Learning habits, anti-herding behaviours, and going beyond the null hypothesis

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"Science is built of facts the way a house is built of bricks; but an accumulation of facts is no more a science than a pile of bricks is a house."
Henri Poincaré

1) Know the 3 big Q's in life & research

1. What is the problem?
2. What are you doing about it?
3. Why should I care?

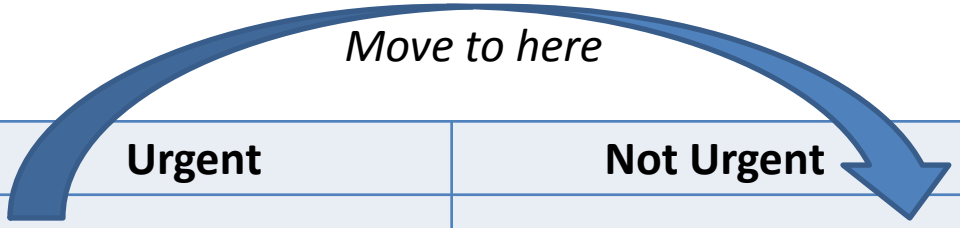
Be sure you know these inside & out!

Be able to explain this on an elevator (30 s), in the hallway (2 min), at a conference (15 min), or over a seminar (45 min)

2) Work hard!

1. Graduate school is **not a 9 to 5 job**, it should be your passion!
2. Have daily, weekly, monthly, semester & graduate career **goals** (write these down!)
3. **Deliver** on these goals. For some this may mean working 60-70 hrs/wk, for others it may only require 50 hrs/wk.

3) Manage your time



	Urgent	Not Urgent
Important	crises, pressing problems, deadline-driven projects	**prevention, recognizing new opportunities, planning**
Not important	interruptions, some calls, some mail, some reports, some meetings, popular activities	trivia, busy work, some mail, some phone calls, time wasters, pleasant activities

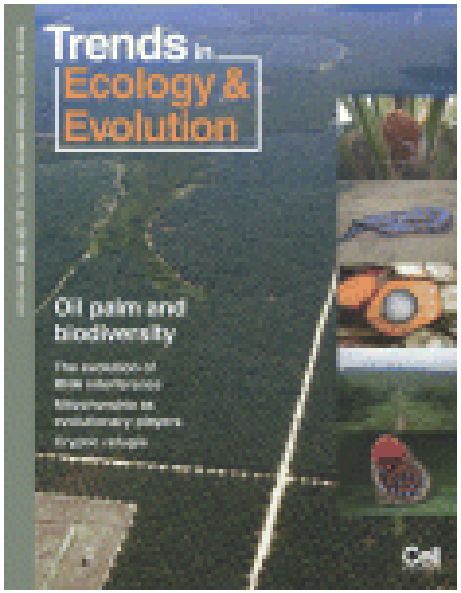
Get rid of these

Stephen R. Covey (1989) 7 Habits of Highly Effective People.

4) Read widely

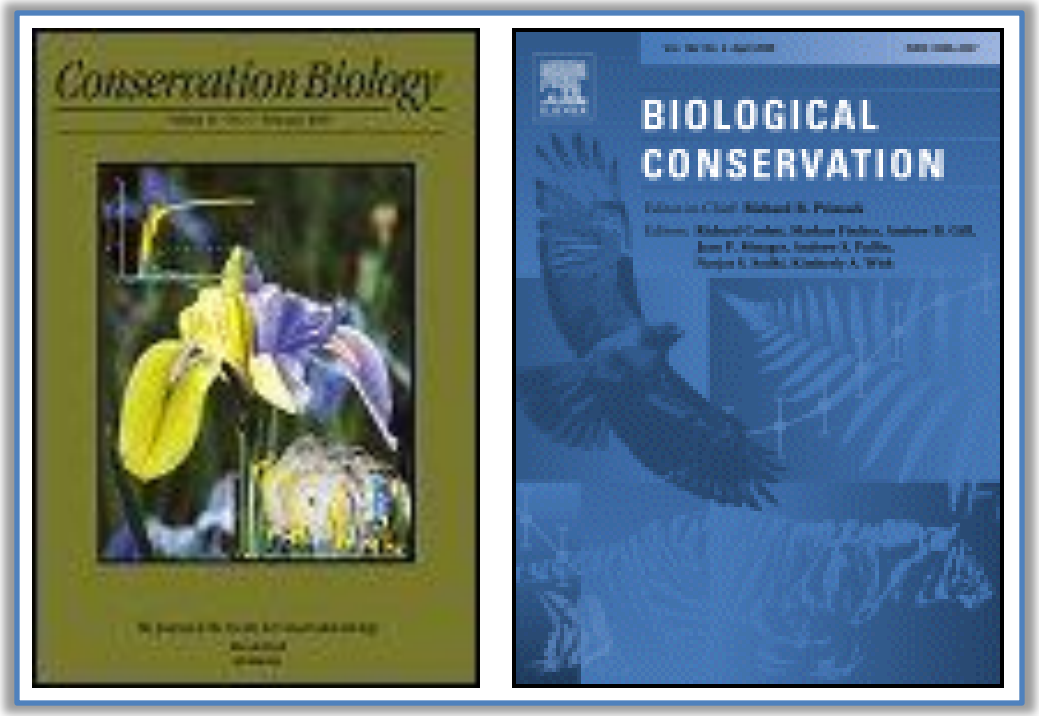
Your primary responsibility in the first year of grad school is to train yourself to absorb the literature

- Be aware of *all current literature* in your field & the emerging sciences in general
- Know the important stuff from the past 30 years (Yes, that is a 3 and a 0)
- If you have deficiencies, ID these & work to overcome them (don't skip this step!)



The current literature

This is where the big (novel) ideas & emerging trends first get published!



Conservation Journals

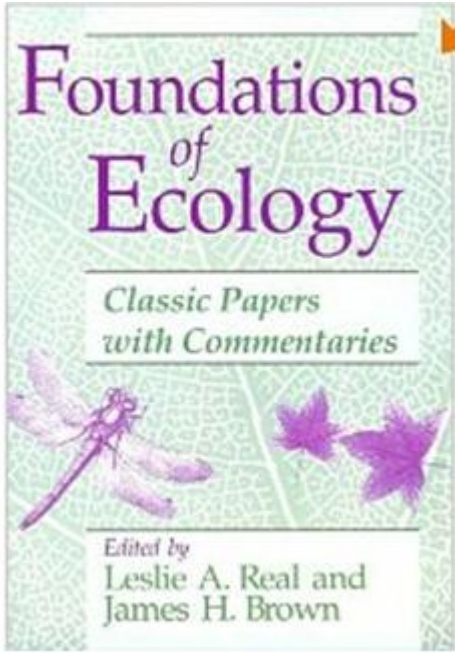
Top row:
Conservation Biology research

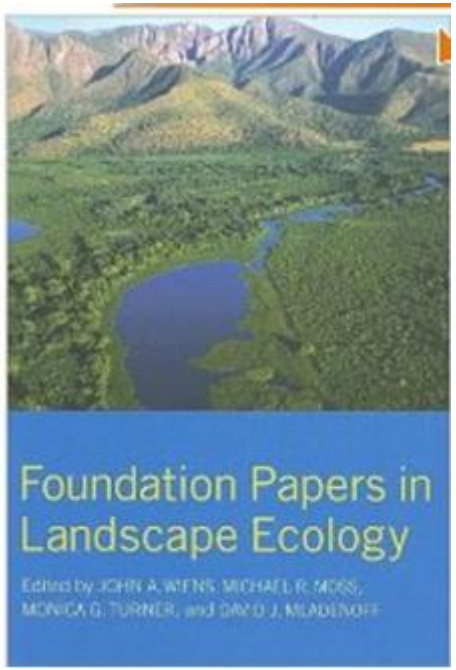
Bottom row:
New direction & novel ideas in ecology & conservation

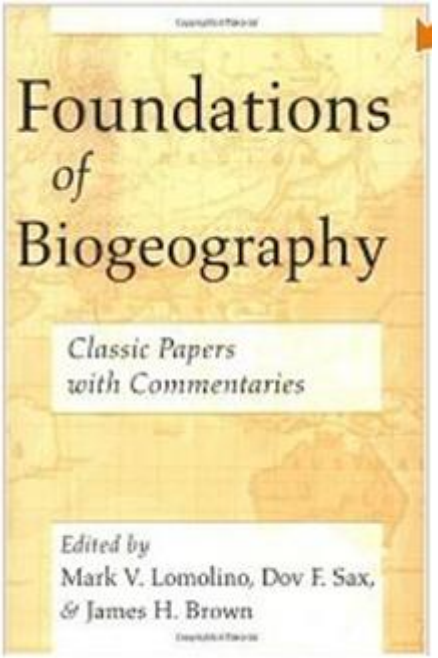
Important stuff from the past...

Use synthesis pieces on key papers compiled by the experts in the field. These are often titled, "*Foundations of*..." or "*Foundation Papers in*..."

Examples for topics that I'm interested in:







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1. Title: Biodiversity hotspots for conservation priorities
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2. Title: Human domination of Earth's ecosystems
Author(s): Vitousek PM, Mooney HA, Lubchenco J, et al.
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5) Question everything!

Winners curse: Science looks for true relationships, but there is uncertainty. Published articles, especially in very competitive journals, have on average exaggerated results.

Be aware of **negative publication bias**

Young *et al*. (2008) PLoS

6) Avoid herding behaviours

Herding: Don't uncritically follow paths of investigation that are popularised, neglecting novel ideas & truly independent investigative paths.

Information cascades: when individuals regard others' earlier actions as more informative than their own information. This encourages conventional behaviours & development of bubble & bust cycles.

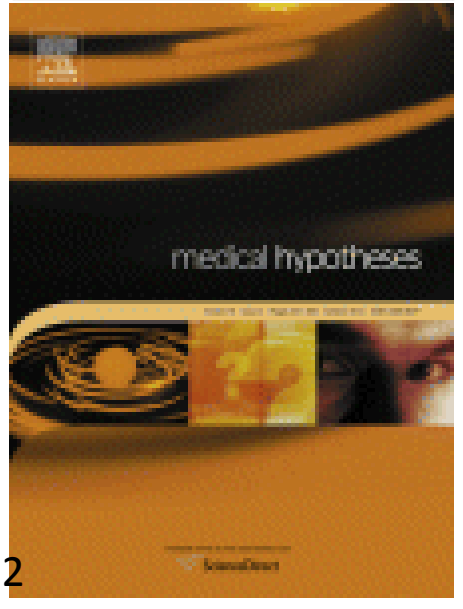
Young *et al*. (2008) PLoS

7) Focus on the idea

Remember that the question or idea (hypothesis) is the most important part of science!

Horrobin's hypothesis

"The history of science has repeatedly shown that when hypotheses are proposed it is impossible to predict which will turn out to be revolutionary and which ridiculous. The only safe approach is to let all see the light and to let all be discussed, experimented upon, vindicated or destroyed." David Horrobin (1975)

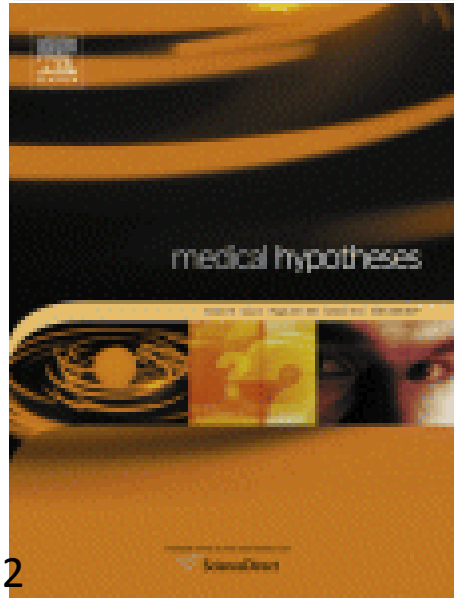


Published online 18 March 2010 | Nature | doi:10.1038/news.2010.132

7) Focus on the idea

Bruce Charlton
Editor, Medical Hypotheses

"Elsevier plan is to continue a zombie *Medical Hypotheses* — i.e. still moving around, but dead inside...I have requested that they do the honest thing and kill the journal outright. I would rather *Medical Hypotheses* existed in its pure form for 35 years than that it has a dwindling and corrupt afterlife.“
Bruce Charlton (2010)



Published online 18 March 2010 | Nature | doi:10.1038/news.2010.132

8) Go beyond the null hypothesis

Use multiple working hypotheses

Traditional approach:

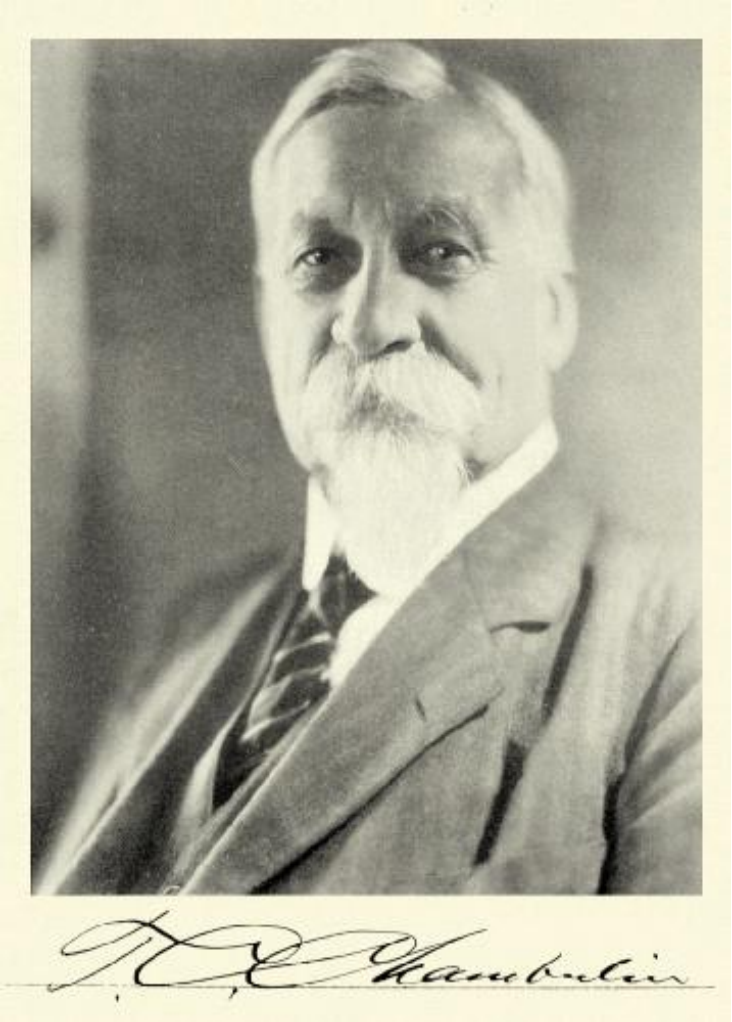
H_0: $\mu_1 = \mu_2$

μ_1 = mean of population 1

μ_2 = mean of population 2

Problems:

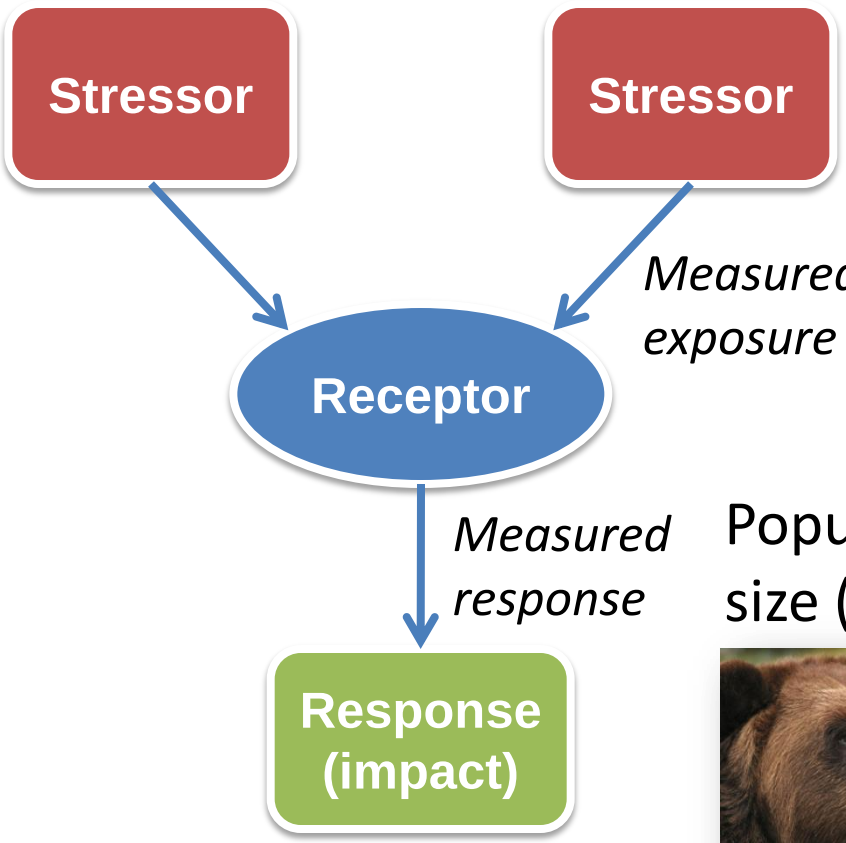
- Often simplistic tests (straw men)
- When testing a dominant idea (Ruling Theory), you can become attached to it.
- MWH distributes the effort, divides the affections (reduces ownership over ideas) & objectively evaluates level of support for ideas

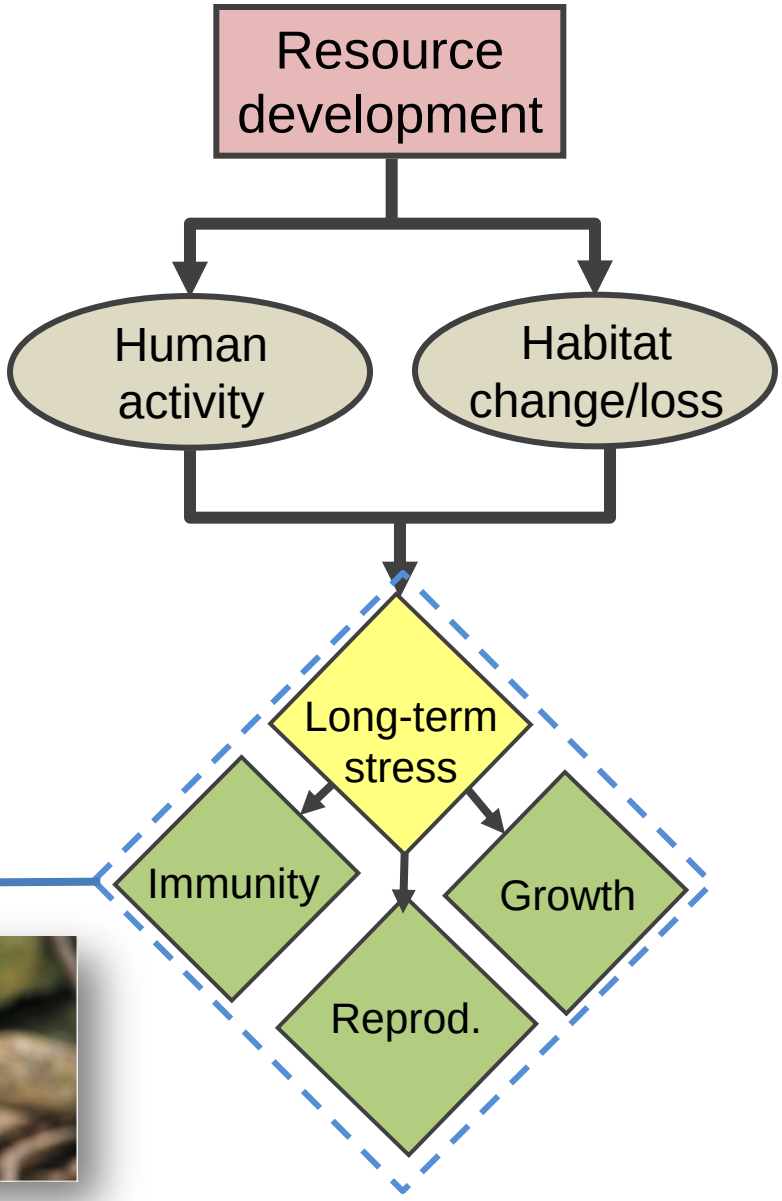


Chamberlin (1890) Science

8) Go beyond the null hypothesis

Use conceptual models & systems thinking to frame your working hypotheses





Population size (*N*)

9) Become problem-orientated

Become problem-orientated, not method-orientated!

"Beware of the man of one method or one instrument, either experimental or theoretical. He tends to become method-oriented rather than problem-orientated." Be willing to consider new methods depending on the problem."

Platt (1964)

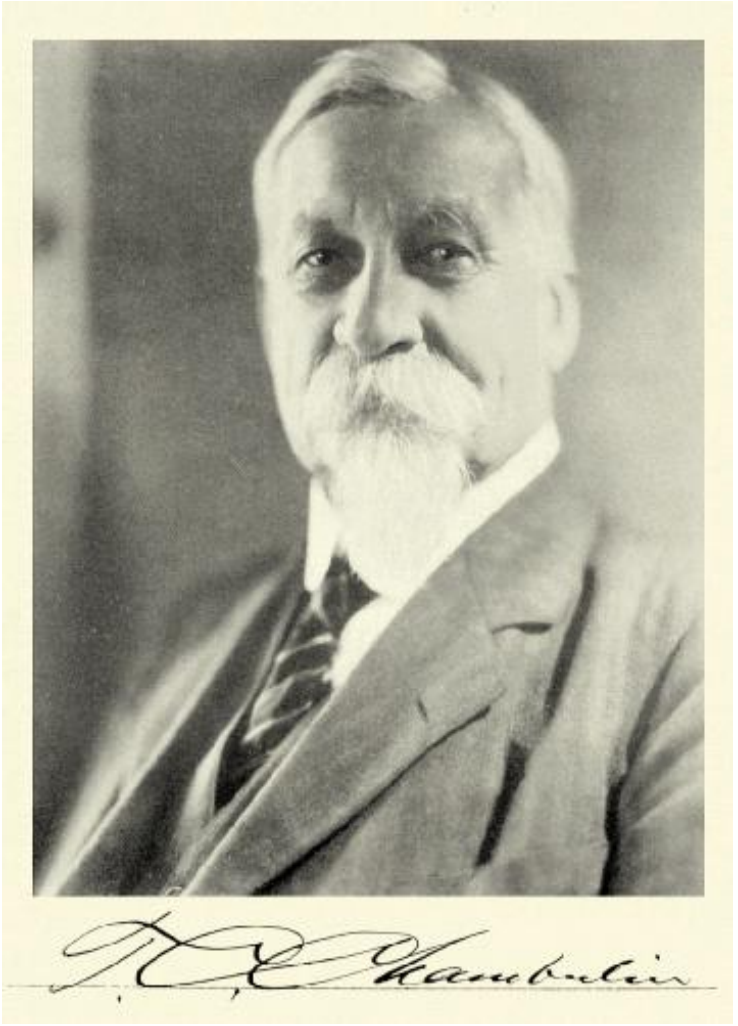
16 October 1964, Volume 146, Number 3642

SCIENCE

Strong Inference

Certain systematic methods of scientific thinking may produce much more rapid progress than others.

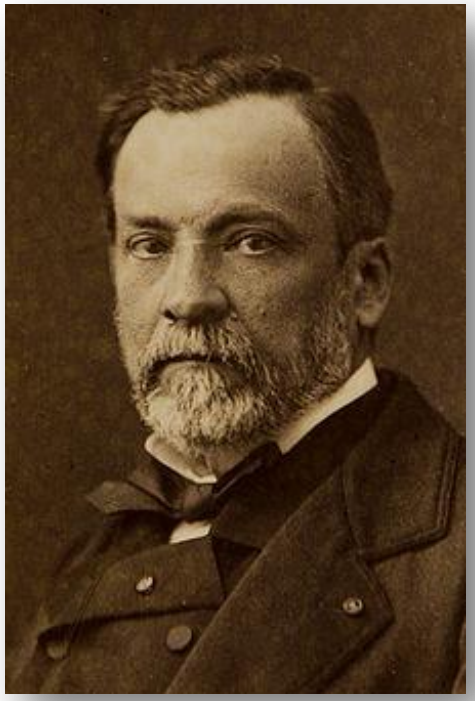
John R. Platt



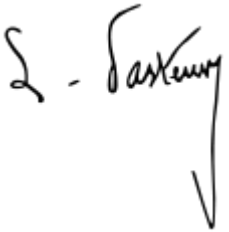
Chamberlin (1890) Science

The ultimate problem-solver...

- Every 2-3 yrs Louis Pasteur moved from one problem to another
  - ✓ *fermentation of beet sugar*
  - ✓ *diseases of silkworms*
  - ✓ *"spontaneous generation"*
  - ✓ *anthrax disease of sheep*
- In each field there were experts in Europe who knew a 100X as much as Pasteur, yet he solved problems in a few months that they had not been able to solve in yrs.
- How did he do it?



Louis Pasteur
(1822–1895)



Platt (1964)

10) Critically think on a daily basis

Devote ½ to 1 hr per day to *critically thinking:*

- hypotheses/alternatives
- logic trees
- conceptual models
- experiments

11) Use a Fermi notebook

Keep a notebook to record:

1. Research goals, questions & hypotheses
2. Daily progress (critical thinking)
3. Results & next experiments

Enrico Fermi
(1901–1954)

16 October 1964, Volume 146, Number 3642 SCIENCE

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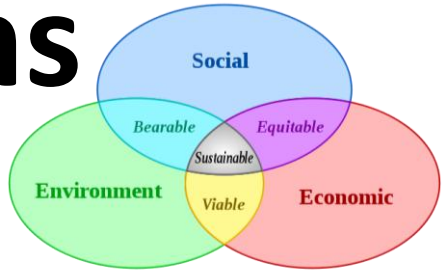
John R. Platt

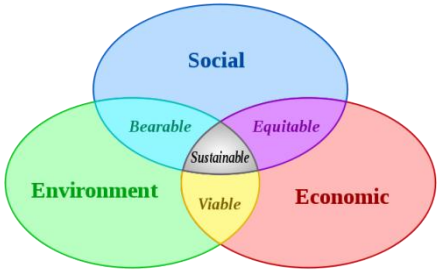
12) Recognize limitations in research



- More rigorous science is needed, but it is not the panacea for controversial natural problems
- Enhance your skills in consensus-building & communication
- Read broadly & take non-traditional courses (understand the problem from different perspectives)

Kroll (2007) JWM

"We can't solve problems by using the same kind of thinking we used when we created them." *Albert Einstein*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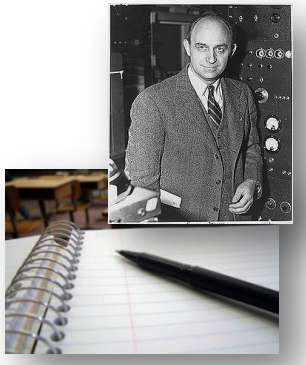
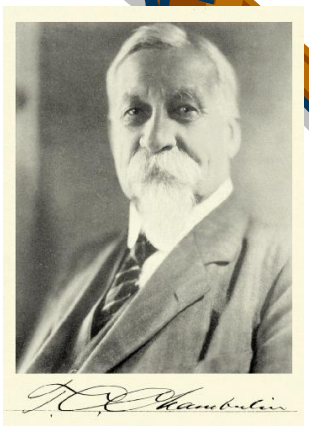


A review



The 3 questions in action...

http://www.youtube.com/watch?v=7SfRgg9botI