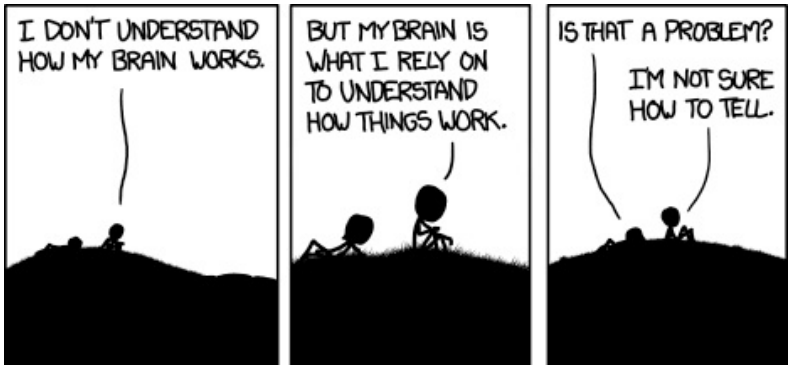
January 23, 2013 Physics 132 Prof. E. F. Redish

- **Theme Music:** **Norah Jones**
  Here we go again
  with Willy Nelson and Wynton Marsalis
- **Cartoon:** **Randall Munroe**
  xkcd



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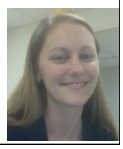
What's different about this class?

- PHYS 131/132 is a designed to respond to calls from biology researchers and medical schools to produce students better prepared both for a research career and for the health care professions in the coming decades.
- Both the content and the pedagogy (teaching methods) of this class have been modified to meet these goals.
- The class is part of a research and development project funded by HHMI and the NSF.



1/23/13 Physics 132

Key differences

- Interdisciplinary
  - Content changed to focus on issues that overlap biology and chemistry
    - Atomic and molecular binding and reactions
    - Random (thermal) motion and its import
- Competency building – Learning to think scientifically
  - Principle based reasoning
  - Scientific modeling
  - Sense making and building coherence

Changing the way you think isn't easy: Modern understanding of brain function

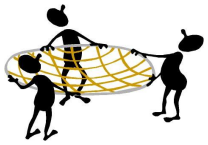
- The mind works on two levels: unconscious and conscious.
- Memory is not veridical (like a recording) but are reconstructive (built out of partial recall plus standard "plausible" pieces).
- Expert knowledge sometimes looks like direct recall, because it happens fast and has become almost automatic, but it is based on complex and well organized knowledge.

Learning to think scientifically

- Sometimes you're fighting your own brain!
  - We often assume an immediate recall ("one-step thinking") is right – and the quicker and easier the recall the more we trust it!
  - We often don't pay attention to the right things!
  - We often assume our intuition is correct but don't check that it makes sense with what we see (or with other things we know)!

Reasoning from principle / Building a web of knowledge

- How do we build a reliable web of knowledge (safety net)?



  - Stakes in the ground! Things we can count on in a wide variety of circumstances (but we need to know the limitations of those circumstances) I call these *foothold ideas*.

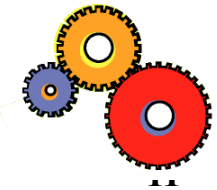
  - Finding different ways to look at the same thing to check for consistency.

Scientific modeling

- How do we model the system we are considering? (System schema)
  - What do we want to consider and what to ignore?
  - What are the parts? interactions and relationships?
  - What are its constraints?
  - When does it work? And when does it fail?
- Having a mental picture: Telling the story of "what happens"
  - Being able to describe the chain of events – and understand why they occur.

Epistemology – How do we know?

- Distinguishing claims from evidence
  - Claim
  - Data (evidence for the claim)
  - Warrant (reason that the evidence supports the claim)
- Understanding what a particular result, observation, or assumption tells you – and what it does not tell you!
- Playing the implications game – "suspension of disbelief".



How the content of 131 changed

- ***What's in***
  - Newton's Laws
  - Energy
  - Electric forces & energy
  - Fluids
  - Molecular models
  - Random motion
    - Diffusion (Fick's law)
    - Kinetic theory
    - Second law of thermo
- ***What's out***
  - Projectile motion
  - Circular motion
  - Universal gravitation
  - Torque and statics
  - Momentum
  - Collisions

Science as discourse

- Science is much more than just a collection of facts and procedures. **Science is a way of holding a conversation to decide to agree that we know something.**
- The best (and most professional) way to learn science is to discuss it with someone who knows about as much as you do – but not exactly the same things.
- In solving hard problems in science, most students run into trouble not because they don't know what they need to know, but because they don't know how to ask the questions that will help them find that knowledge – either in their own heads or from elsewhere.