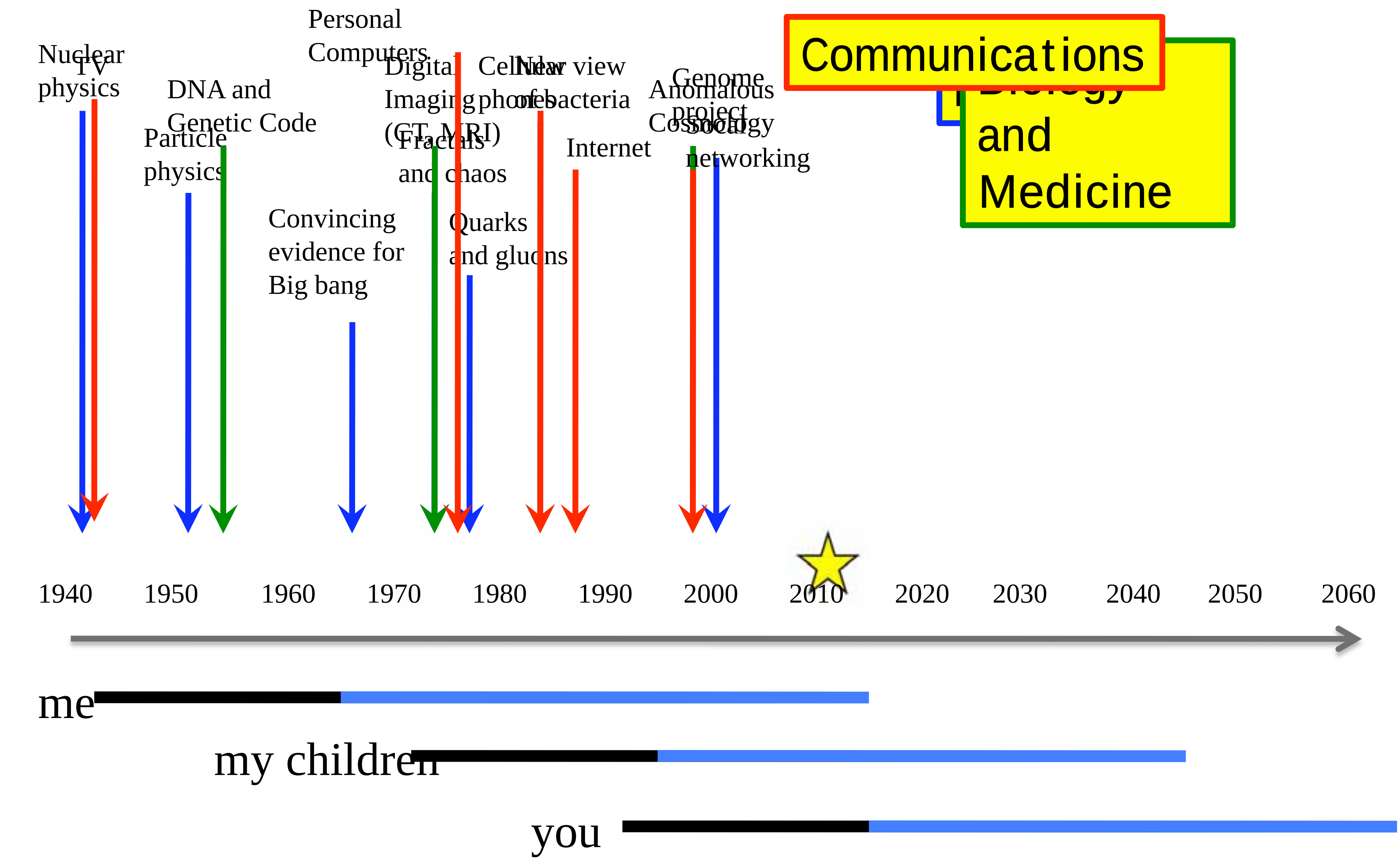
January 26, 2011 Physics 122 Prof. E. F. Redish

- **<u>Theme Music:</u> Sarah Brightman**
  Memory
- **<u>Cartoon:</u> Jef Mallet**
  Frazz

Motivation

- Much of what we learn in school is a result of historical accident.
- But your education is not just for the purpose of getting you the certificate that lets you move on to the next stage.
- It should prepare you to be ready to respond to the future – not live in the past.

Time Line



Nuclear physics
TV
DNA and Genetic Code
Particle physics
Personal Computers
Convincing evidence for Big bang
Digital Imaging (CT, MRI)
Fractals and chaos
Quarks and gluons
New view of bacteria
Internet
Genome project
Anomalous Cosmology
Social networking
Communications
and
Medicine
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
me
my children
you

The changing work force

- Think about how the character of the American workforce has changed in the past 100 years.
  - 1900: Dominated by agriculture
  - 1950: Dominated by manufacturing
  - 2000: Dominated by computers/software
  - 2050: ?

Adaptive expertise

- The rapid pace of change in science implies that critical skills for scientists (and health-care professionals) in the next few decades will be
  - the ability to continue to learn
  - the ability to understand the implications of new discoveries
  - the ability to integrate new tools and knowledge into their practice of science.


THE PROBLEM WITH THE FUTURE IS THAT IT KEEPS TURNING INTO THE PRESENT.

In order to learn
how to learn more effectively,
we need to know something
about how we think.

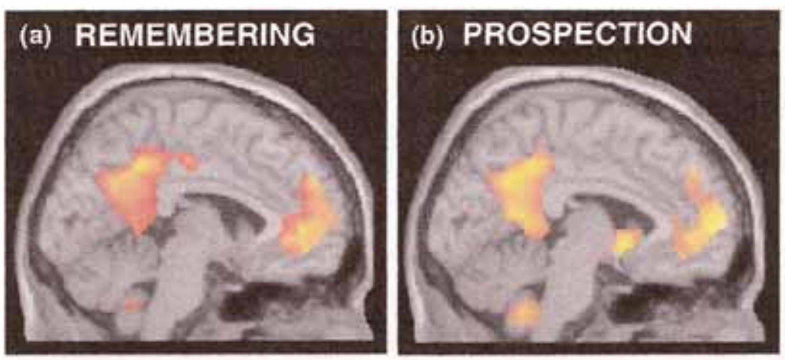
A model of memory: Predicting the Past

(a) Recalling past events

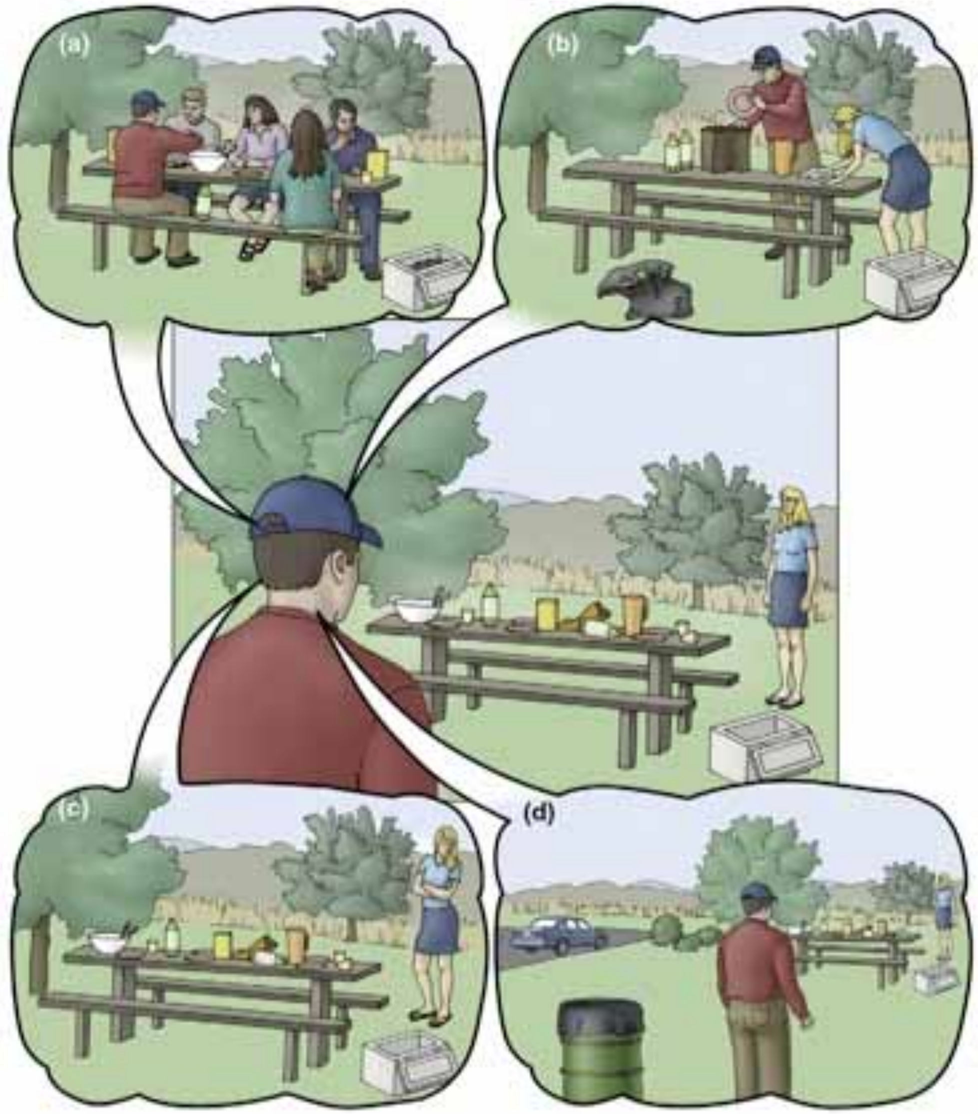
(b) Imagining future events

(c) Seeing things from someone else's perspective

(d) Navigation



From Buckner & Carroll
Trends in Cog. Sci. 11:2 (2006)



The danger of one-step recall: Coherence – your safety net

- <u>One-step recall</u> – **simple association – often leads you astray.**
- **Often the first thing you remember is wrong – even when you are confident about it.**
- Throughout the class we will be looking to make connections between the physics we are learning and what we know well.
- We will try to see physical situations in a variety of different ways.
- **The consistency among the different views protects us against errors of reconstructed memory.**

How do we know? Why do we believe…?

- This class is not about learning a set of scientific facts. It is about learning how to reason scientifically.
- The important thing is NOT (just) the correct answer; it's
  - Why do we think an answer is the answer?
  - What's the evidence for the answer?
  - How do we know if we are right once we think we have an answer?

What's the most frequently unnoticed element in this class?

- The laws, principles, and equations are about <u>physical systems</u>.
- Therefore, it is crucial to think about <u>what is happening in the physics</u> first.
- This may mean being able to run a movie in your head – run it slo-mo or stop frame – and be able to read off different variables from that movie.
- It may mean thinking about the parts of the system, how they interact, and how the fundamental physical principles apply.

Differences that make a difference

- It is essential to distinguish:
  - A quantity (e.g., position)
  - A change in a quantity (e.g., displacement)
  - A rate of change of a quantity (e.g., velocity)

$$q$$

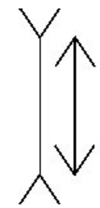
$$\Delta q = q_{final} - q_{initial}$$

$$\frac{dq}{dt}$$

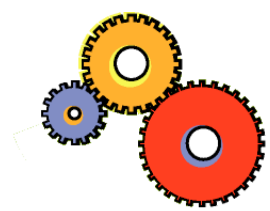
Knowledge Games

- Shopping for ideas
- Choosing foothold ideas
- Reconciling intuition
- Multiple representations



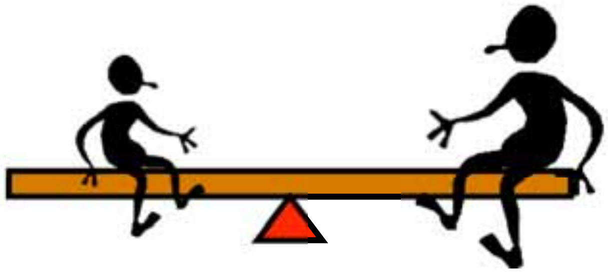


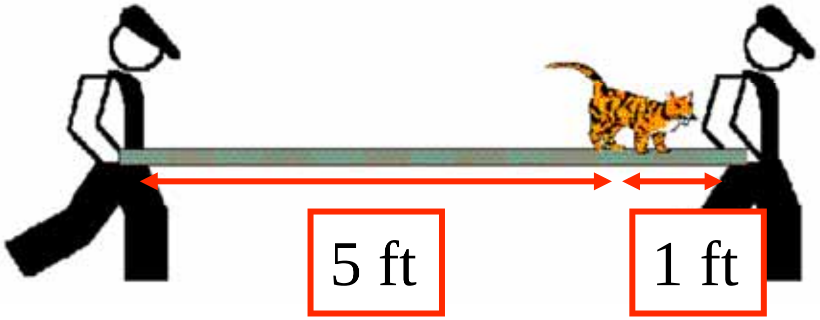

- Elaboration / Implication
- Seeking consistency
- Sense making



Knowledge Games: Shopping for Ideas

- When we begin the study of a subject we will often explore our experience to try to create a basis for understanding what's happening.
- Example: Torque





Knowledge Games: Seeking Consistency

- Building scientific knowledge is not a collection of independent facts.
- Every "fact" has implications.
- Everything has to fit together.
- This provides a safety net that allows you to check whether you have remembered your "facts" (or better, used your principles) correctly.

Knowledge Games: Choosing Foothold Ideas

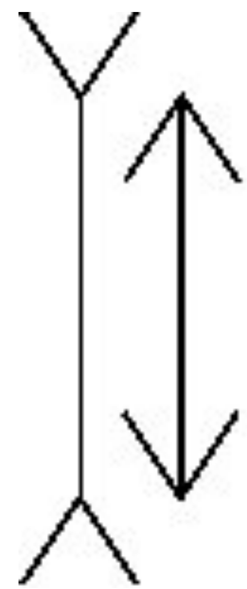
- As we gather our experiences and data on a topic, we propose general principles that correlate and make sense of our observations.
- We then assume they are true and see what they imply.
- If those implications don't pan out (agree with observation), we may have to go back and modify them.

Example: Building Newton's Laws

- When we first starting looking into how to change an object's state of motion, we only looked at motion on a table. We found:
  - Objects only feel forces when something touches them. (Normal, tension, or frictional forces)
- We later decided we had missed something.
  - Objects only feel forces when something touches them (*N*, *T*, or *f*) plus the long-range (non-touching) force of gravity coming from the earth.

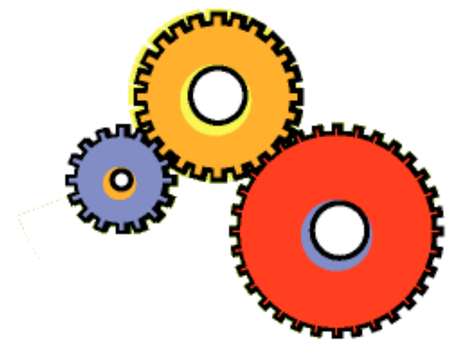
Knowledge Games: Reconciling Intuition

- Our intuitions are often based on direct, one-step reasoning;
  - "if A, then B"
  - but often it's really: "if A (and C is not changed), then B"
- We often have other intuitions that contradict our DOSR – but we just haven't noticed.
  - Putting those carefully together is reconciling.



Knowledge Games: Elaboration / Implication

- Our "foothold ideas" become *principles* we reason with.
- Everything we assume is true has implications for situations other than the one in which we figured it out.
- *Reasoning from principle* is the fundamental characteristic of a mature science.



Knowledge Games: Sense Making

- We should more than just "know" a result in physics – it should make sense to us.
- If you can see a result as making sense, you will find it much easier to remember accurately.
  - Memory is not like a photograph. It is highly compressed.
  - When you recall it, it is "reconstituted" using stock elements – and may mix together distinct memories.

Four mantras to keep in mind

- Beware one-step recall!
  Look for coherence with what else you know.
- Build your understanding on a sense of the physical and integrate it with your equations!
- Be careful to distinguish a quantity, a change in that quantity, and the rate of change of that quantity!
- ***The physics we are learning in this class is simple – but seeing that it is simple is very difficult!***