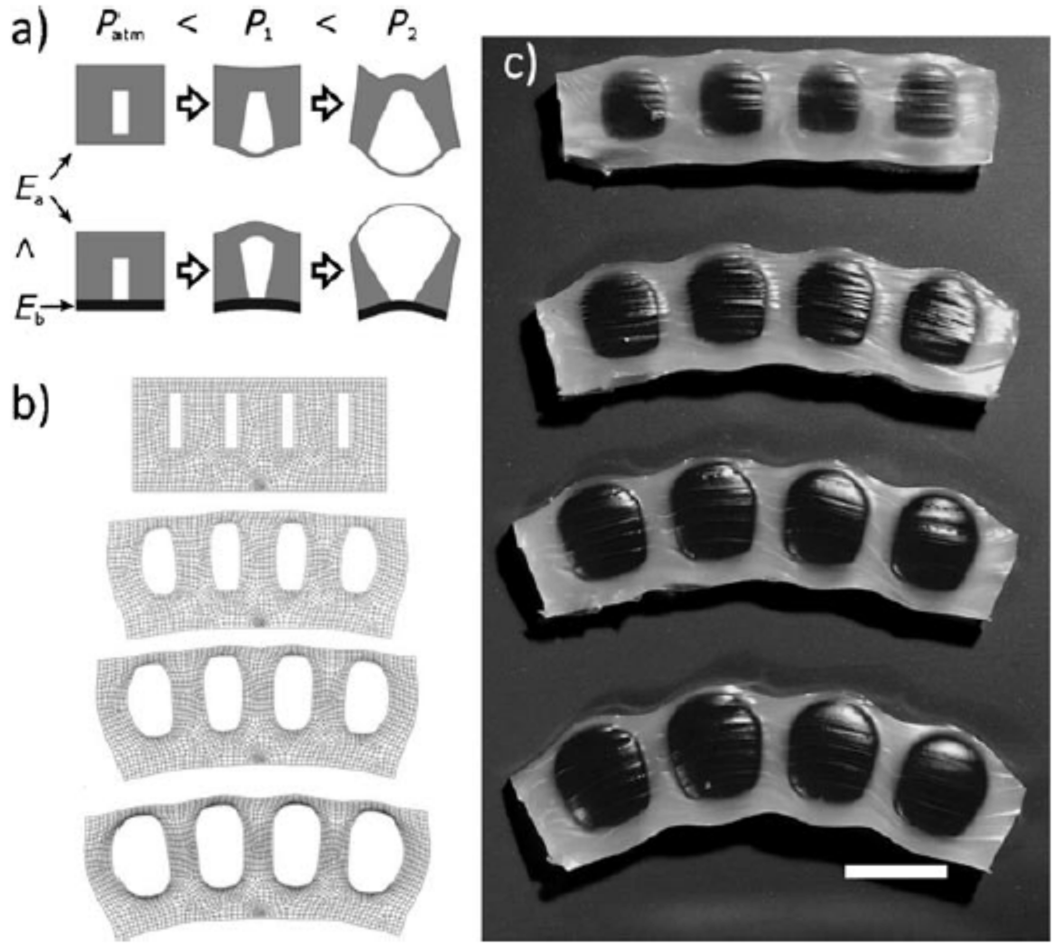
Example: a bionic hand

http://www.biomed.engsoc.org/system/files/images/terminator-arm.jpg
Terminator 2 (1991)

DARPA (2007)
http://www.youtube.com/watch?v=GRuizeW-3Hc

Example: pneumatically actuated grippers





Gripper in action

Background/motivation

Robotics

REVIEW

Mobile Robots: Motor Challenges and Materials Solutions

John D. Madden

Bolted-down robots labor in our factories, performing the same task over and over again. Where are the robots that run and jump? Equaling human performance is very difficult for many reasons, including the basic challenge of demonstrating motors and transmissions that efficiently match the power per unit mass of muscle. In order to exceed animal agility, new actuators are needed. Materials that change dimension in response to applied voltage, so-called artificial muscle technologies, outperform muscle in most respects and so provide a promising means of improving robots. In the longer term, robots powered by atomically perfect fibers will outrun us all.

In this article, the application of actuator technologies is considered specifically for robots that are humanlike in form. Marc Raibert and his group at Massachusetts Institute of Technology (MIT) showed in the 1980s that robots can walk, run, and do flips (*1*). These robots are not free, however, but rather are attached to their power supplies. The incredible achievements and the limitations of successive lifelike robots provide insight into the challenges of using conventional actuators to drive machines that mimic human form and motion. The focus of this article is on robots and humanoids in particular, but much of the discussion of actuators is relevant to any active mechanical system and particularly those that involve intermittent rather than continuous motion, such as prosthetics, medical devices, valves, locks, and toys.

Combustion Engines: Powerful But Hard to Carry

The power per unit mass achieved in internal combustion engines is 1000 W/kg, about 10 times greater than the continuous power output of our own muscle (*2*). High power makes combustion engines excellent for the propulsion of vehicles, and particularly for highway driving, where abrupt changes in speed or direction are unusual. This power is combined with the long range afforded by the use of gasoline, which has an energy per unit mass that is about 20 times higher than that of a good battery, even after accounting for the ~30% efficiency typical in an internal combustion process. There are two particularly notable challenges to using the combustion engine on a robot, however. The first is that the engine operates best over a narrow range of rotation speeds, providing no torque at all at zero speed. Cars have transmission systems, including clutches and gears, that enable acceleration from a complete stop up to high speed. This transmission is not suited to the abrupt motions required of a robot, such as reaching for an object, then holding it for some time at a fixed position, and then throwing it away. The second challenge is simply carrying the hot, loud, and fuming engine on a robot while operating it efficiently and effectively, with space left for fuel.

Steve Jacobsen and his colleagues have demonstrated particularly impressive use of hydraulics to drive robots (*3*). Hydraulic actuation is a sophisticated version of the system used to drive the shovel on a front-end loader. Jacobsen's hydraulic robotics perform extremely lifelike movements and have been demonstrated in Disney theme park humanoid robots and Jurassic Park dinosaurs. However, these rely on an external power source. The Berkeley Robotics Laboratory has shown that a hydraulic motor can be taken on board (*4*, *5*). Its 75-kg device is not a free-standing robot but rather an exoskeleton with powered ankles, knees, and hips. The robot is attached at the feet and the hips, and it works in parallel with the wearer, allowing an additional 75 kg to be carried. This capability is intended to relieve a foot soldier's burden. The combined hydraulic system, empty fuel tank, valves, actuating pistons, and internal combustion engine exhibit a power-to-mass ratio that is about the same or perhaps a bit lower than that of muscle itself (*6*). Hydraulics are not terribly efficient for walking, which requires high power output only for brief periods of time. For the remainder of the time the system is needlessly shunting fluid. Primarily as a result of this inefficiency, BLEEX expends three times more energy in walking than a human does (*4*). A further drawback is the noise and heat of the combustion engine. The device certainly augments human strength, but so far soldiers are better off building up their own muscle if they can.

One key to reducing weight and increasing efficiency, and thereby making hydraulics more practical, may be to redesign the internal combustion engine to allow for the bursts of power needed during walking, running, or jumping (*7*, *8*). A potential weight-saving measure is to use lightweight pneumatic actuators in place of heavier hydraulic pistons, although this increases the mass of the pump (*9*). Either way, it is very hard to beat muscle.

Electric Motors: Jogging But Not Sprinting

Electric motors are attractive because they feature high continuous power per unit mass [up to 300 W/kg when using rare earth magnets (*10*) and twice that when actively cooled (*11*)] and high efficiency (can be >90%) (*2*). They are also relatively quiet and generate high torques at low speeds, making the transmission easier than it is in the combustion engine. Honda's impressive ASIMO is a battery-powered, untethered humanoid robot driven by electric servomotors (*12*–*14*). There is a motor for each of the 34 joints, including arms, legs, hips, hands, feet, head, and fingers. The fast rotary motion of the electric motors (which deliver maximum power at high speed) is converted to slower joint rotation by using a compact reduction system known as a harmonic drive. The drive has the same effect as going into very low gear on a bicycle. This transmission system, however, is heavy, bringing the overall power per unit mass down to or below that of muscle. Honda's latest robot, shown in Fig. 1, is able to do a slow run (6 km/hour, equivalent to a 16-min-mile pace), with both feet leaving the ground simultaneously between steps, clearing the ground by about 3 cm (*13*). It can also do light work, picking up 1 kg (about four coffees) when using both hands. Similar complexity and performance are demonstrated in other battery-powered servomotor-driven robots, including Sony's QRIO robot (*15*, *16*), which is much smaller than ASIMO and was the first to run, and Kawada's HRP-2 (*16*, *17*), which is about the same size as ASIMO but does not run.

Why can't ASIMO and the others go faster, jump higher, or carry a larger load? Speed is limited by the peak power output. Peak power requirements triple in the progression from walking to sprinting (*18*), so ASIMO's motors need to be three times heavier to achieve a fast run

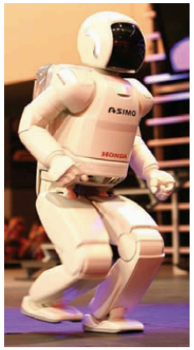


Fig. 1. Honda's humanoid robot ASIMO on the run. Reproduced from (*13*) with the permission of the Honda Motor Company.

Department of Electrical and Computer Engineering, University of British Columbia, Vancouver, BC V6T 1Z4, Canada. E-mail: jmadden@ece.ubc.ca

Group exercise –due next Friday March 16

- Write a 1 or 2-paragraph summary of a proposal based on the Ilievski paper, focusing on what you' d like to do **next** (anything)
  - The summary should follow the modified *Nature* format discussed during class (see reading on ctools)
  - The summary should identify both the intellectual merit and broader impact of your proposed work

- In addition to the summary, identify <u>3 or 4 specific aims</u> of your proposed research. Each aim should be described in 1-2 sentences. You should also think of how you will measure your progress toward each aim (i.e., qualify/characterize results). You don' t need to write about this though.

- For class on March 16:
  - Bring 10 copies of your team's summary (for a peer review exercise)
  - Be ready to explain and defend your aims in front of the class

The modified *Nature* format

General and specific background (WHY)

One or two sentences providing a ***basic introduction*** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of ***more detailed background***, comprehensible to scientists in related disciplines.

Your key question(s) or major objective (WHAT NOW)

One sentence clearly stating the ***general problem*** being addressed by this particular study.

Summary of aims/ methods (HOW)

One sentence summarising the main result (with the words "***here we show***" or their equivalent).

Two or three sentences explaining what the ***main result*** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

Expected outcomes: both intellectual merit and broader impact should be clear (WHAT LATER)

One or two sentences to put the results into a more ***general context***.

Two or three sentences to provide a ***broader perspective***, readily comprehensible to a scientist in any discipline, may be included in the first paragraph if the editor considers that the accessibility of the paper is significantly enhanced by their inclusion. Under these circumstances, the length of the paragraph can be up to 300 words. (The above example is 190 words without the final section, and 250 words with it).

During cell division, mitotic spindles are assembled by microtubule-based motor proteins[1,2]. The bipolar organization of spindles is essential for proper segregation of chromosomes, and requires plus-end-directed homotetrameric motor proteins of the widely conserved kinesin-5 (BimC) family[3]. Hypotheses for bipolar spindle formation include the 'push–pull mitotic muscle' model, in which kinesin-5 and opposing motor proteins act between overlapping microtubules[2,4,5]. However, the precise roles of kinesin-5 during this process are unknown. Here we show that the vertebrate kinesin-5 Eg5 drives the sliding of microtubules depending on their relative orientation. We found in controlled *in vitro* assays that Eg5 has the remarkable capability of simultaneously moving at ~20 nm s^{-1} towards the plus-ends of each of the two microtubules it crosslinks. For anti-parallel microtubules, this results in relative sliding at ~40 nm s^{-1}, comparable to spindle pole separation rates *in vivo*[6]. Furthermore, we found that Eg5 can tether microtubule plus-ends, suggesting an additional microtubule-binding mode for Eg5. Our results demonstrate how members of the kinesin-5 family are likely to function in mitosis, pushing apart interpolar microtubules as well as recruiting microtubules into bundles that are subsequently polarized by relative sliding. We anticipate our assay to be a starting point for more sophisticated *in vitro* models of mitotic spindles. For example, the individual and combined action of multiple mitotic motors could be tested, including minus-end-directed motors opposing Eg5 motility. Furthermore, Eg5 inhibition is a major target of anti-cancer drug development, and a well-defined and quantitative assay for motor function will be relevant for such developments.

Homework

- See references on ctools
- Soft robots proposal exercise (slide 52)

More slides to be discussed next week

PhD Research Process | Winter 2012

Research proposal assignment

Due on ctools at 2p Friday, March 30. Bring paper copy to class also.

a. Guided by your background report, identify the following:
   1. The key question/topic your research will seek to address. You should be able to express this in one sentence.
   2. The steps you expect to take (i.e., the research activities) in order to answer your question. These will be refined into the specific aims of your proposal.
   3. The most relevant background info to motivate your key question, and to justify your choice of aims.

b. Based on the analysis from (a) write a proposal with the following sections:
   1. Summary (1-2 paragraphs) according to the modified *Nature* "first paragraph" format discussed in class.
   2. Background. This is selected text, possibly written more compactly, from your report.
   3. Rationale and novelty, i.e., why your work fills an important need in light of the current status of your field, and why your approach is unique. This is VERY important.
   4. Description of proposed research, including at least 3 major tasks or aims. Each aim should be summarized in one sentence, followed by a more detailed description, and should have a measurable outcome. Each aim should stand reasonably well on its own, although later tasks may build upon previous findings.
   5. Expected outcomes, assuming your research is successful (BOTH scientific and practical).
   6. A timeline, indicating the start/end and duration of each of your research aims. The timeline resolution need not be finer than 3 months.
   7. Description of your qualifications (1 paragraph), i.e., why you are (or will be) qualified to do the proposed work.

c. The proposal must be 4-5 pages, with 1" margins (left/right/top/bottom), single-spaced, 11- or 12-point font. Sections should be divided with headings. The page limit excludes figures (plan for 0.5-1 page total area, more is OK) and references. Use the *Nature* reference format.

The summary must be convincing!

Working through a tall stack of proposals on voluntarily-donated time, a committee member rarely has time to comb proposals for hidden answers. So, say what you have to say immediately, crisply, and forcefully. The opening paragraph, or the first page at most, is your chance to grab the reviewers attention. Use it. This is the moment to overstate, rather than understate, your point or question. You can add the conditions and caveats later.

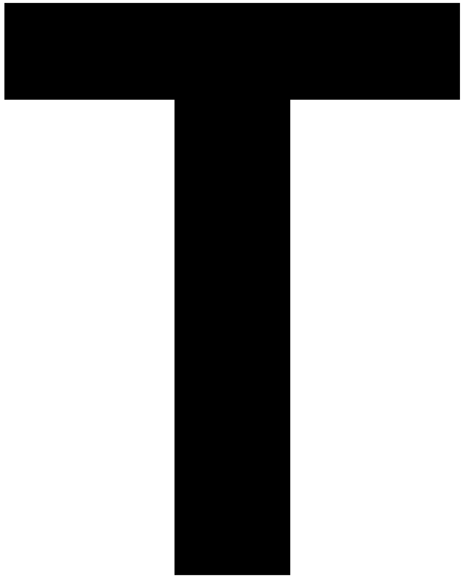
- See my NSF project summary

Przeworski and Salomon, "On the Art of Writing Proposals"

The background

- The general importance of your research topic
- The key findings that relate to your proposed work
  - Important findings that motivate your study
  - Important background information
  - This can include your own work (sometimes that's a separate section)
- Don't criticize past work (= makes reviewers angry), rather state *opportunities* for improvement

- This is a difficult balance of breadth and depth

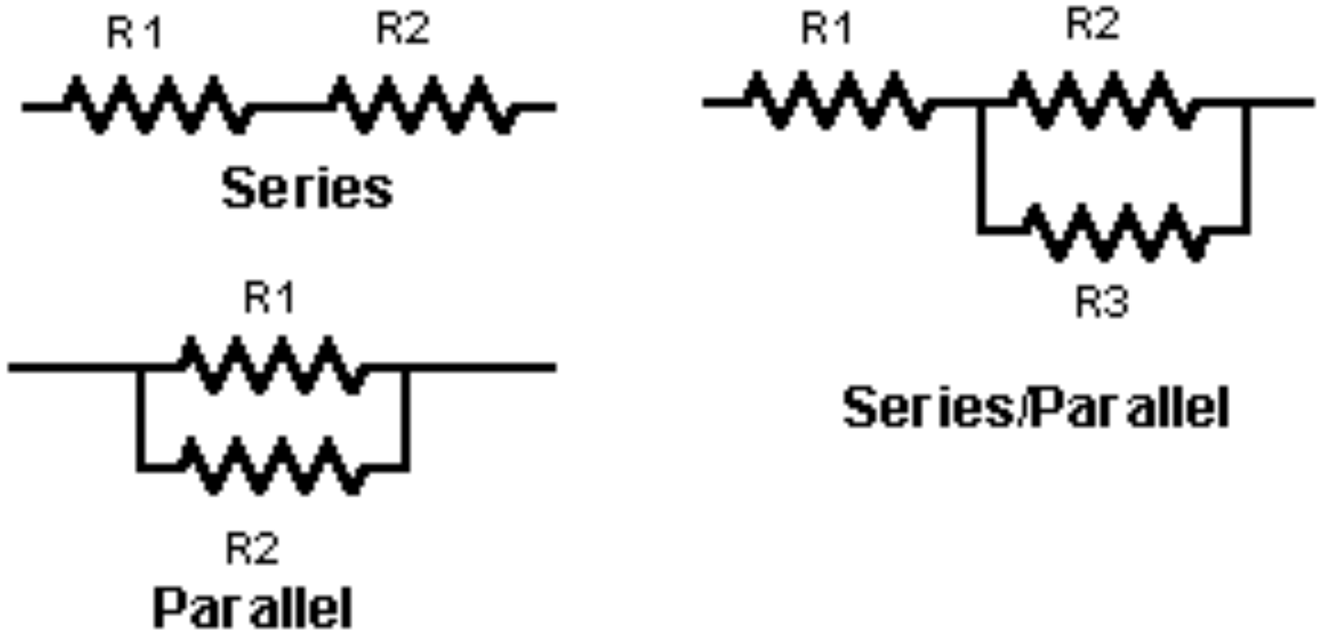


The rationale and novelty

- What is the main idea of the proposal?
- Why is it important? (why is it needed?)
- Why is it unique?

Dividing the big idea: objectives/aims

Planning: series and parallel



- What happens if a wire breaks?
  → *Risks and countermeasures*

http://www.guitarnuts.com/wiring/serpar.php

The GAP must be clear

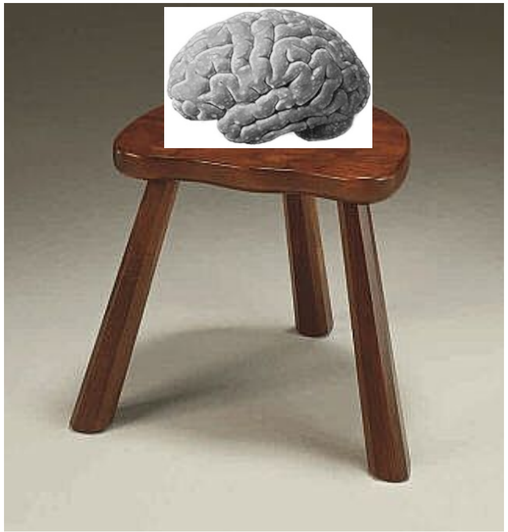
relationship-economy.com

http://ictkm.cgiar.org/

Think long-term

By the time you write your proposal, obtain funding, do the research, and write it up, you might wish you were working on something else. So if your instinct leads you to a problem far from the course that the pack is running, follow it—not the pack: nothing is more valuable than a really fresh beginning.

A good proposal has a lot of legs



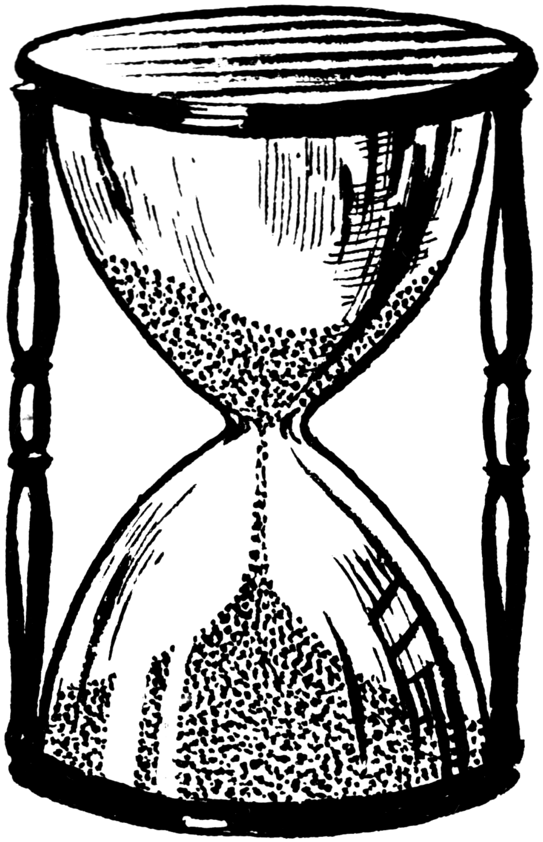
A good idea is necessary but not sufficient for a successful proposal. Especially, the reviewers will want to know what you will do if something goes wrong. Your idea and approach must be robust to their concerns.

Overall: the hourglass design

Beginning

Middle

End



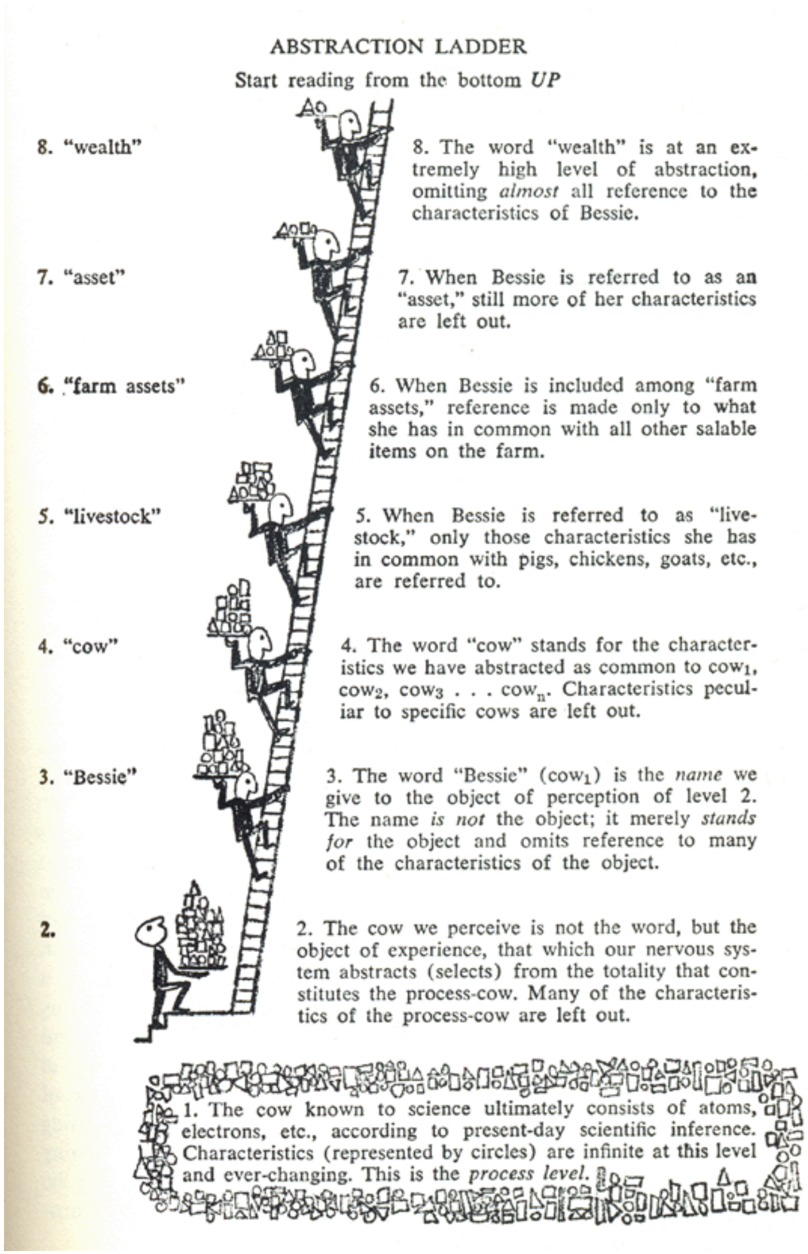
Think about the context and the objectives

WHY
WHAT
HOW/WHO

- Context
  - Defined broadly with clear motivation (e.g., quantification if possible)
  - Connect the big issue to your specific focus
  - It should be clear why your work (if successful) is unique and will make a difference

- Objectives/tasks should be
  - Specific (= what will be done)
  - Measurable (= how you will measure the outcome)
  - Practical (= can be done)
  - Logical (= makes sense, on its own and in combination with other tasks)

The ladder of abstraction [Hakayawa]



ABSTRACTION LADDER

Start reading from the bottom *UP*

8. "wealth" — 8. The word "wealth" is at an extremely high level of abstraction, omitting *almost* all reference to the characteristics of Bessie.

7. "asset" — 7. When Bessie is referred to as an "asset," still more of her characteristics are left out.

6. "farm assets" — 6. When Bessie is included among "farm assets," reference is made only to what she has in common with all other salable items on the farm.

5. "livestock" — 5. When Bessie is referred to as "livestock," only those characteristics she has in common with pigs, chickens, goats, etc., are referred to.

4. "cow" — 4. The word "cow" stands for the characteristics we have abstracted as common to cow$_1$, cow$_2$, cow$_3$ . . . cow$_n$. Characteristics peculiar to specific cows are left out.

3. "Bessie" — 3. The word "Bessie" (cow$_1$) is the *name* we give to the object of perception of level 2. The name *is not* the object; it merely *stands for* the object and omits reference to many of the characteristics of the object.

2. — 2. The cow we perceive is not the word, but the object of experience, that which our nervous system abstracts (selects) from the totality that constitutes the process-cow. Many of the characteristics of the process-cow are left out.

1. The cow known to science ultimately consists of atoms, electrons, etc., according to present-day scientific inference. Characteristics (represented by circles) are infinite at this level and ever-changing. This is the *process level.*

Level Four	economy
Level Three	farm assets
Level Two	cattle
Level One	**Bessie, the cow**

Use action words (see ctools)

ACTION WORDS

A resume should sound alive and vigorous. Using action verbs helps achieve that feeling. "I changed the filing system" lacks punch and doesn't really indicate if the system was improved. "I *reorganized* and *simplified* the filing system" sounds much better and provides more accurate information.

Review the sentences below to get a feel for action words. Then quickly scan the words in the following list and check any you think you might want to use in your resume. Don't try to force them in; use them when they feel right.

Conducted long-range master planning for the Portland water supply system.

Monitored enemy radio transmissions, analyzed information, and identified enemy strategic and tactical capabilities.

Planned, staffed, and organized the intramural sports program for this 1,200-student college.

Produced daily reports for each trial and made sure documents and evidence were handled properly.

Presented seminars to entry-level secretaries and worked to increase the professionalism of secretaries in the county system.

Improved the coordination, imagination, and pantomime techniques of adults through mime and dance training.

Allocated and dispensed federal moneys to nine counties as board member of the CETA Advisory Board.

However, don't be too dreamy (foofy)

- *Foofy* -- Vague, evasive, betraying lack of mastery and confidence; exaggerated claim without evidence
- *Foofy example:* "Nanotechnology promises enormous economic benefits."
- *Less foofy:* "Smith, writing in the Wall Street Journal, estimates that nanotechnology will have a $100 billion impact on the world economy in five years [ref]."

Formatting makes a difference too

- Font size and margins
- Spacing between paragraphs
- Clarity of figures
- Often, less is more! The decision is based on the **important** things

11pt
1" margins
3pt betw parag

3. Proposed research

This section details our plans to fabricate active 3D CNT microstructures, to characterize their mechanical properties and dynamic performance, and to demonstrate their utility as sensors and responsive surfaces. First, we introduce the capillary forming technique which is the foundation for this project, and then we describe the three main research tasks.

3.1 Fabrication of 3D CNT microstructures by capillary forming

The proposed research on morphing CNT microstructures will build from our novel "capillary forming" [1] method of fabricating robust 3D CNT microstructures from vertically-aligned CNT templates. The capillary forming process is shown in Fig. 4. First, a film of Fe catalyst (1 nm thickness) is patterned by optical lithography on a silicon wafer substrate. Next, microstructures made of vertically aligned CNTs (CNT "forests") are grown by atmospheric pressure thermal chemical vapor deposition (CVD) [61, 62]. Next, a solvent such as acetone is condensed on the substrate. This is done by inverting the substrate with CNTs over a beaker containing a boiling solvent such as acetone, or within a low-pressure chamber where the substrate rests on a cold stage. The solvent condenses on the substrate, and, due to capillary rise, the solvent is drawn into each CNT microstructure independently. After the substrate has been exposed to the vapor stream for the desired duration, the substrate is removed from the beaker and the liquid is evaporated under ambient conditions. During infiltration and evaporation of the liquid, the CNTs within each structure densify, and each structure is shaped individually by the forces resulting from capillary action. Different starting forest shapes give different force distributions, enabling design and fabrication of the 3D structures shown later.

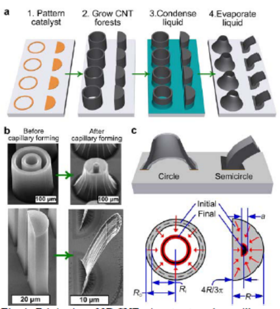


Fig. 4. Fabrication of 3D CNT microstructures by capillary forming: (a) schematic; (b) SEM images of contracting (circular) and bending (semicircular) shapes; (c) schematic of corresponding densification mechanisms.

During capillary forming, surface tension causes the CNTs to aggregate locally due to an elastocapillary energy balance [63-65], and the CNT forest globally contracts toward the centroid of its cross-sectional shape. Thus, for a circle, the contraction is toward the center (Fig. 4c); while for a semicircle, the contraction is toward the point at a distance $4R/3\pi$ from the straight edge of the semicircle (Fig. 4c). As this contraction occurs, the CNTs near the substrate are pulled inward toward the centroid, and this in turn pulls down on the upper portions of the forest. For circles, the force distribution is axisymmetric and the final structure therefore slopes toward its apex. For semicircles, the force distribution is asymmetric due to the asymmetric location of the centroid. This causes the structure to deflect laterally, creating a curved beam.

Understanding capillary forming of circular and semicircular CNT forests has guided us in fabrication of a variety of novel 3D microstructures (Fig. 5). For instance, circular arrangements of bending structures can be designed to face inward or outward from a common point, resembling trusses or flowers. Intricate micro-twists with deterministic handedness are formed from shapes comprising semicircles merged with a thin annulus. These catalyst shapes combine the elementary motions of contraction and bending, and the helical angle and pitch of the final structure are determined by the dimensions…

1

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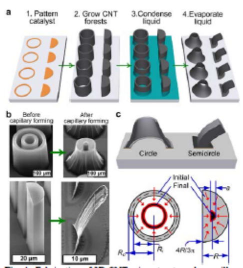

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1

10pt
0.5" margins
0pt betw parag

Procrastination is the enemy of good proposals

- Success not proportional to how much time you spend!
- but is proportional to how clear your ideas are
- and clarifying your ideas takes time
- So, it's important to be efficient, and it's obvious when you read a proposal that has been rushed

The infamous Procrastination Monster // by jordanspilman

Why proposals are rejected

…short-comings of 605 proposals rejected by the National Institutes of Health is worth pondering. The list is derived from an article by Dr. Ernest M. Allen (Chief of the Division of Research Grants, National Institutes of Health) that appeared in Science, Vol. 132 (November 25, 1960), pp. 1532-34. (The percentages given total more than 100 because more than one item may have been cited for a particular proposal.)

Problem (58 percent)

1.The problem is not of sufficient importance or is unlikely to produce any new or useful information. (33.1)
2.The proposed research is based on a hypothesis that rests on insufficient evidence, is doubtful, or is unsound. (8.9)
3.The problem is more complex than the investigator appears to realize. (8.1)
4.…

Approach (73 percent)

1.The proposed tests, or methods, or scientific procedures are unsuited to the stated objective. (34.7)
2.The description of the approach is too nebulous, diffuse, and lacking in clarity to permit adequate evaluation. (28.8)
3.The overall design of the study has not been carefully thought out. (14.7)
4.…

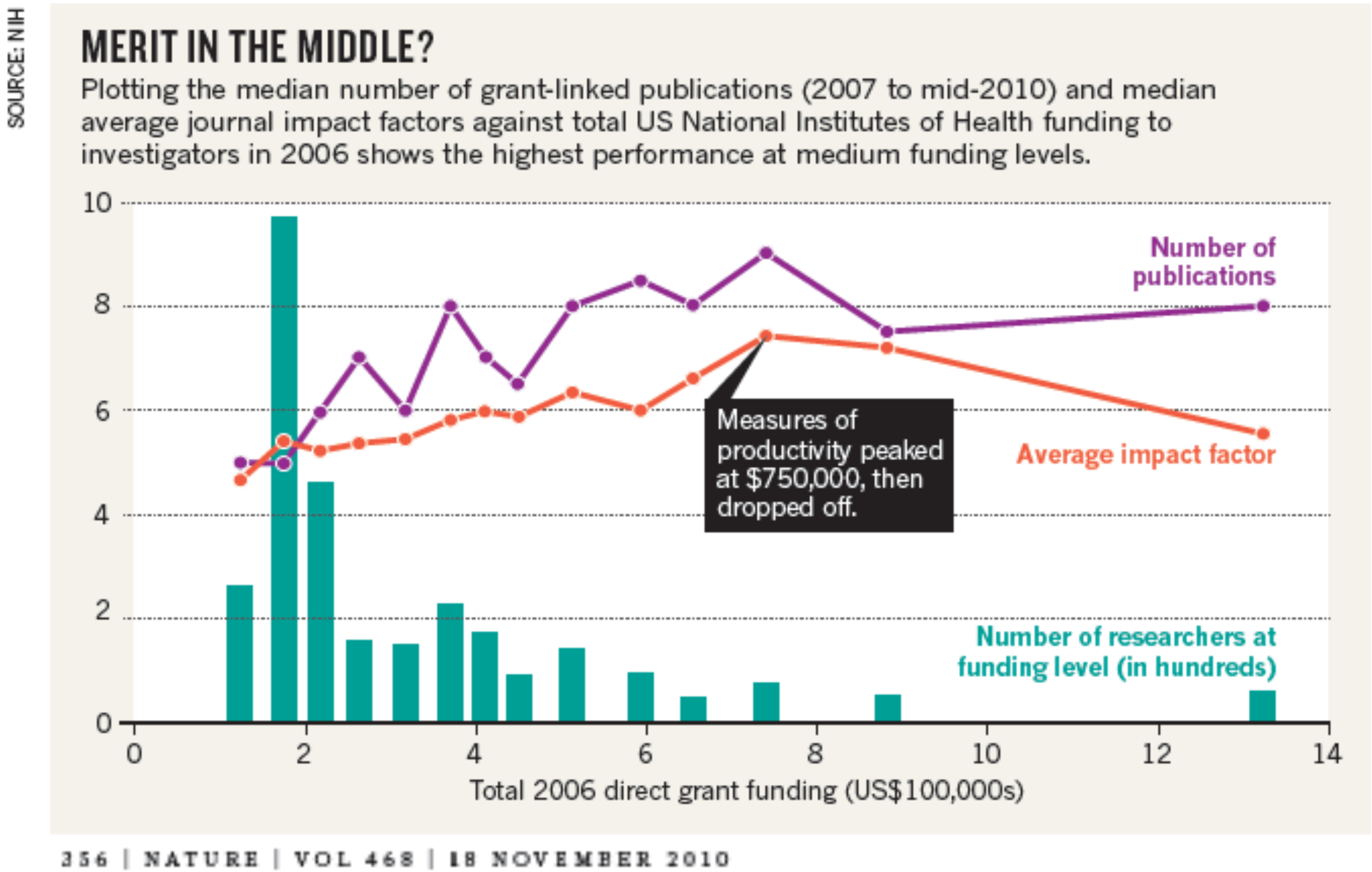
Investigator (55 percent)

1.The investigator does not have adequate experience or training for this research. (32.6)
2.The investigator appears to be unfamiliar with recent pertinent literature or methods. (13.7)
3.The investigator's previously published work in this field does not inspire confidence. (12.6)
4.…

Other (16 percent)

1.The requirements for equipment or personnel are unrealistic. (10.1)
2.….

From the other side



Graduate fellowships = freedom!

- You'll be decoupled (mostly) from external funding sources
- Access to new opportunities, e.g., workshops
- Excellent for your CV

- As a result, graduate fellowships are considered recognition of you, not just the research you're doing
  - However, a strong proposal is indicative of your ability to do research
  - Same is true for faculty young investigator awards

The NSF GRFP essay

In a clear, concise, and original statement, present a complete plan for a research project that you may pursue while on fellowship tenure and how you became interested in the topic.

Your statement should demonstrate your understanding of research design and methodology and explain the relationship to your previous research, if any. Describe how you propose to address the two NSF Merit Review Criteria of Intellectual Merit and Broader Impacts. Refer to the program announcement for specific guidance.

Format: Include the title, key words, hypothesis, research plan (strategy, methodology,
and controls), anticipated results or findings, literature citations, and a statement attesting to the originality of the research proposal. If you have not formulated a research plan, your statement should include a description of a topic that interests you and how you would propose to conduct research on that topic.

2 pages!

Know your audience

- Who will review the proposal?
- What are their selection criteria? (even if your idea is great…)
  - Person/expertise vs. what the research is about
  - Relevance to their interests
  - Fundamental understanding vs. practical applications
  - Education/outreach?
  - …
- Talk to someone who knows the agency/program/topic
  - Faculty talk to program managers
  - Students talk to others who applied for the fellowship before
- Envision the match
  - They may have a problem looking for a solution
  - You may have a solution looking for a problem

Homework

- See references on ctools
- Soft robots proposal exercise