Getting What You Came For: An Anteater's Guide to Navigating a Math PhD

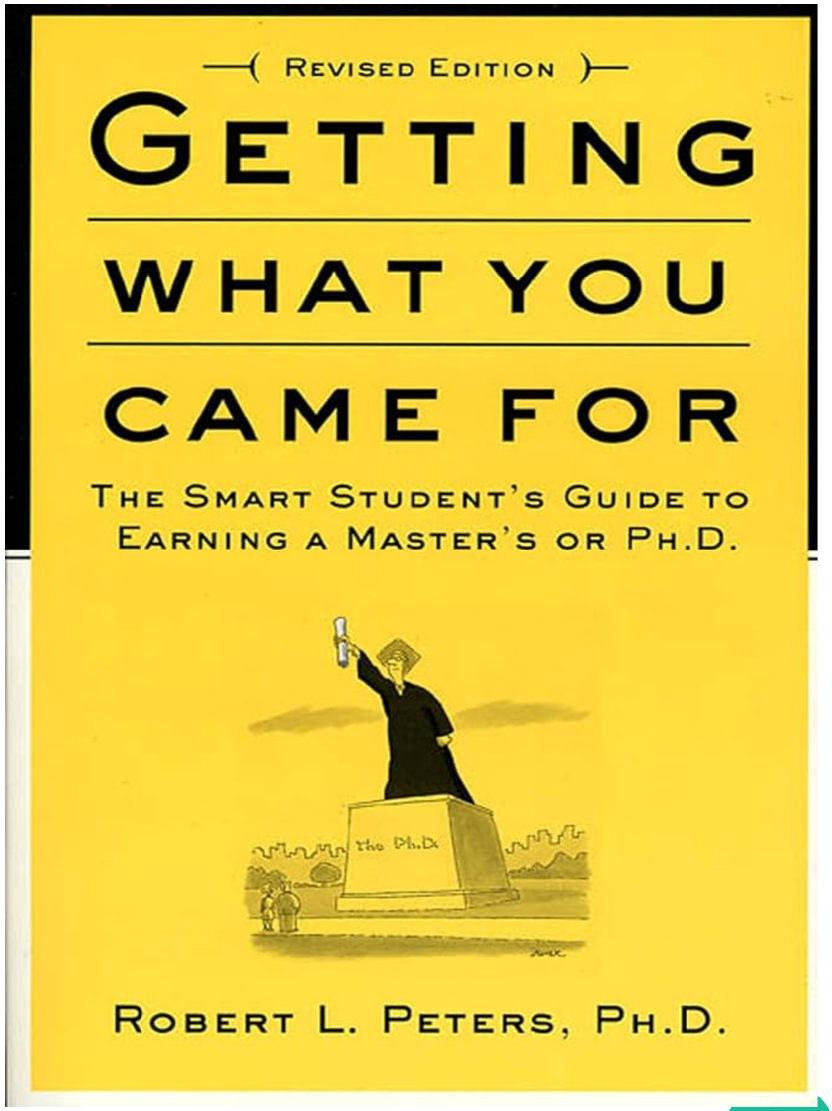
by Adam Larios



University of California, Irvine, 10 May 2024

You can research research!

- Books!
- Blogs/Articles
- YouTube
- Stack Exchange
- UCI Division of Career Pathways
- Workshops/Training



About me

- PhD, UCI 2011 on PDEs, with Prof. Edriss Titi
- (Originally intended to study algebra/number th.)
- Spent summers in Los Alamos National Lab
- Started in community college
- Not a child prodigy, son of a teacher and a salesman
- Always felt like I could lose it all, so I worked hard
- Currently Associate Professor with tenure at University of Nebraska-Lincoln (Math Dept.)
- Life is pretty great

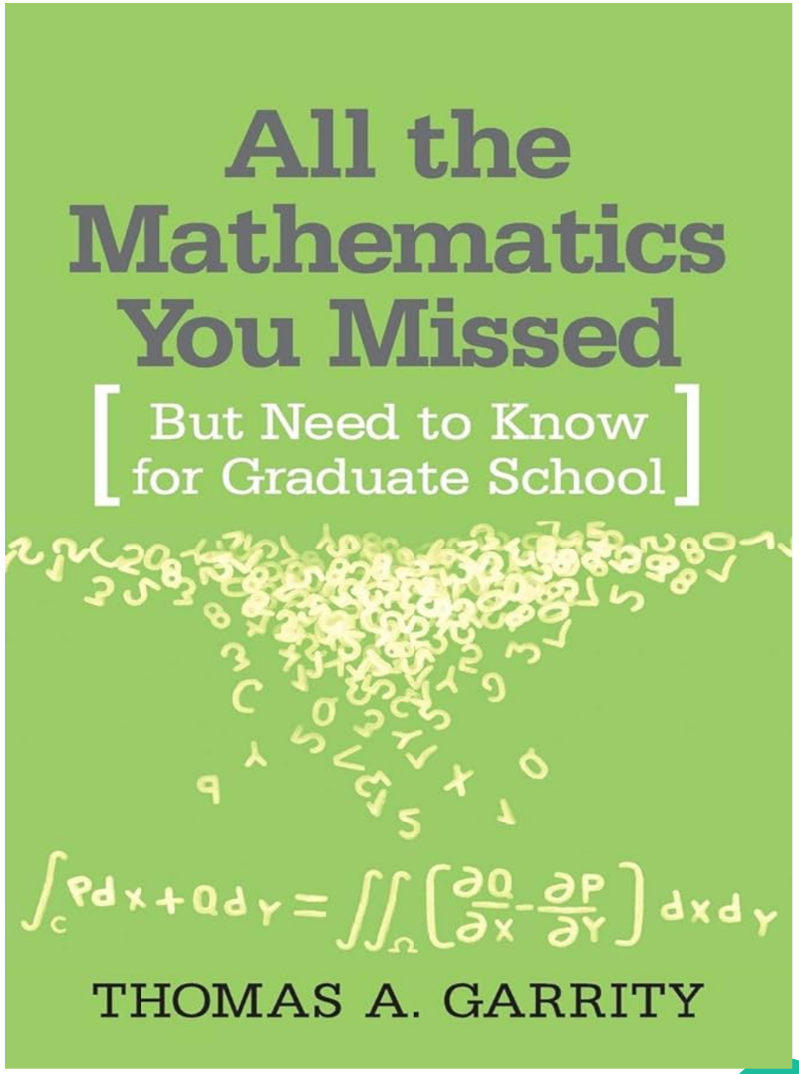
The First Two Years



The mindset of the PhD

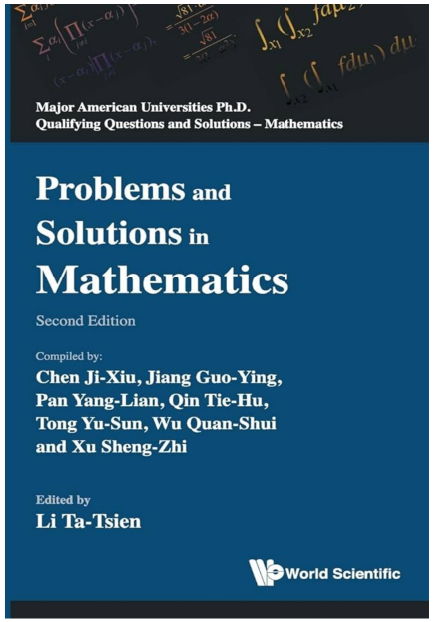
- Remember that you are a mathematician

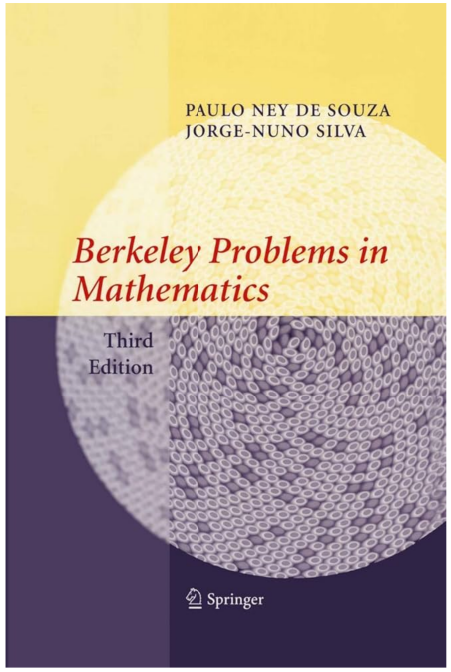
  (this is not a rehearsal)
- Take courses seriously, and ask for help
- Form study groups, but for challenges, not co-dependency
- A PhD is a “phase change” - Prof. Michael Cranston



Main Goal: Pass Your Exams (and do well)

- Passing comp/qual exams early can jump-start your research
- There exists N>0 such that if you do k>N problems well, you will (likely) pass exams. The evidence: N is large.
- Do every problem in the book, and then more!
- The NSF-GRFP $138,000





Wellness, Health & Counseling Services

- **A PhD can test your limits**
- **You may find out things about yourself that are troubling**
- **You are not “broken” if you need help**
- **You are trying to optimize your brain for math: it needs your help!**
- **Don’t say anything about yourself that you wouldn’t say to others (no negative self-talk)**



Counseling Center: (949) 824-6457
Student Health Center: (949) 824-5301

Common Blocks

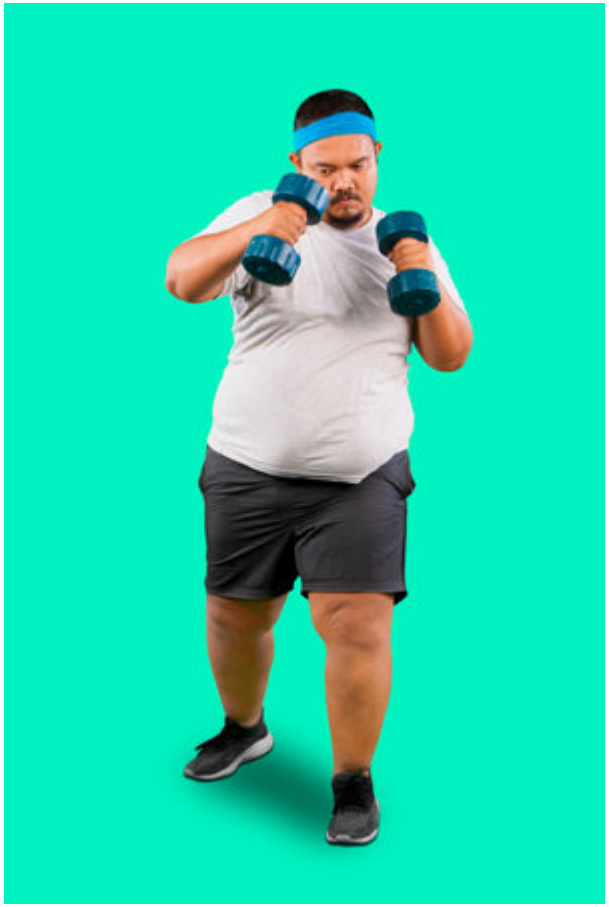
- Imposter Syndrome
- Anxiety
- Depression
- Perfectionism
- Burnout
- Loneliness
- Guilt



Many of your favorite mathematicians, comedians, actors, artists, etc. had these too!

Managing Stress

- If you have a human body, it needs regular exercise
- Exercise “burns” cortisol, the “stress” hormone
- Stress makes you bad at math
- Meditation or breathing exercises can help
- Do it with a friend!
- Avoid drugs/alcohol
- Social times: schedule if you must



Sleep: A Missing Piece in Education

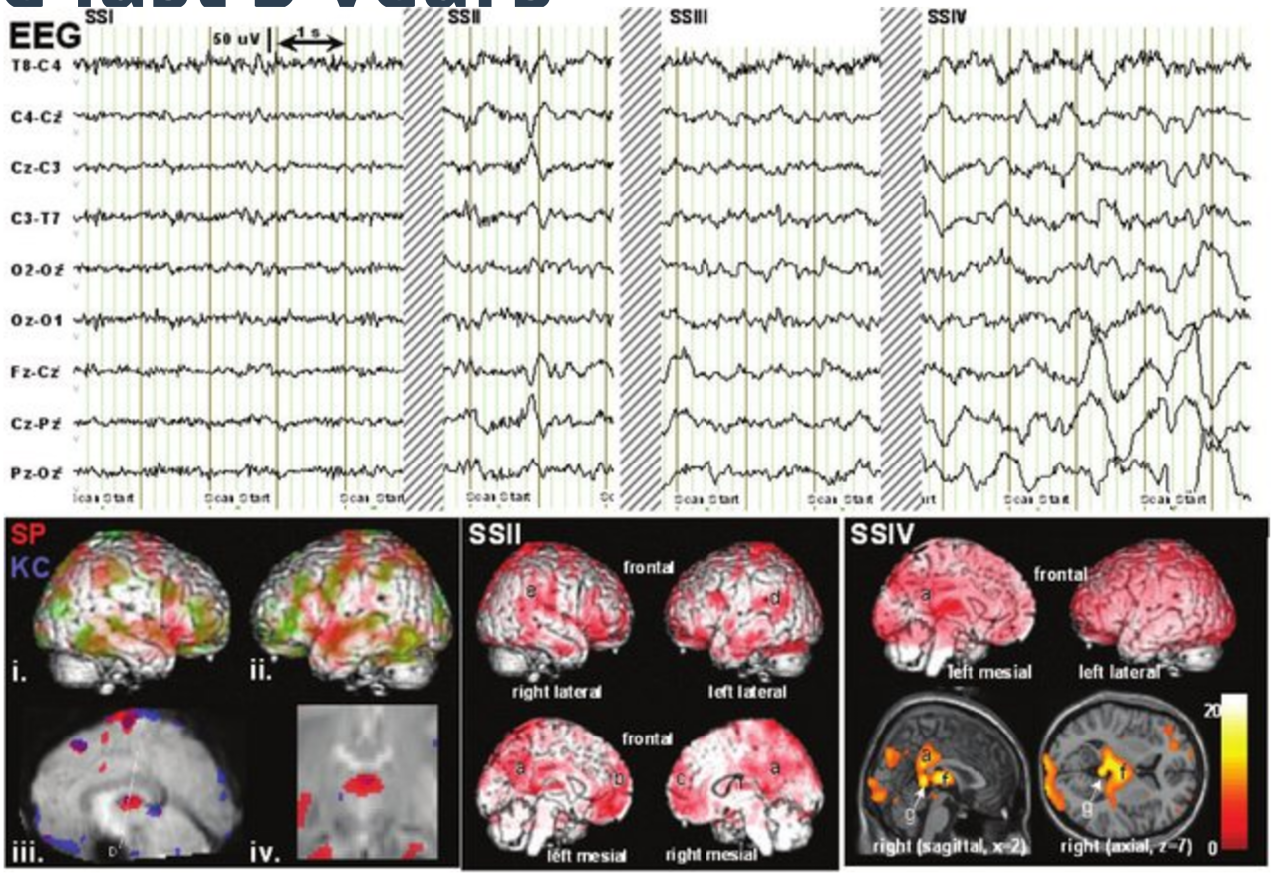
" If sleep doesn't serve an absolutely vital function, it is the biggest mistake evolution ever made."

- Dr. Allan Rechtschaffen, U. Chicago



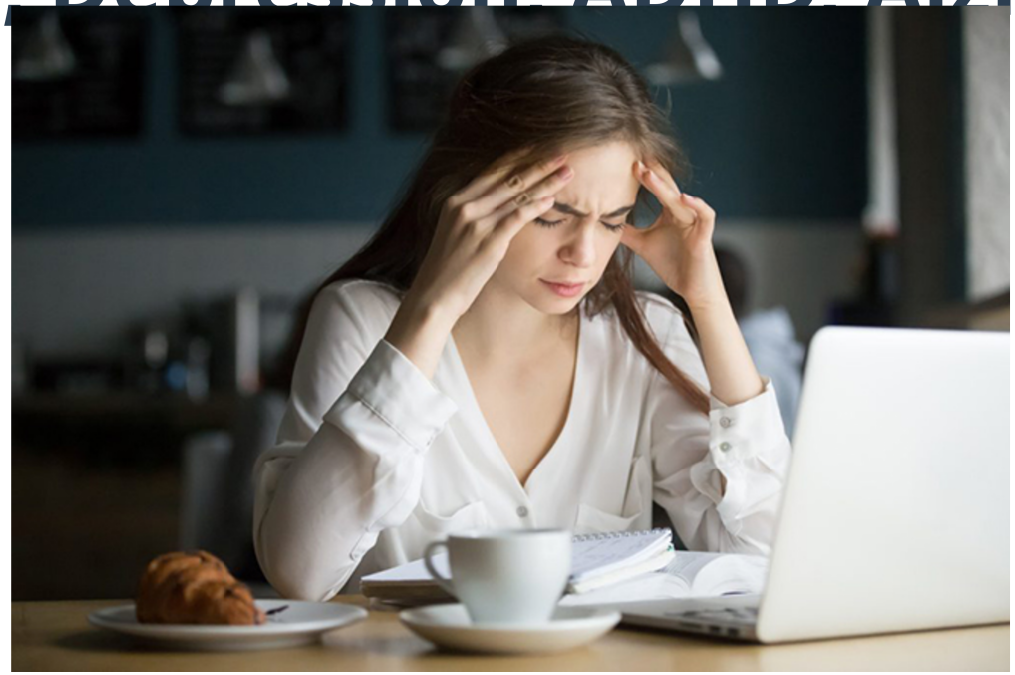
Sleep: The Research is New

- **fMRI/EEG have massively improved in the last 5 years**



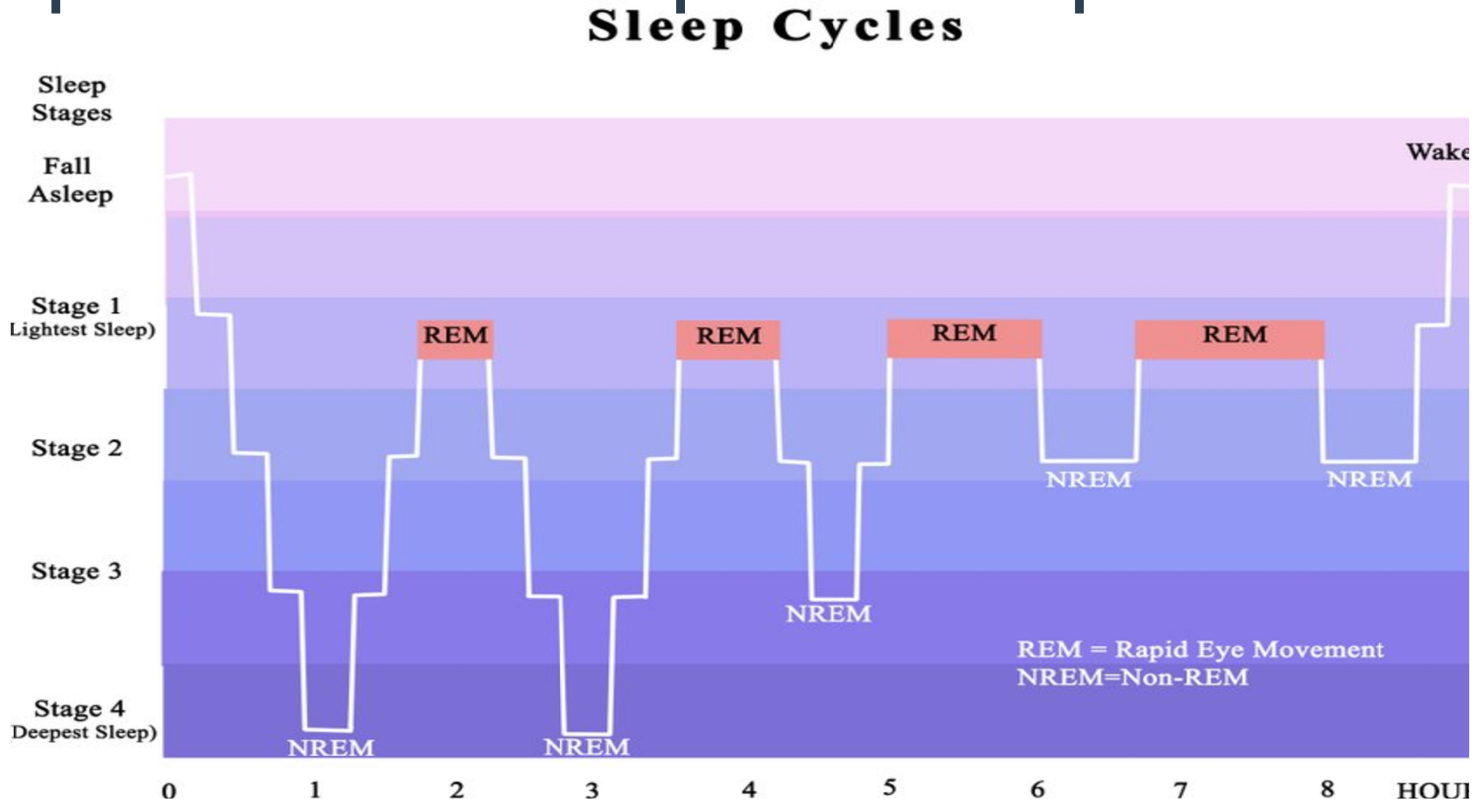
Sleep and Mental Health

- ***Every*** **studied mental illness is made worse by even 1 hour of lost sleep**
- **Anxiety, Depression, ADHD, Alzheimer's…**



How Sleep Works

- Every human needs 7-9 hours of sleep (amount is genetic)
- Night-owl vs. morning-lark status is genetic
- Sleep cannot be “stored up” or “made up for”



Sleep is *active*, not passive

- **NREM sleep**

  - Hits the “save” button

  - Etches memories at rapid speed

  - Consolidation of declarative memory



- **REM sleep**

  - Chaotic free-associative thought patterns

  - Dreaming

  - *Intense creativity*



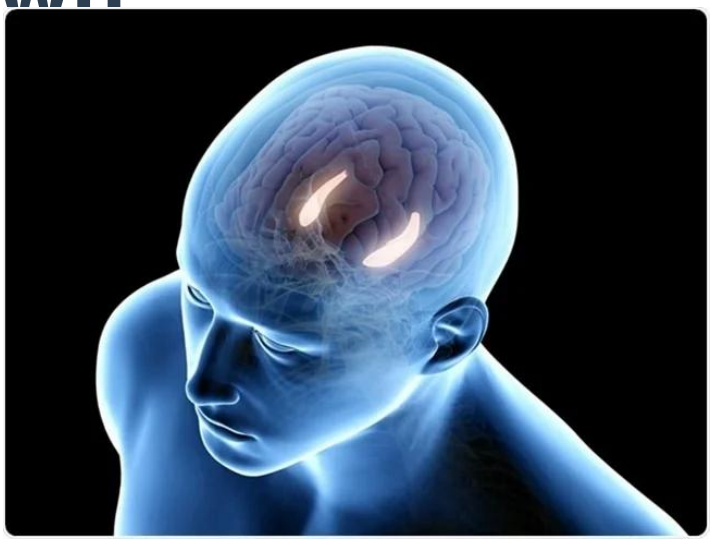
Sleep and Physical Health

- 4 hours of lost sleep

  = 70% reduction in immune system activity
- W.H.O. now classifies nighttime shift work as a probable carcinogen
- Short sleep predicts all-cause mortality
- Getting 6 hours of sleep (vs. 8) for 1 week massively alters the epi-genome

The All-Nighter (sleep deprivation)

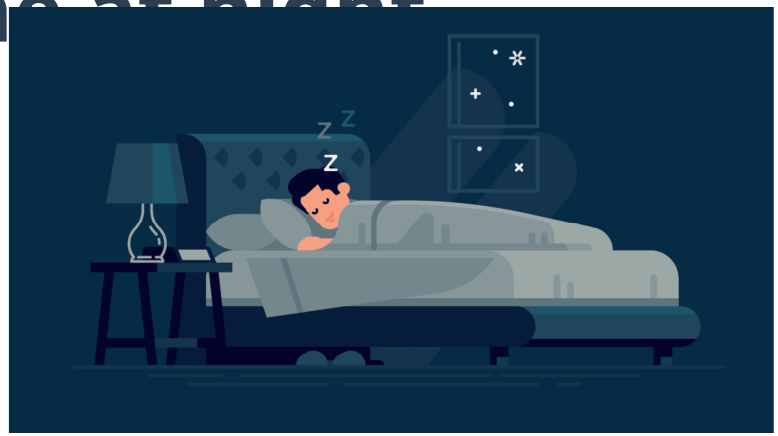
- 40% drop in ability to make new memories (A grade vs. F grade)
- The hippocampus, the “inbox” of the brain is almost totally shut down
- Affects learning both before and after sleep deprivation



Tips for better sleep

- Cool room: 65°F (18°C)
- Dark, pitch black room (no blue LEDs)
- No blue light 2 hours before bed
- Avoid alcohol and caffeine at night
- Regular sleep schedule,

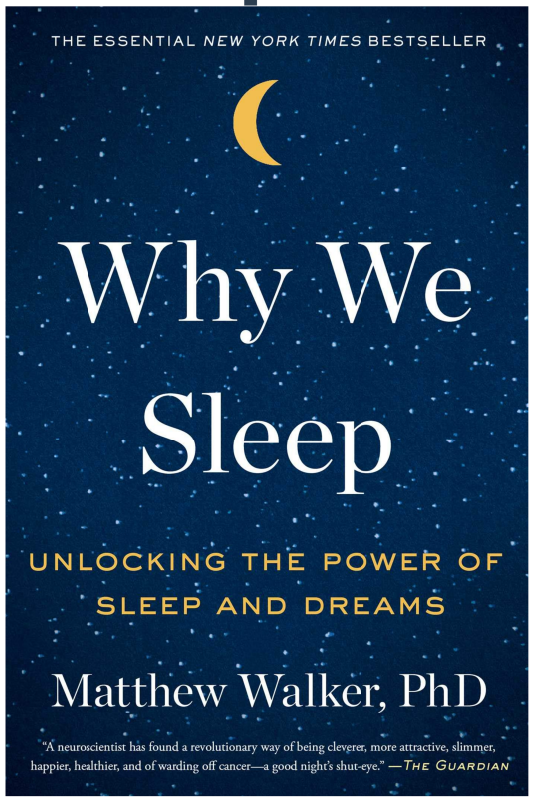
  even during weekends



Sleep Hygiene

- Don’t do late-night studying/grading
- Set a “done for the day” deadline (8:00pm?)
- Read up on Sleep Hygiene
- Take sleep seriously





Finding an advisor



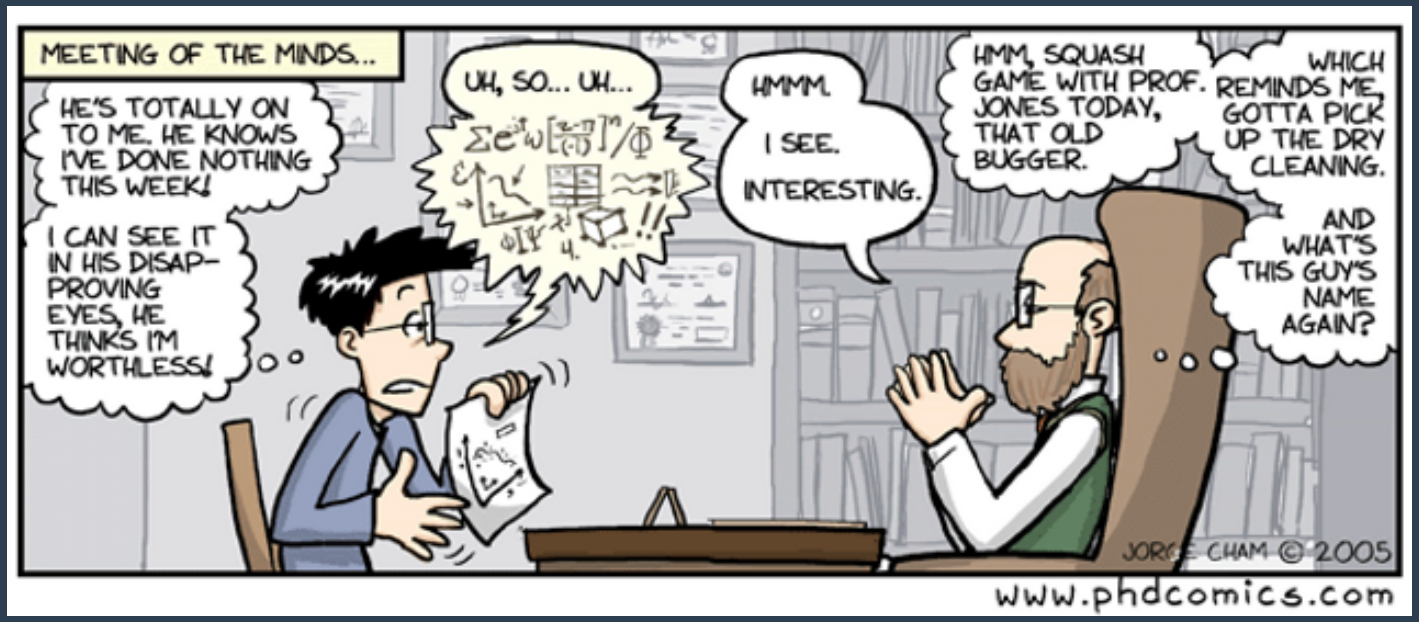
Finding an advisor

- Go to seminars!
- Do your homework on UCI's websites
- Don't be afraid to interview advisors early
- Considerations:
  - Are they accepting students? Ask them!
  - How have their previous students done?
  - Short-term and long-term support
- This is a mutual decision! It is OK to say no!
- You should be interested in the work

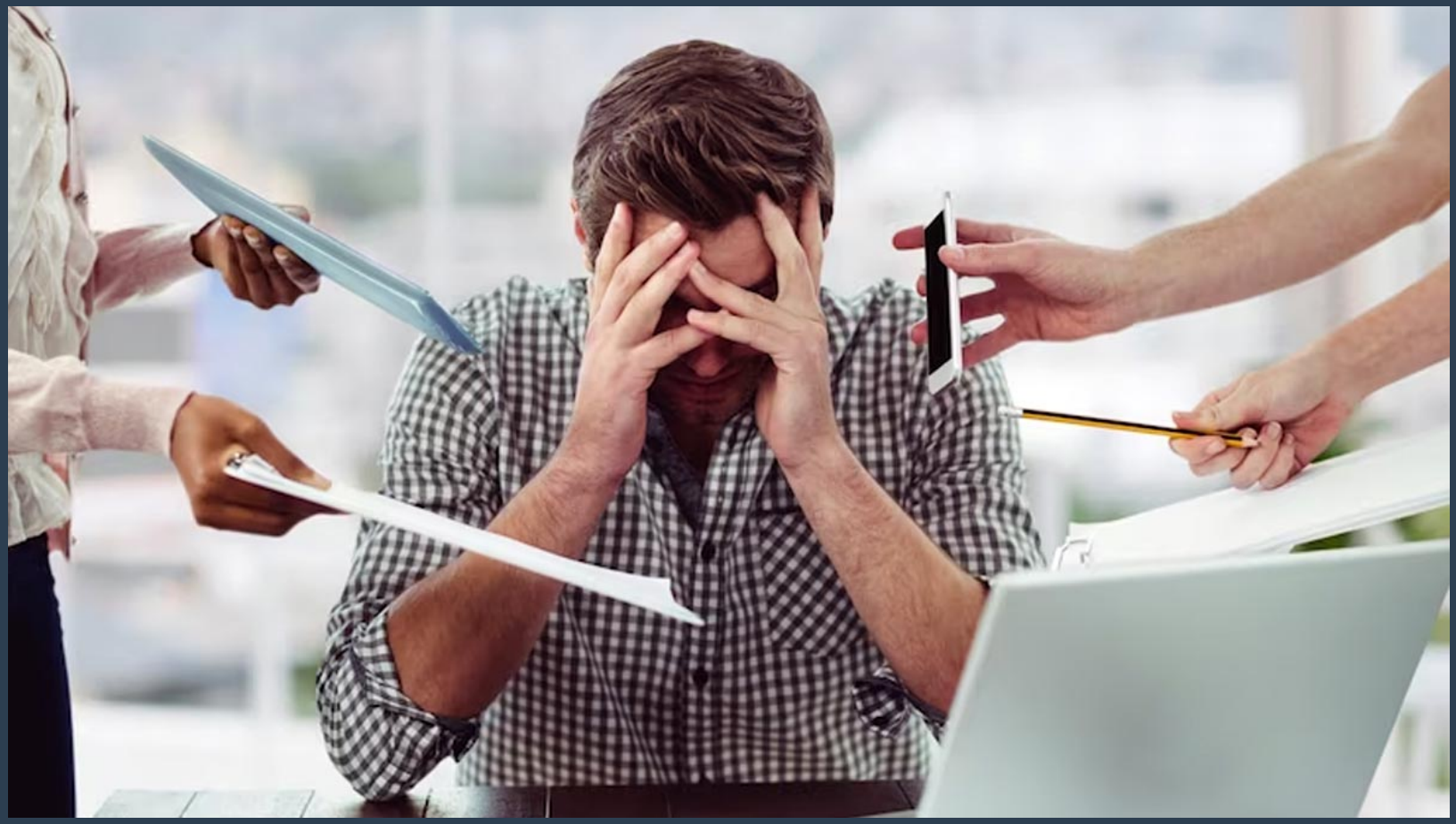
Working with an advisor

- **Meet often, and never cancel! (unless sick)**
- **Be available (don't disappear!)**
- **You don't have to make a break-though. Your job is to keep going.**
- **Getting stuck means you are making progress. Tell your advisor!**
- **"You were not working for me, I was working for you." -Prof. Edriss Titi**

You are stronger than you know



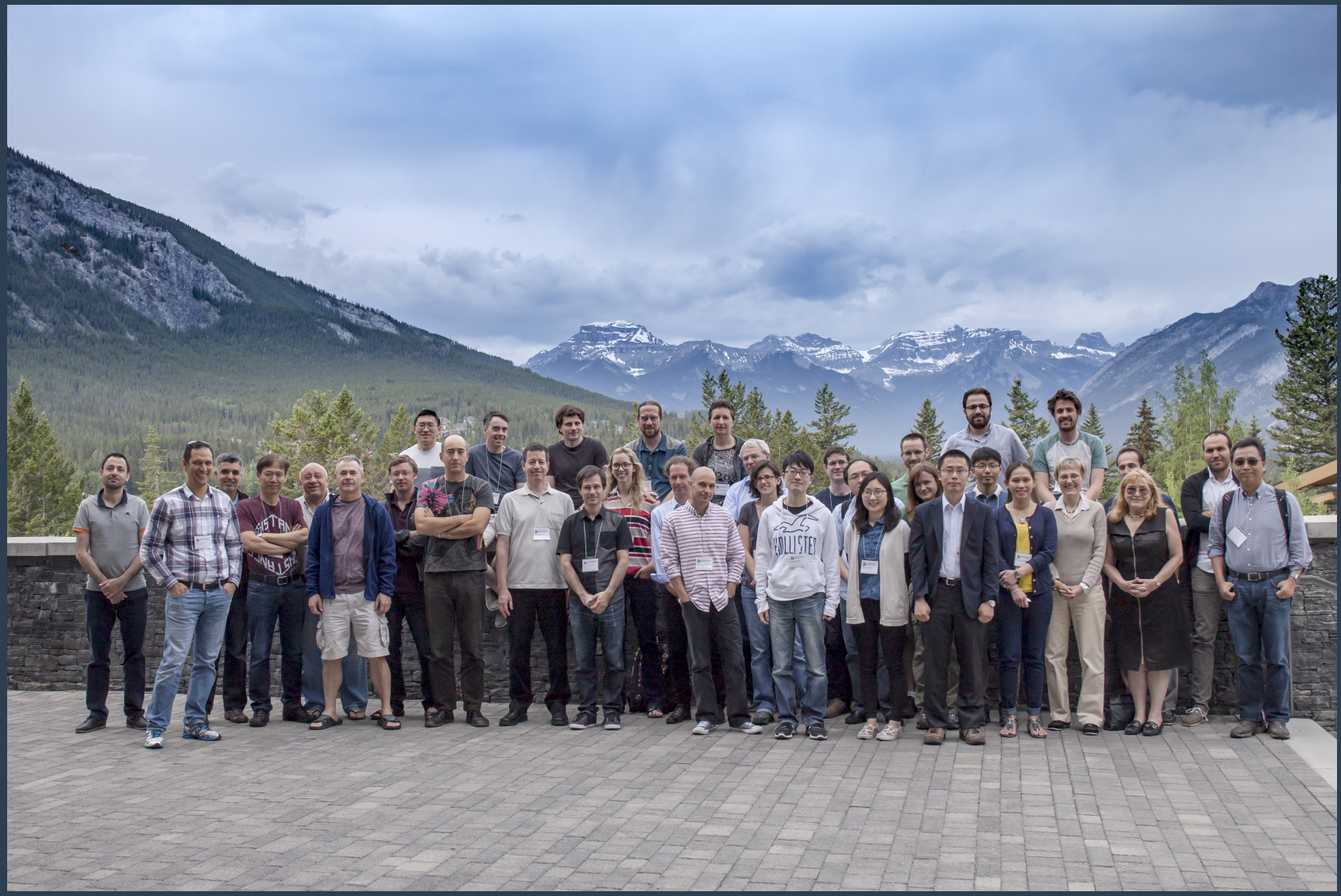
Research and Life



Embracing the struggle

- Learn to love your work
- Always carry some mathematics to read
- Seek out peers who love math
- Keep an “ideas notebook”
- Solve math problems regularly
- Read about mathematicians you admire
- Build mathematical a community for yourself

Conferences and Workshops



Conference Tips

- Go to conferences! Say yes!
- Give a talk (or poster) if possible (for the CV!)
- Ask for funding
- You are mostly there for the people
  (the math is secondary)
- Don’t isolate, join the crowd
- Ask advisor about conferences/workshops
- SIAM, AMS, MAA, AIM, ICIAM, ASME, IEEE, ASCB,…
- Smaller is (usually) better

Making Summer Count



Summer is for work!

- Go to conferences/workshops/internships
- Ask your advisor for summer funding
- Schedule research time
- Finish papers, projects, learn a new area, meet with collaborators
- Visit other universities to do research
- Teach a “CV-building” class
- Avoid going down “rabbit holes”

Programming and Computational Skills



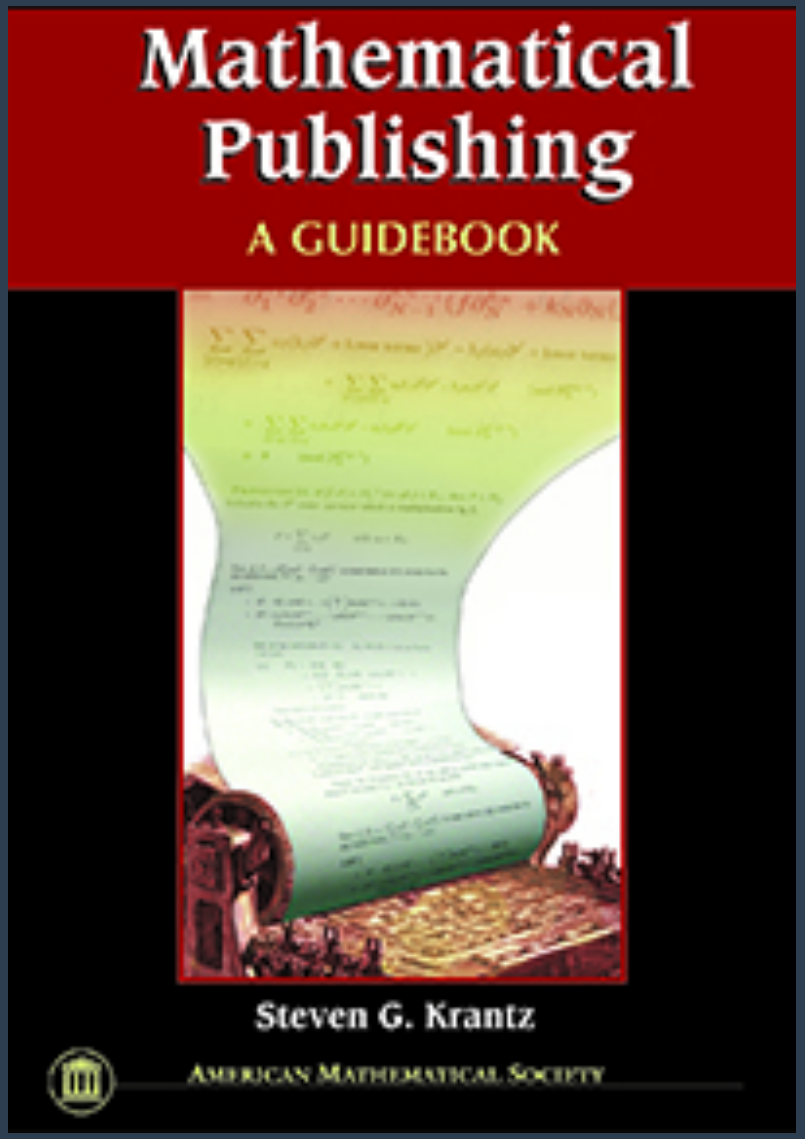
Why learn to program?

- Job Security
- Explore and generate new ideas
- The mathematics of programming is actually beautiful
- Great for undergrad projects
- Even if you don’t code, your co-authors may

Where to start?

- Avoid books (mostly)
- The language doesn’t matter very much…
- … but consider Matlab, Python, or Macaulay2
- Get a project (e.g., solve a differential equation, process some data, compute a Gröbner basis, etc.)
- Use Google, Stack Exchange
- Use AI only sparingly

Papers and Publishing



Tips for papers

- Write every day (schedule it)
- Study writing
- Practice your craft
- 100% avoid AI
- 40 pages = 2 papers?
- Ask your advisor to walk you through the process
- Pay attention to journals



Professional Development

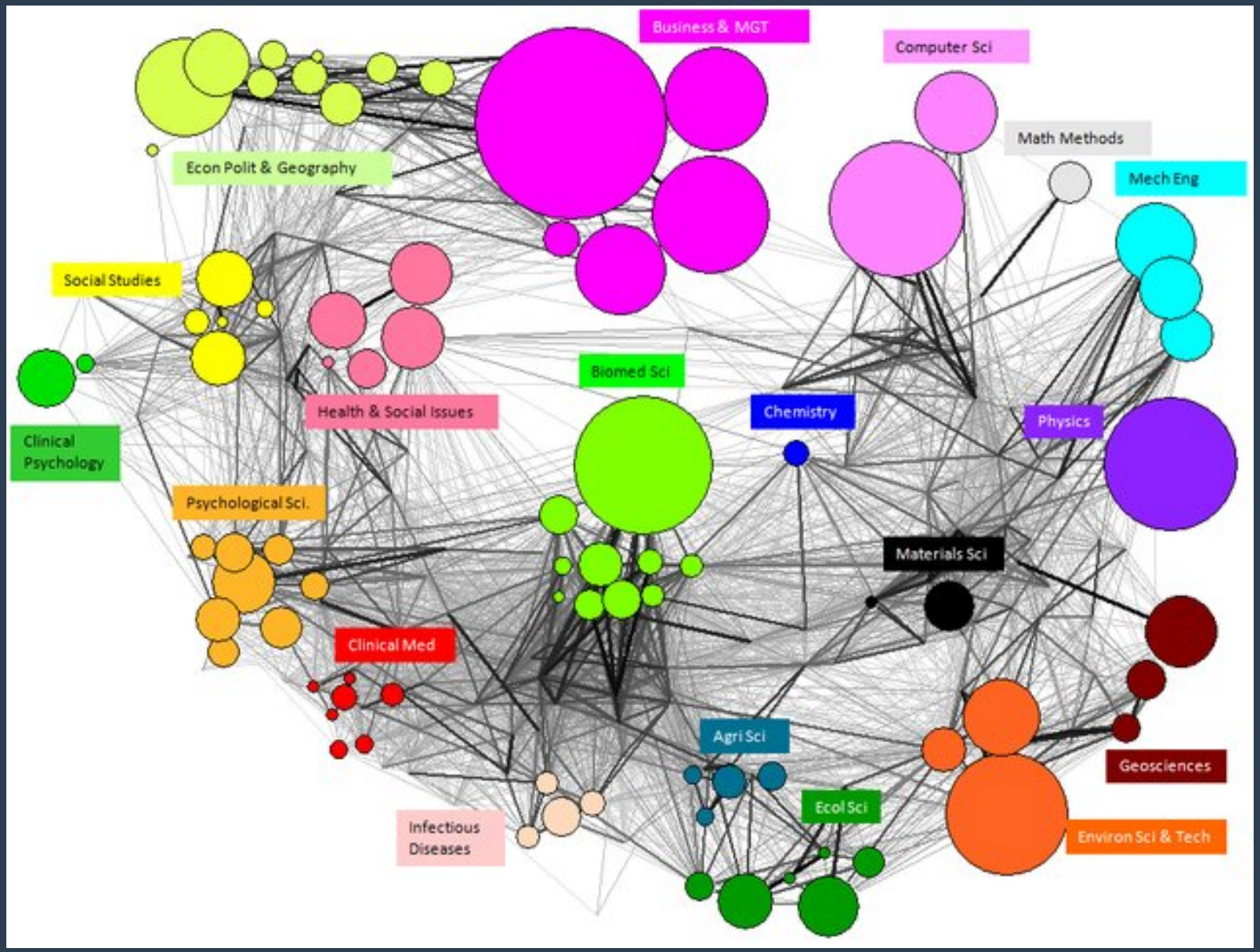


Tips for professional development

- Look for workshops at UCI
- Teach a course as “instructor of record” if possible
- Organize things (math grad talks, local conferences, writing group, etc.)
- Get involved
- Take a speech or drama class



Interdisciplinary Opportunities



Don’t wait for them to reach out

- Think broadly about how your research connects to other areas
- Go to seminars in other departments (if applicable)

Academic Job Materials



Letters of recommendation

- You have already started
- Be visible, talk to professors
- Outside letters can add strength
- Arm your letter writers with info!
- Ask early
- Send reminders

The CV

- Start now (to keep track of everything)
- Add every (academic) thing you can think of
- Seek out CV opportunities
- Ask to be nominated for awards
- Skills & techniques vs. listing courses

The Research Statement

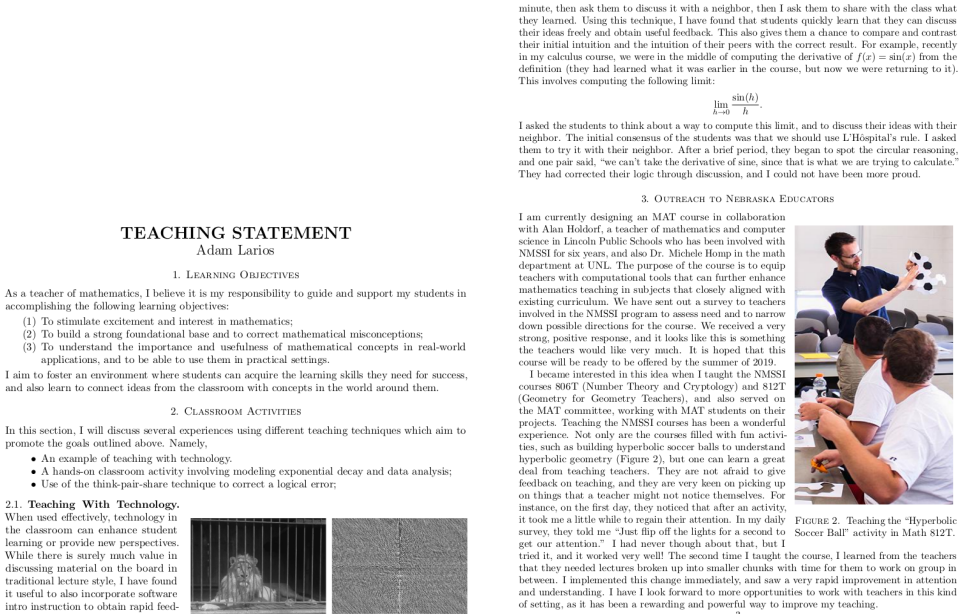
- **This is NOT a “report”**
- **You are trying to convince readers that you have a long-term, growing research program**
- **People *outside* your field will read this! Help them out! (Bad intro: “Let X be a Banach space…”)**
- **People *inside* your field might read this. Impress them!**
- **Don’t worry too much about page limits**
- **Focus on the future**

The Teaching Statement

- Learn about modern pedagogical techniques
- Don’t be boring!
  (“I teach my classes by preparing lessons and asking challenging questions…”)
- Describe actual examples of interaction with students
- What went wrong during teaching, and how did/would you fix it?
- What is it like to be in your class?

Example: My Teaching Statement

- 5 pages
- Teaching a grad course
- Teaching with technology
- Examples of hands-on projects



TEACHING STATEMENT
Adam Larios

1. Learning Objectives

As a teacher of mathematics, I believe it is my responsibility to guide and support my students in accomplishing the following learning objectives:

(1) To stimulate excitement and interest in mathematics;
(2) To build a strong foundational base and to correct mathematical misconceptions;
(3) To understand the importance and usefulness of mathematical concepts in real-world applications, and to be able to use them in practical settings.

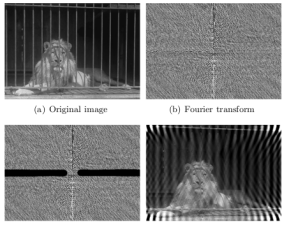
I aim to foster an environment where students can acquire the learning skills they need for success, and also learn to connect ideas from the classroom with concepts in the world around them.

2. Classroom Activities

In this section, I will discuss several experiences using different teaching techniques which aim to promote the goals outlined above. Namely,

- An example of teaching with technology.
- A hands-on classroom activity involving modeling exponential decay and data analysis;
- Use of the think-pair-share technique to correct a logical error;

2.1. **Teaching With Technology.** When used effectively, technology in the classroom can enhance student learning or provide new perspectives. While there is surely much value in discussing material on the board in traditional lecture style, I have found it useful to also incorporate software intro instruction to obtain rapid feedback from students, and also in exploring new ideas and concepts. For example, when learning about Fourier coefficients in a course like Math 447 (Numerical Analysis), students are often able to compute the coefficients by hand, but they have a hard time understanding what the coefficients mean. In order for the students to build an intuition about the concepts, I have them use free image manipulation software that can perform Fourier transforms. The guiding principal behind this exercise is to use Vygotsky's "zone of proximal development," namely, that students need to be given opportunities to stretch their minds with challenges that still lie within their grasp. First, we build their intuition with warm-up exercises, then a challenge is presented for them to solve on their own. The activity consists of transforming back and forth between Fourier space and image space, observing how changes in one space affects the other space. After warming up with 1D examples (Fourier transforms of audio data and data from



(a) Original image (b) Fourier transform
(c) Delete Fourier coeffcients (d) Inverse Fourier transform

Figure 1. Technology in the classroom: A lion is "freed" from its cage by image manipulation in Fourier space.

1

minute, then ask them to discuss it with a neighbor, then I ask them to share with the class what they learned. Using this technique, I have found that students quickly learn that they can discuss their ideas freely and obtain useful feedback. This also gives them a chance to compare and contrast their initial intuition and the intuition of their peers with the correct result. For example, recently in my calculus course, we were in the middle of computing the derivative of $f(x) = \sin(x)$ from the definition (they had learned what it was earlier in the course, but now we were returning to it). This involves computing the following limit:

$$\lim_{h \to 0} \frac{\sin(h)}{h}.$$

I asked the students to think about a way to compute this limit, and to discuss their ideas with their neighbor. The initial consensus of the students was that we should use L'Hôspital's rule. I asked them to try it with their neighbor. After a brief period, they began to spot the circular reasoning, and one pair said, "we can't take the derivative of sine, since that is what we are trying to calculate." They had corrected their logic through discussion, and I could not have been more proud.

3. Outreach to Nebraska Educators

I am currently designing an MAT course in collaboration with Alan Holdorf, a teacher of mathematics and computer science in Lincoln Public Schools who has been involved with NMSSI for six years, and also Dr. Michele Homp in the math department at UNL. The purpose of the course is to equip teachers with computational tools that can further enhance mathematics teaching in subjects that closely aligned with existing curriculum. We have sent out a survey to teachers involved in the NMSSI program to assess need and to narrow down possible directions for the course. We received a very strong, positive response, and it looks like this is something the teachers would like very much. It is hoped that this course will be ready to be offered by the summer of 2019.

I became interested in this idea when I taught the NMSSI courses 806T (Number Theory and Cryptology) and 812T (Geometry for Geometry Teachers), and also served on the MAT committee, working with MAT students on their projects. Teaching the NMSSI courses has been a wonderful experience. Not only are the courses filled with fun activities, such as building hyperbolic soccer balls to understand hyperbolic geometry (Figure 2), but one can learn a great deal from teaching teachers. They are not afraid to give feedback on teaching, and they are very keen on picking up on things that a teacher might not notice themselves. For instance, on the first day, they noticed that after an activity, it took me a little while to regain their attention. In my daily survey, they told me "Just flip off the lights for a second to get our attention." I had never though about that, but I tried it, and it worked very well! The second time I taught the course, I learned from the teachers that they needed lectures broken up into smaller chunks with time for them to work on group in between. I implemented this change immediately, and saw a very rapid improvement in attention and understanding. I have I look forward to more opportunities to work with teachers in this kind of setting, as it has been a rewarding and powerful way to improve my teaching.

Figure 2. Teaching the "Hyperbolic Soccer Ball" activity in Math 812T.

3

The Diversity Statement

- Tell your story, overcoming obstacles, etc.
- Focus on: race, gender, social class, sexual orientation (i.e., common definitions)
- Avoid false parallels
- What have you done to help those from underrepresented backgrounds?
- Discuss your commitment to DEI issues
- Do your homework

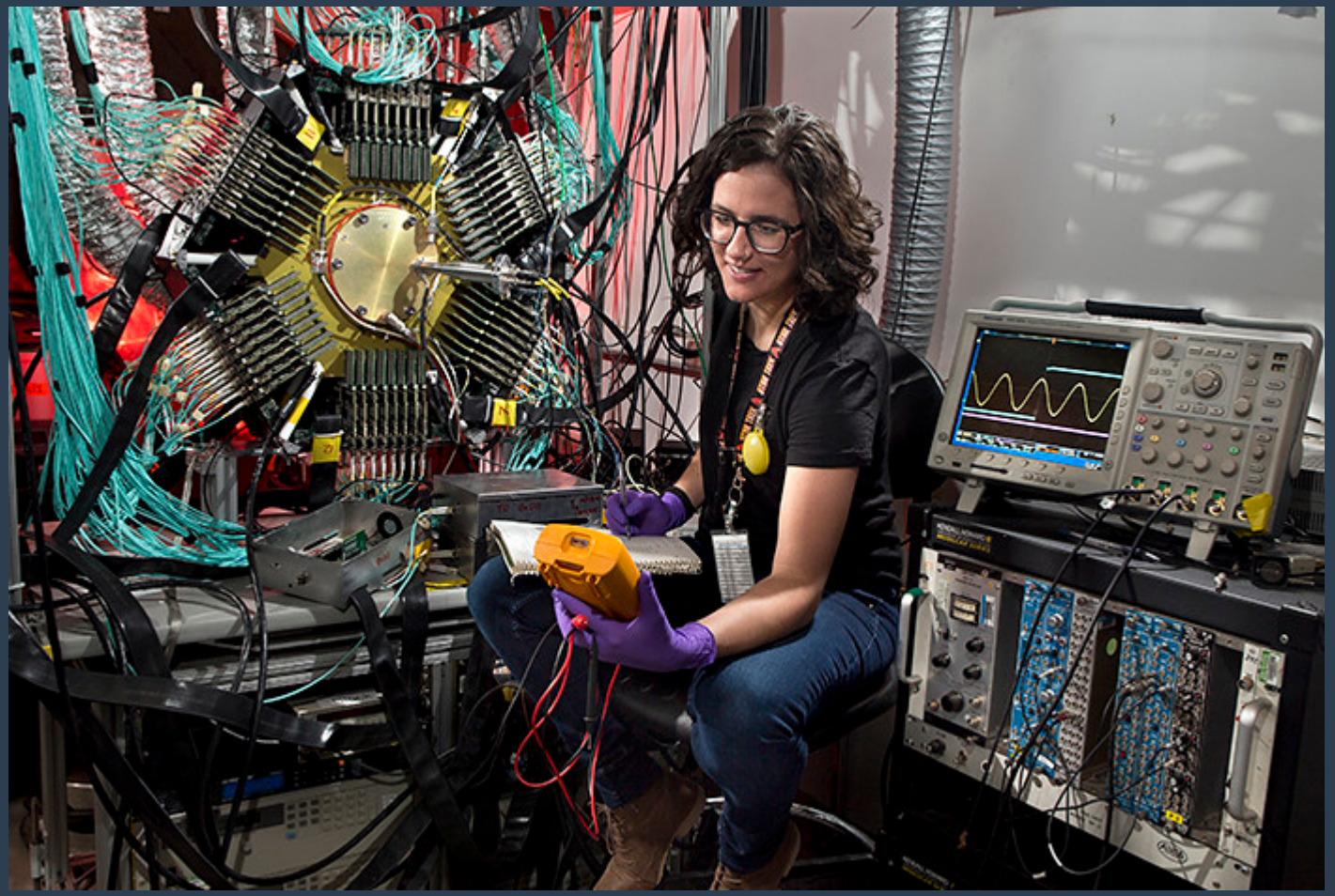
Industry Positions



Tips on Industry positions

- Document your code in a “coding portfolio” (e.g., github.org)
- Do a summer internship if possible
- Attend industry conferences, workshops, and seminars, job fairs, etc.
- Learn/understand business!
- Short resume vs. long CV
- Consider Postdocs or Further Training in Applied Areas

Laboratory Positions



National Labs

Office of Science Laboratories

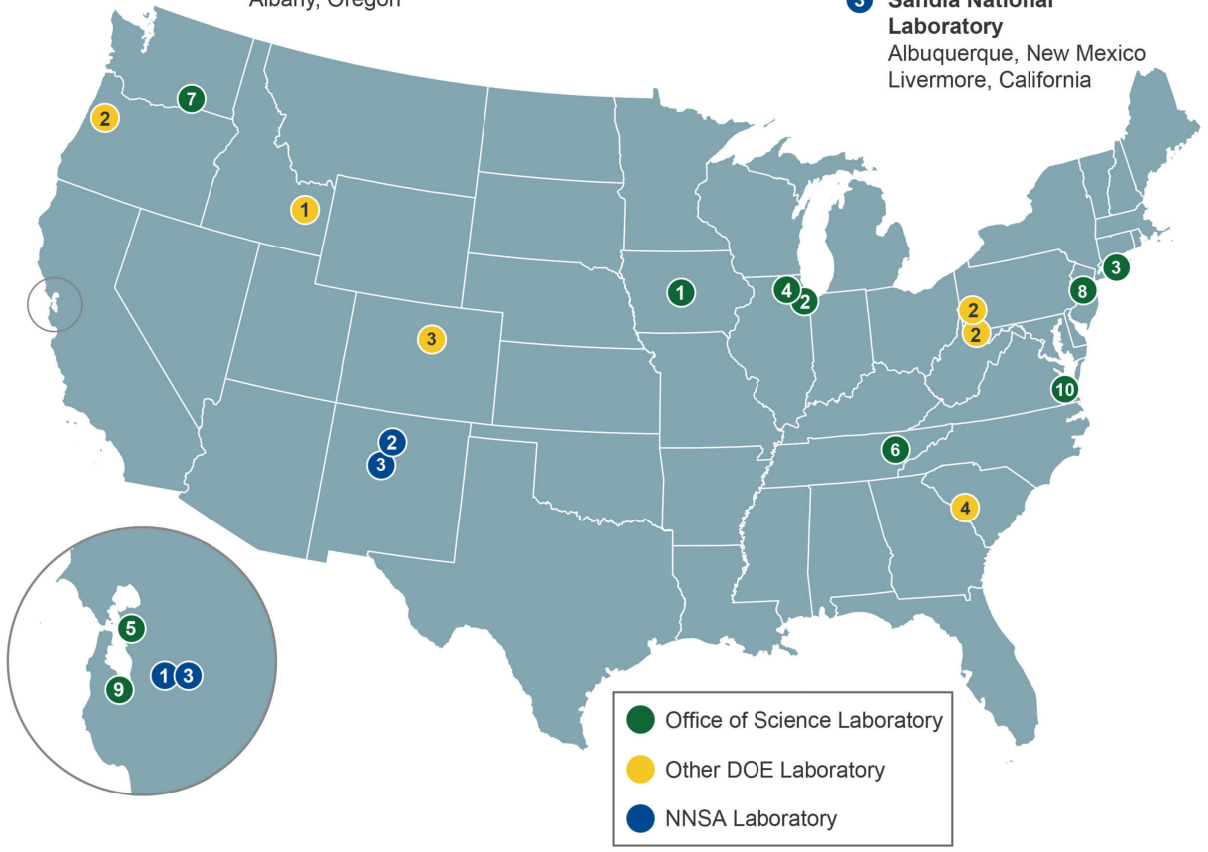
1. **Ames Laboratory**
   Ames, Iowa
2. **Argonne National Laboratory**
   Argonne, Illinois
3. **Brookhaven National Laboratory**
   Upton, New York
4. **Fermi National Accelerator Laboratory**
   Batavia, Illinois
5. **Lawrence Berkeley National Laboratory**
   Berkeley, California
6. **Oak Ridge National Laboratory**
   Oak Ridge, Tennessee
7. **Pacific Northwest National Laboratory**
   Richland, Washington
8. **Princeton Plasma Physics Laboratory**
   Princeton, New Jersey
9. **SLAC National Accelerator Laboratory**
   Menlo Park, California
10. **Thomas Jefferson National Accelerator Facility**
    Newport News, Virginia

Other DOE Laboratories

1. **Idaho National Laboratory**
   Idaho Falls, Idaho
2. **National Energy Technology Laboratory**
   Morgantown, West Virginia
   Pittsburgh, Pennsylvania
   Albany, Oregon
3. **National Renewable Energy Laboratory**
   Golden, Colorado
4. **Savannah River National Laboratory**
   Aiken, South Carolina

NNSA Laboratories

1. **Lawrence Livermore National Laboratory**
   Livermore, California
2. **Los Alamos National Laboratory**
   Los Alamos, New Mexico
3. **Sandia National Laboratory**
   Albuquerque, New Mexico
   Livermore, California



National Labs: Job Postings

https://nationallabs.org/work-here/care



National Labs: Where to start?

- Talk to collaborators for connections
- Apply for summer internships: https://www.energy.gov/jobs-national-labs
- Cold e-mail (?)
  - Make it very brief (2-3 sentences)
  - State your reasons clearly
  - Include your materials (CV, research statement)

Job Interviews

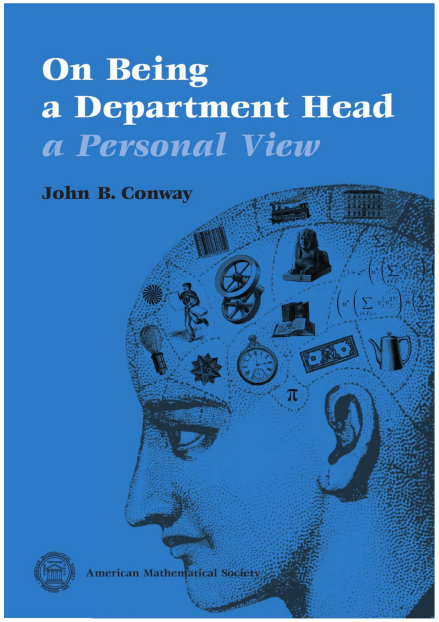


Job Interview Tips: I

- Dress the best
- Do your homework on the institution
  - What programs are they focused on?
  - What are they proud of?
  - What is the town or city like?
  - Who works there, and what do they do?
- Show enthusiasm and engage in discussions
- Always have a question ready…

Job Interview Tips: II

- Always have a question ready:
  - What is the tenure/career path?
  - What is daily life like?
  - Are there opportunities for interdisciplinary collaboration?
  - What tools are available to you?
  - How are important decisions made?
  - What are some good tips for advancement?
  - What are early/mid career expectations?
  - What are the department's goals for the next 5-10 years?
  - What would they change in the department?



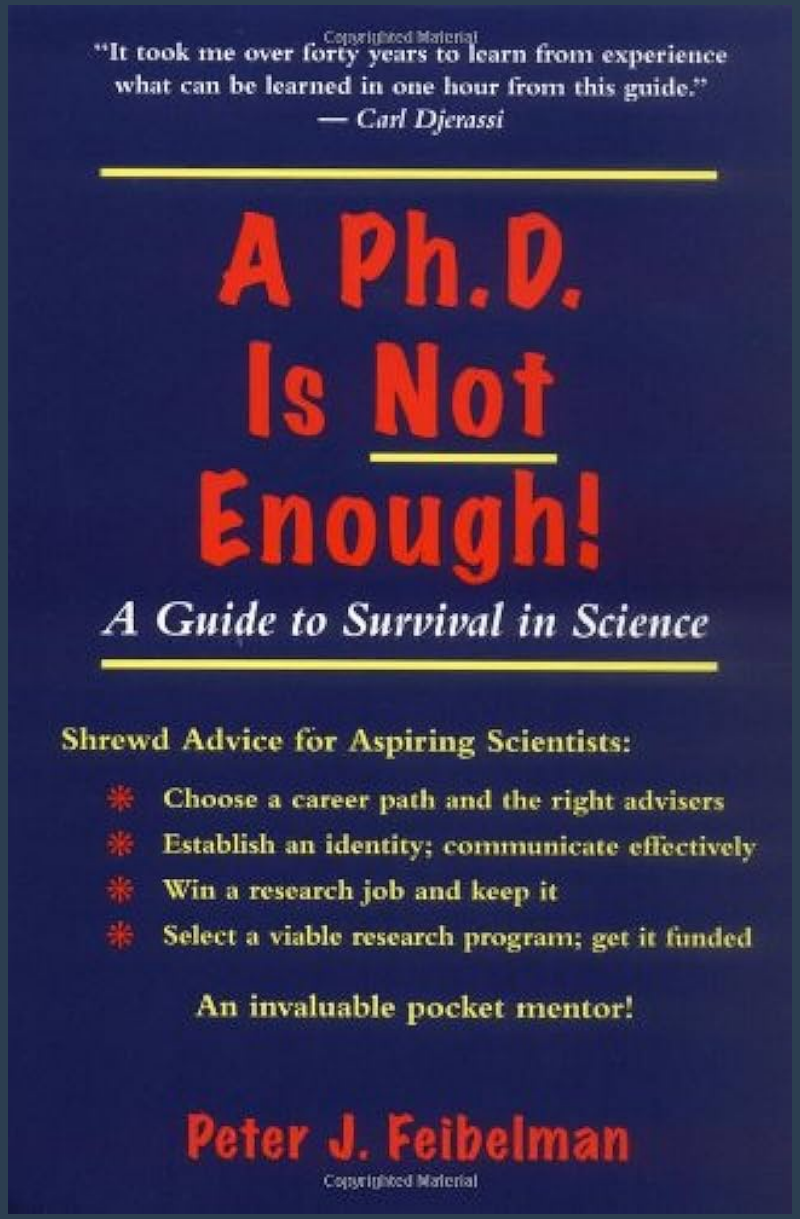
Job Interview Tips: III

- **Avoid asking:**
  - About a spousal hire
  (ask *after* you get the offer)
  - Questions that put the institute in a bad light
  - Questions that show you haven't done your homework

Job Interview Tips: IV

- After the interview, send a thank you
- Do some research on “how to negotiate an academic job offer”
- Ask you advisor for advice!

Post-PhD Planning



Post-PhD Tips

- You (almost surely) need to do a postdoc, but…
- Postdoc positions aren’t that bad!
- Apply for the NSF Postdoc if possible
- Apply *everywhere* (I applied to 160 positions)
- Get involved with writing grants
- Take grant-writing workshops
- Build your research program

This is your journey! Make it count!

