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)

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

<table>
<thead>
<tr>
<th></th>
<th>good</th>
<th>improve</th>
</tr>
</thead>
<tbody>
<tr>
<td>creativity</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>communication</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>time mgmt, organization, efficiency</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>fundamentals, theory, analysis</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>searching/retaining information</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>perseverance, confidence</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
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
What rank is UM’s research budget among all US universities?

As a single entity, UM is #1

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**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)

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

All other institutions                 | 34,996| 36,690| 38,511|

S&E = science and engineering.

* 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.

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.

A.J. Hart | 13
Figure 1: Research Expenditures by Major Sponsor Group FY2001-2011

- U-M (internal) sponsors
- Non-federal sponsors
- Federal sponsor
Table 1: U-M Research Expenditures by Major Sponsor Group, FY2011

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

**Subcontracts from industry under federal government as the prime sponsor are not included in this number; see Table 3.**
Table 2: U-M Research Expenditures
Percent Change by Major Sponsor Group, FY2010-2011

<table>
<thead>
<tr>
<th>Sponsor Group</th>
<th>FY10</th>
<th>% of total</th>
<th>FY11</th>
<th>% of total</th>
<th>$ Chg.</th>
<th>% Chg.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Federal</strong></td>
<td>$750,937,273</td>
<td>65.9%</td>
<td>$824,752,621</td>
<td>66.7%</td>
<td>$73,815,348</td>
<td>9.8%</td>
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<tr>
<td>NIH</td>
<td>$507,485,540</td>
<td>44.5%</td>
<td>$571,188,536</td>
<td>46.2%</td>
<td>$63,702,996</td>
<td>12.6%</td>
</tr>
<tr>
<td>NSF</td>
<td>$67,331,716</td>
<td>5.9%</td>
<td>$74,246,980</td>
<td>6.0%</td>
<td>$6,915,264</td>
<td>10.3%</td>
</tr>
<tr>
<td>DOD</td>
<td>$65,970,563</td>
<td>5.8%</td>
<td>$62,738,099</td>
<td>5.1%</td>
<td>$3,232,464</td>
<td>-4.9%</td>
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<tr>
<td>Energy</td>
<td>$27,145,008</td>
<td>2.4%</td>
<td>$35,409,948</td>
<td>2.9%</td>
<td>$8,264,940</td>
<td>30.4%</td>
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<tr>
<td>N.A.S.A.</td>
<td>$16,412,115</td>
<td>1.4%</td>
<td>$15,339,972</td>
<td>1.2%</td>
<td>-$1,072,143</td>
<td>-6.5%</td>
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<tr>
<td>Transportation</td>
<td>$10,456,674</td>
<td>0.9%</td>
<td>$7,782,251</td>
<td>0.6%</td>
<td>-$2,674,423</td>
<td>-25.6%</td>
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<tr>
<td>Commerce</td>
<td>$9,489,189</td>
<td>0.8%</td>
<td>$10,788,559</td>
<td>0.9%</td>
<td>$1,299,370</td>
<td>13.7%</td>
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<tr>
<td><strong>Total Non-Federal</strong></td>
<td>$106,762,901</td>
<td>9.4%</td>
<td>$105,629,030</td>
<td>8.5%</td>
<td>-$1,133,871</td>
<td>-1.1%</td>
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<tr>
<td>Industry</td>
<td>$39,269,613</td>
<td>3.4%</td>
<td>$40,839,950</td>
<td>3.3%</td>
<td>$1,570,337</td>
<td>4.0%</td>
</tr>
<tr>
<td>Foundations</td>
<td>$24,881,157</td>
<td>2.2%</td>
<td>$21,487,269</td>
<td>1.7%</td>
<td>-$3,393,888</td>
<td>-13.6%</td>
</tr>
<tr>
<td>State of Mi./Local Govt.</td>
<td>$3,792,924</td>
<td>0.3%</td>
<td>$1,838,644</td>
<td>0.1%</td>
<td>-$1,954,280</td>
<td>-51.5%</td>
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<tr>
<td><strong>Total U-M</strong></td>
<td>$249,658,394</td>
<td>24.6%</td>
<td>$281,793,811</td>
<td>24.7%</td>
<td>$32,135,417</td>
<td>12.9%</td>
</tr>
<tr>
<td>Total Expenditures</td>
<td>$1,139,493,986</td>
<td></td>
<td>$1,236,510,624</td>
<td></td>
<td>$97,016,638</td>
<td>8.5%</td>
</tr>
</tbody>
</table>
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
<table>
<thead>
<tr>
<th>Unit</th>
<th>FY11</th>
<th>Change</th>
<th>Unit</th>
<th>FY11</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical School</td>
<td>$544.9M</td>
<td>9.3%</td>
<td>Rackham</td>
<td>$6.1M</td>
<td>1.4%</td>
</tr>
<tr>
<td>Engineering</td>
<td>$178.8M</td>
<td>-0.7%</td>
<td>Social Work</td>
<td>$5.6M</td>
<td>4.0%</td>
</tr>
<tr>
<td>LSA</td>
<td>$138.7M</td>
<td>24.6%</td>
<td>Nursing</td>
<td>$4.9M</td>
<td>-0.1%</td>
</tr>
<tr>
<td>ISR</td>
<td>$114.1M</td>
<td>13.7%</td>
<td>Kinesiology</td>
<td>$4.5M</td>
<td>4.3%</td>
</tr>
<tr>
<td>Public Health</td>
<td>$83.0M</td>
<td>35.6%</td>
<td>Information</td>
<td>$4.3M</td>
<td>12.8%</td>
</tr>
<tr>
<td>OVPR Units</td>
<td>$29.9M</td>
<td>-5.1%</td>
<td>Law</td>
<td>$3.7M</td>
<td>8.4%</td>
</tr>
<tr>
<td>Dentistry</td>
<td>$19.9M</td>
<td>1.1%</td>
<td>Public Policy</td>
<td>$3.6M</td>
<td>29.8%</td>
</tr>
<tr>
<td>SNRE</td>
<td>$15.3M</td>
<td>13.6%</td>
<td>Arch. &amp; Urban Pl.</td>
<td>$1.1M</td>
<td>27.2%</td>
</tr>
<tr>
<td>Education</td>
<td>$12.0</td>
<td>15.2%</td>
<td>UM-Flint</td>
<td>$672K</td>
<td>16.0%</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>$8.4M</td>
<td>3.6%</td>
<td>Music</td>
<td>$259K</td>
<td>-19.7%</td>
</tr>
<tr>
<td>Business</td>
<td>$7.4M</td>
<td>-4.9%</td>
<td>Art and Design</td>
<td>$101K</td>
<td>-26.5%</td>
</tr>
<tr>
<td>UM-Dearborn</td>
<td>$7.2M</td>
<td>16.1%</td>
<td>Other Units</td>
<td>$35.0M</td>
<td>4.4%</td>
</tr>
</tbody>
</table>
ME department only

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,

- 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 xxx
  - 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: incoherence 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
NEWBORN TO 2 YEARS / BOOK & CD

SOUNDS | RHYMES | SONGS

LIVING LANGUAGE®
**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/macro scale systems. Special emphasis is 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)

0: Catalyst film
Fe
Al₂O₃

1: Form nanoclusters
Fe

2: Nucleate CNTs

3: Grow CNTs
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

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

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

- ...
The day after I came to Ann Arbor...
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 nanotubes (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
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 recommendation.

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.

New objective: learn how to remove the forest

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.
Industrial SuperAbrasive 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,

[Signature]

Richard Hall  
Technology Director
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
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.ingsoc.org/system/files/images/terminator-arm.jpg
Terminator 2 (1991)

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

The U.S. military is building an ambitious bionic arm that is controlled by thought and provides sensory feedback. Here's the latest prototype, showing the movements of the hand.
Example: pneumatically actuated grippers

Gripper in action
Background/motivation

Mobile Robots: Motor Challenges and Materials Solutions

John D. Madden

Boil-down robots labor in our factories, performing the same task over and over again. Where are the robots that run and jump? Equalizing 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 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 lifecycles of 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 mechatanical 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 gear ratios 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 picking up 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 humming engine on a robot while operating it efficiently and effectively, with space left for fuel.

Steve Jacobsen and his colleagues have demonstrated particularly effective 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 robots perform extremely lifelike movements, as seen in the Disney-themed 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 foot 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 high efficiency (up to ~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 or 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-minute pace), with both feet leaving the ground simultaneously between steps, clearing the ground by about 3 cm (15). It can also do light work, picking up 1 kg (about four golf balls) 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 trotting 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.
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 3 or 4 specific aims 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
During cell division, mitotic spindles are assembled by microtubule-based motor proteins\(^\text{1-5}\). The bipolar organization of spindles is essential for proper segregation of chromosomes, and requires plus-end-directed homotetrameric motor proteins of the kinesin-5 (BimC) family\(^\text{6}\). Hypotheses for bipolar spindle formation include the 'push–pull mitotic muscle' model, in which kinesin-5 and opposing motor proteins act between overlapping microtubules\(^\text{2,5}\). 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 \(\sim 20\) 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 \(\sim 40\) nm s\(^{-1}\), comparable to spindle pole separation rates in vivo\(^\text{8}\). 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
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]

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.

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.

3. The word “Bessie” (cow₁) 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.

4. The word “cow” stands for the characteristics we have abstracted as common to cow₁, cow₂, cow₃ . . . cowₙ. Characteristics peculiar to specific cows are left out.

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

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.

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

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

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
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. (12.7)
4....

**Other (16 percent)**
1. The requirements for equipment or personnel are unrealistic. (10.1)
2....
From the other side

MERIT IN THE MIDDLE?
Plotting the median number of grant-linked publications (2007 to mid-2010) and median average journal impact factors against total US National Institutes of Health funding to investigators in 2006 shows the highest performance at medium funding levels.

Measures of productivity peaked at $750,000, then dropped off.

Number of researchers at funding level (in hundreds)

Average impact factor

Number of publications

Total 2006 direct grant funding (US$100,000s)
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