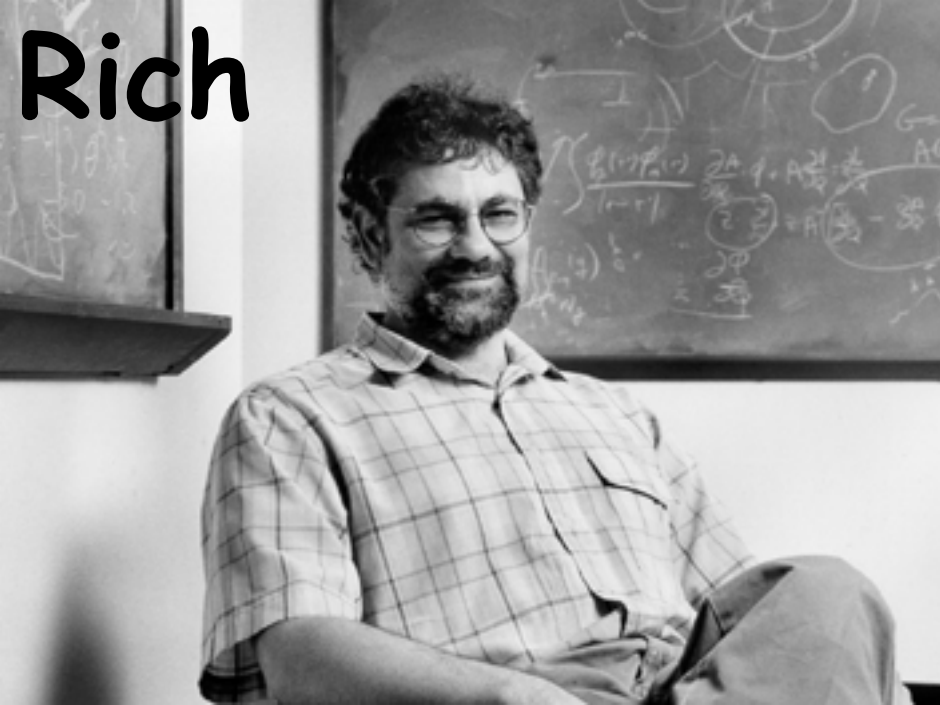




Havemeyer Hall, Columbia University
Water color by Bonnie Folkins

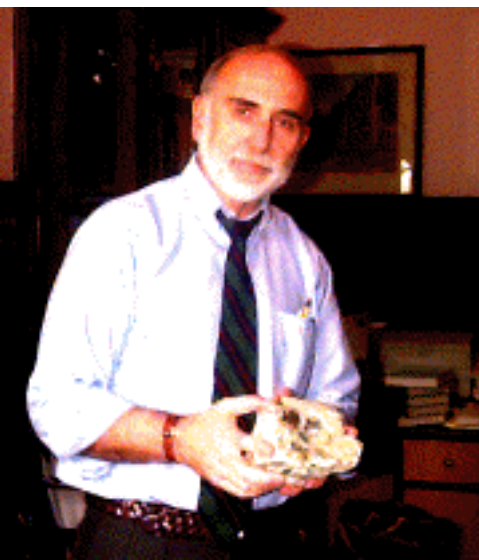
Rich



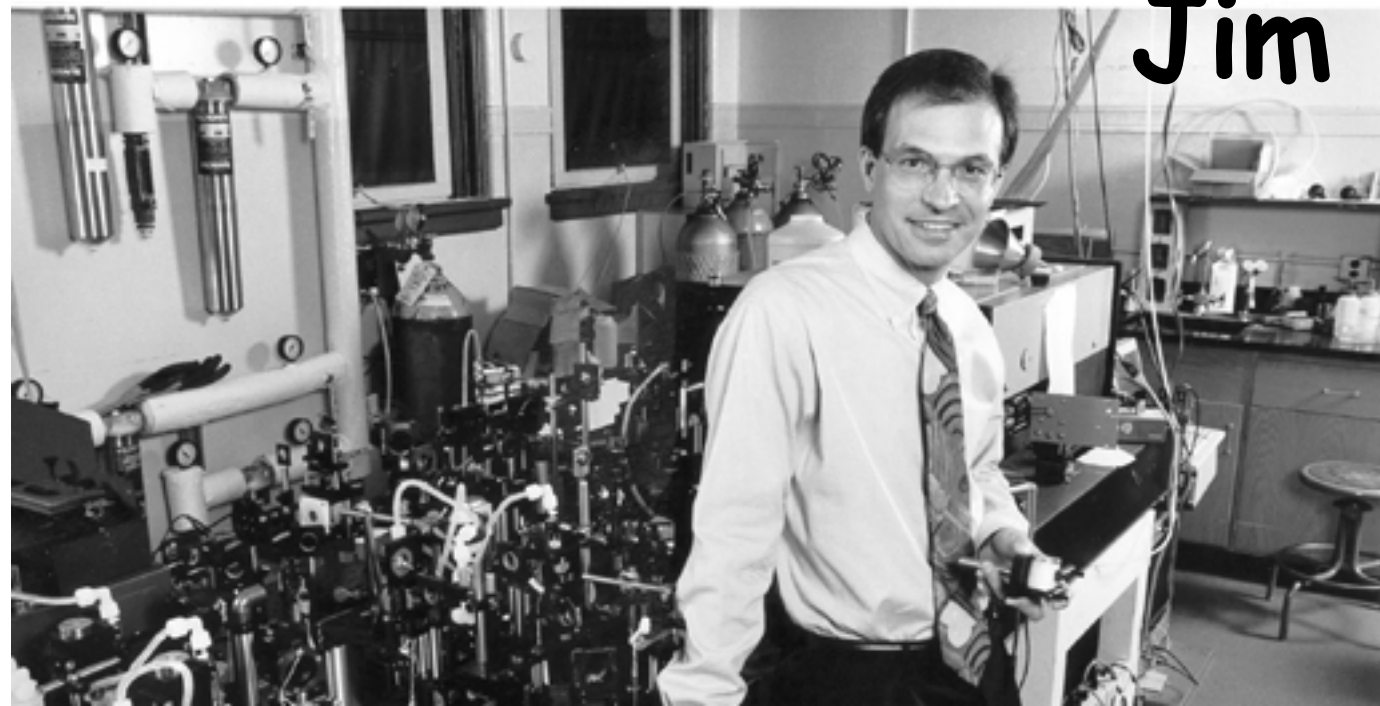
Dave



Len



Jim



Chemistry 1403x

Fall Term, 2002

- Len Fine
 - Polymer chemistry; materials science
 - Science/engineering education
- Rich Friesner
 - Theoretical chemistry, QM/MM methods
 - Modeling protein-active site chemistry
- Dave Adams
 - Materials chemistry, nanoscale optics/electronics
- Jim Valentini
 - Physical chemistry, photochemical/biomolecular mechanisms

Syllabus for the Course

- Textbook: OXTOBY-Science of Change
 - 4th Ed (ThomsonLearning/BrooksCole), 2003
- Student Solutions Manual
- Reserve Books
- Website
 - http://www.columbia.edu/itc/chemistry/c1403_1404

Lectures and Exams

- Lectures
 - MW 11:00-12:15
 - TR 11:00-12:15
 - TR 1:10-2:25
- Exams
 - Three 75-minute Period Exams
 - Tuesday (10/2, 10/30, and 12/4) @ 7:30 P.M.
 - Results: 16% each
 - There are no make-up exams. No Kidding! No Fooling!
 - One 180-minute Comprehensive Final (26%)

Chemistry 1403x

Support Staff

- Luis Avila
 - Undergraduate Office / Room 318 Havemeyer
 - Socky Lugo and Daisy Melendez
 - Preceptor
 - Sara Cummings
 - Web masters
 - Michael Clayton
 - Andrew Eng

Eighteen Recitation Sections

Choose one!

- Each is 50-minutes
- Preceptor
 - Sara Cummings
- Senior Assistants
 - Jacob Newman
 - Brian White
- Teaching Assistants
 - Valadimir Blagogevic
 - Greg Carroll
 - Michael Harris
 - Bryte Kelly
 - Heedong Yoon
 - Jinyou Zhuang

Additional Information

- Inventions / Discoveries
- Demonstrations
- Review sessions
- Help sessions
- Office hours
 - TA Hours TBA
 - Professor Hours
 - MW 12:30 P.M.
 - T 2:30 P.M.
- Quizzes
 - Best 5 of 7 (10%)
 - No Make-up Quizzes. No Kidding!
- CHEMWrite (16%)
 - No excuses for missing deadlines. No Fooling!
- Online Assessment (2%)



Columbia's Mission

- **Wide-ranging perspective on human achievement in.....**
 - Literature
 - Philosophy
 - History
 - Music
 - Art
 - Science and Technology

Columbia's Mission

- **Principal goals of a liberal education**
 - Rational thought
 - Careful analysis
 - Logical choice
 - Imaginative experimentation
 - Clear communication

Columbia's Mission

- **Science and Engineering**
 - The science of chemistry is the science of molecules and chemical bonds.
 - It is a way of thinking about the natural/unnatural world.
- **Technology**
 - The application of science and engineering to the production of human works.
- **Discovery and Invention**

Columbia's Mission

Discovery and Invention

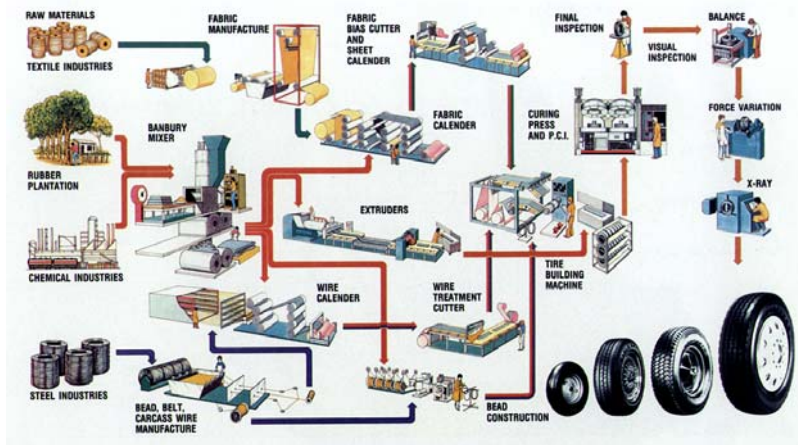
- Air bag
- Air conditioning
- Anesthesia and Aspirin
- Bakelite
- Electric light bulb
- Internal combustion engine
- Kevlar
- MRI
- Microprocessor

Columbia's Mission

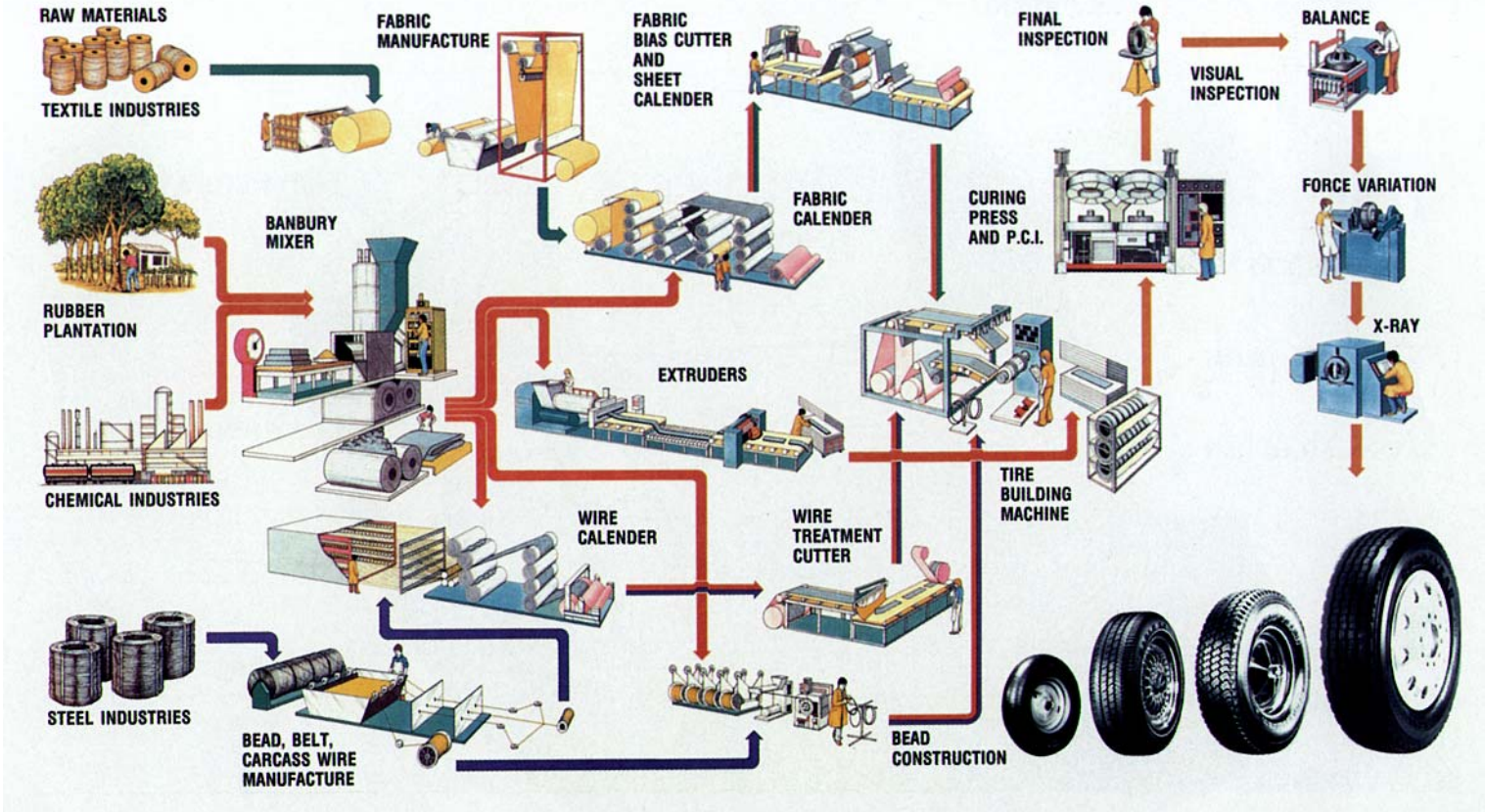
Discovery and Invention

- Microwave oven and the smoke detector
- Nylon
- pH Meter
- Photocopier
- Prozac / Prempro
- Laser
- STM
- Transistors and LEDs
- Vulcanization of Rubber

Failure at High Speed



- Complex, multi-step process
- Totally automated



Failure at High Speed

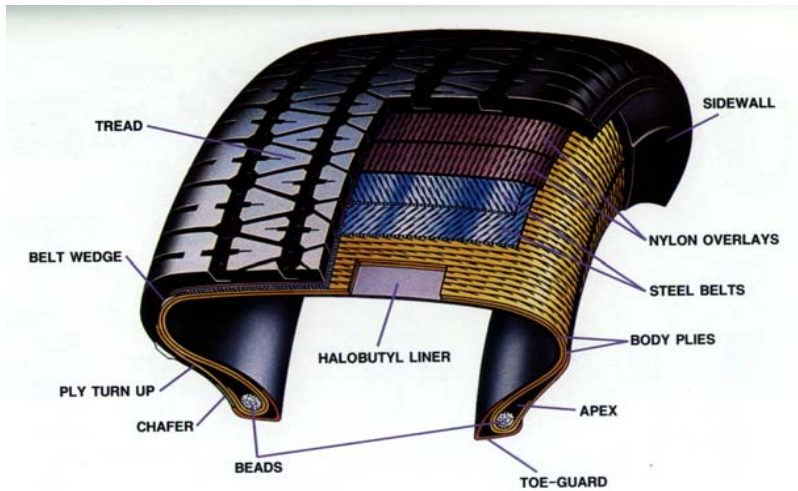


FIGURE 3 Cross section of a high-performance passenger tire.

- Tires are textile-steel-rubber composites.
- Layers of steel wire lying under the tread serve to
 - stiffen the casing
 - improve wear and handing
 - provide hazard protection.

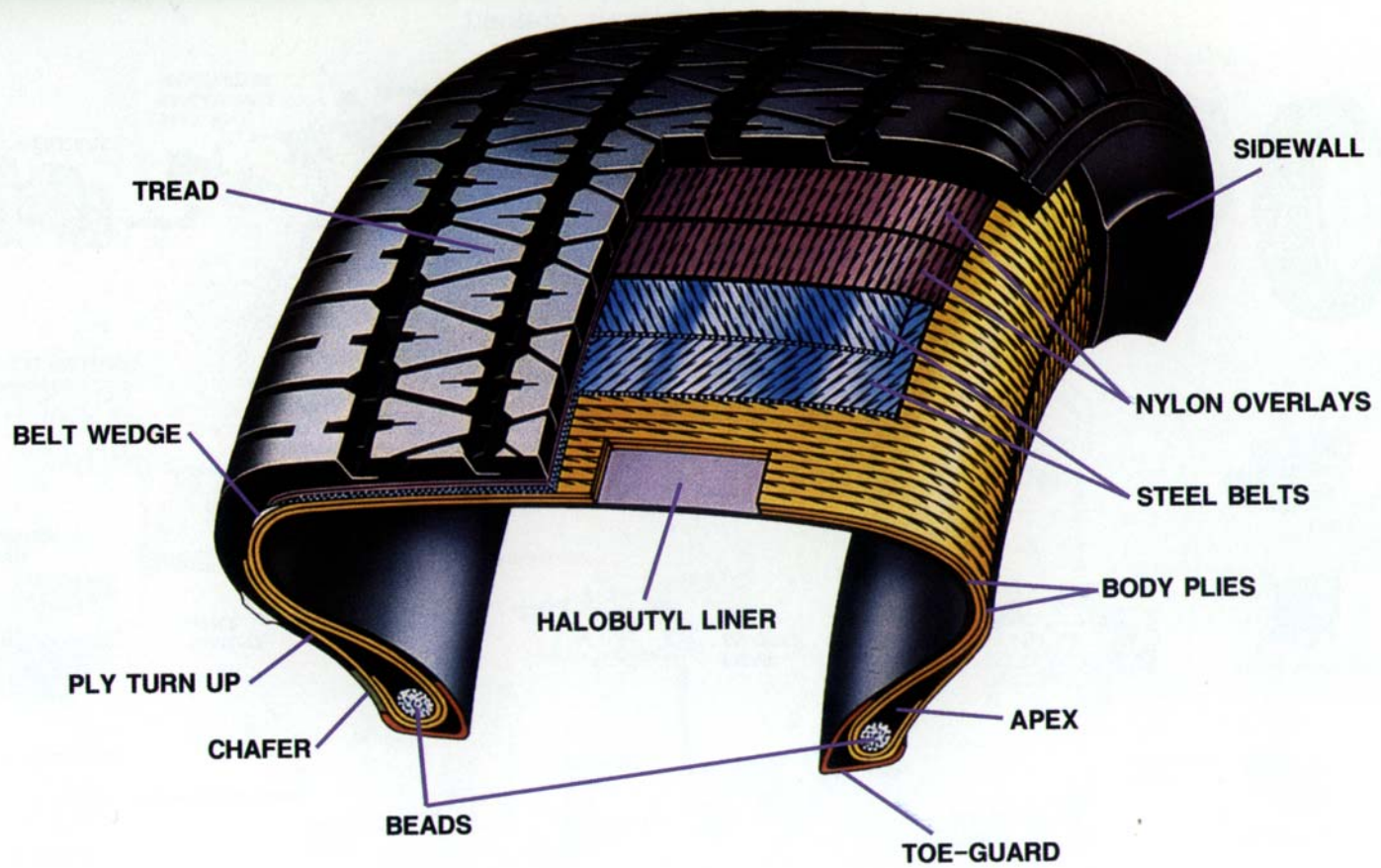
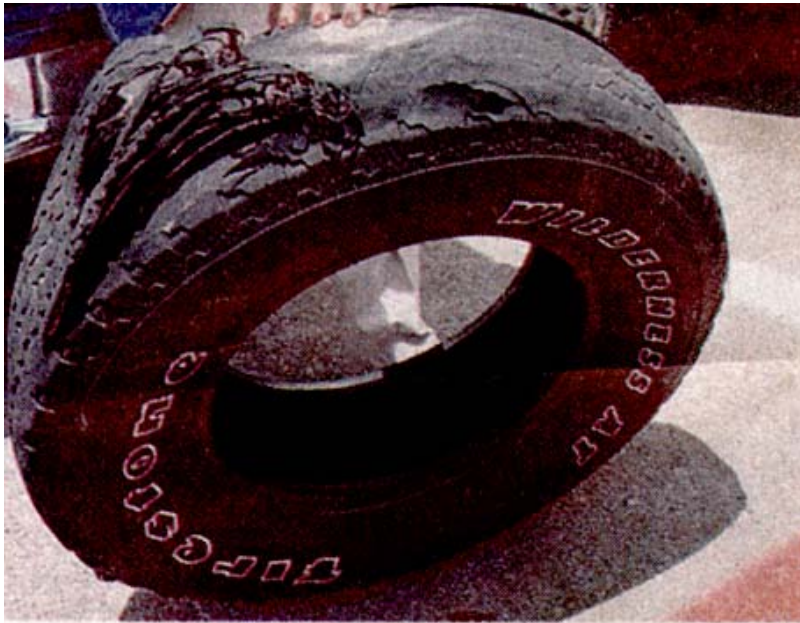
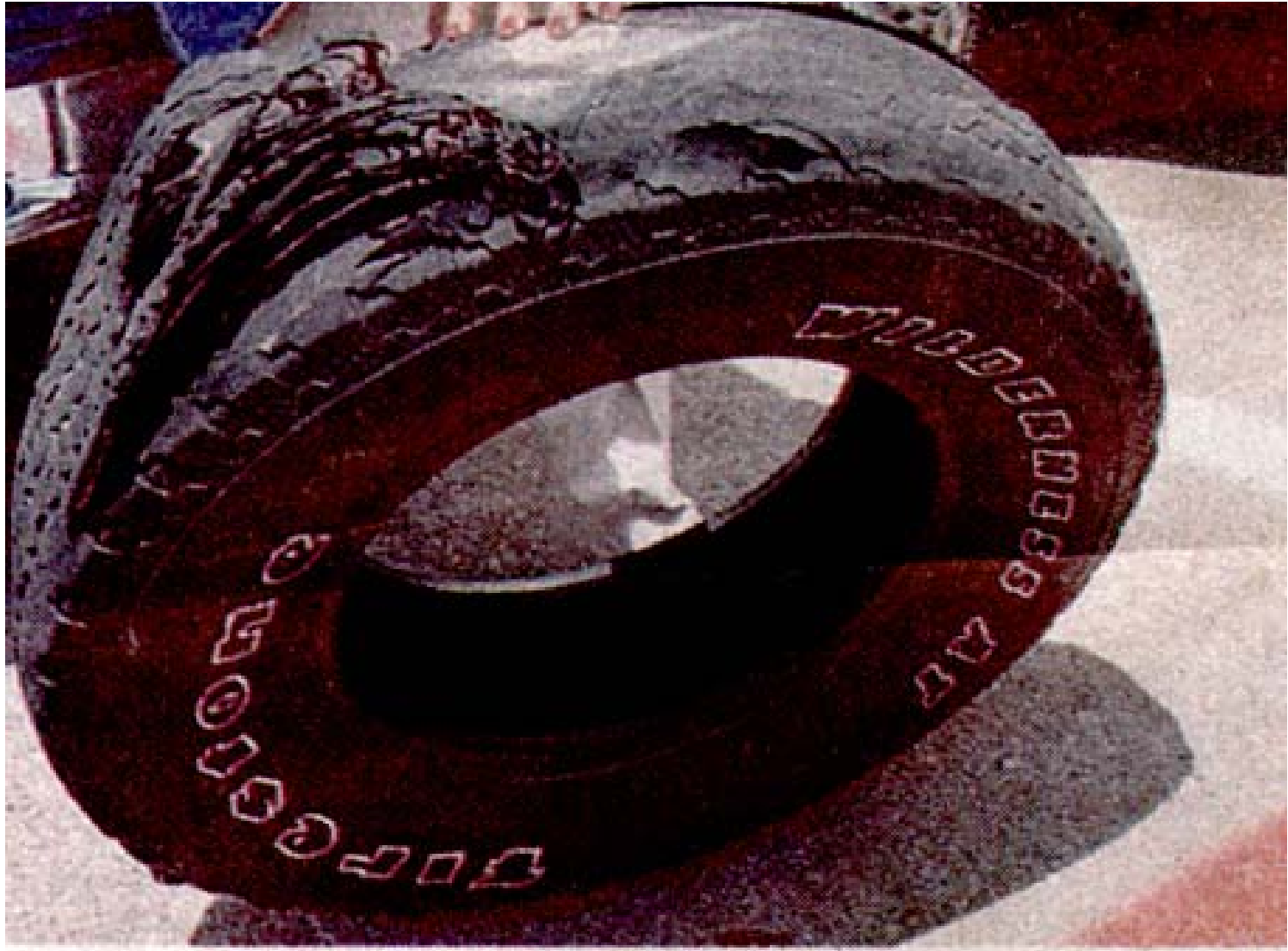


FIGURE 3 Cross section of a high-performance passenger tire.

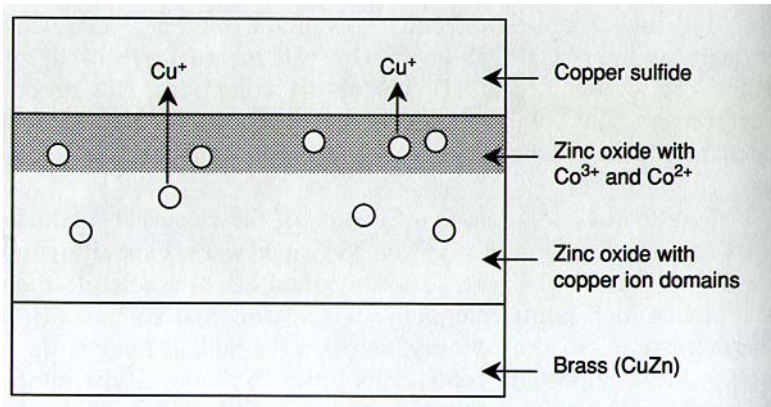
Failure at High Speed



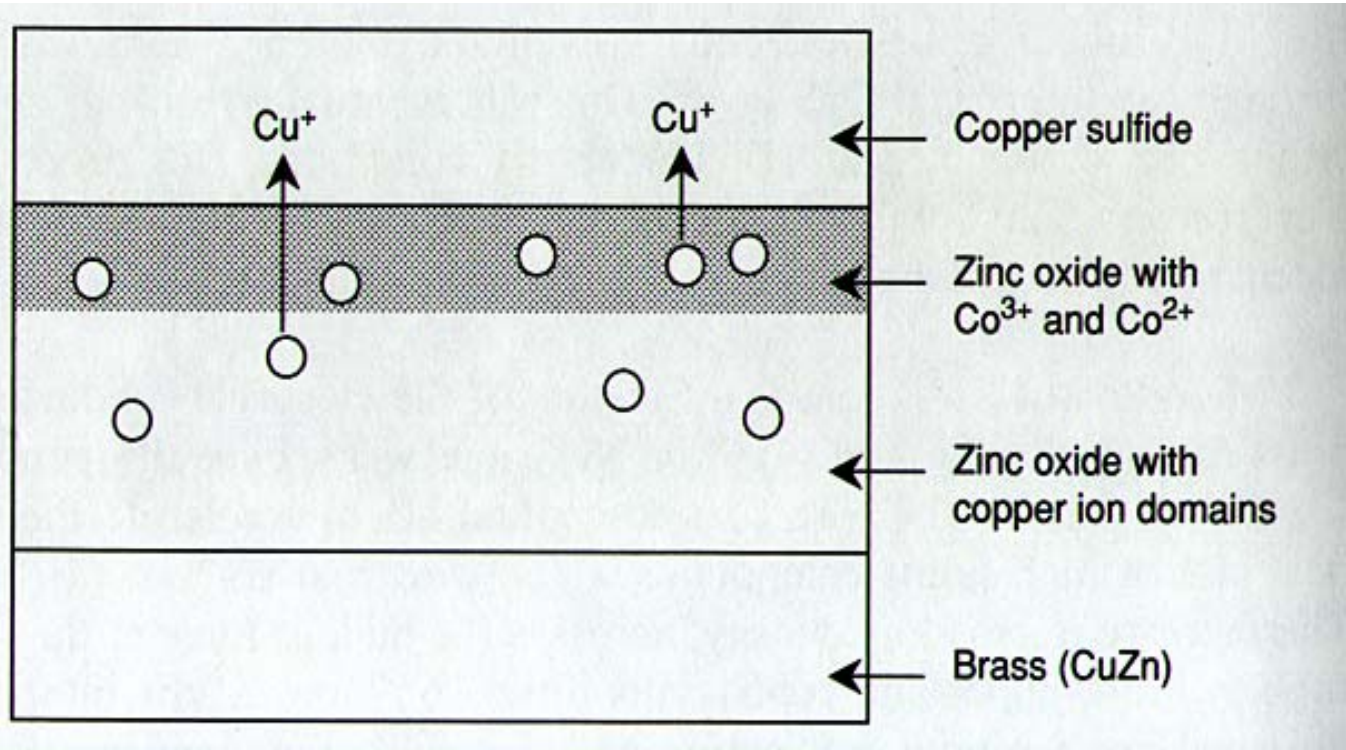
- Firestone Wilderness tire failure.
- Factors:
 - Temperature
 - Pressure
 - Belting
 - Weave
 - Bonding



Failure at High Speed



- Thin brass coating on steel cord is the primary adhesive used in steel-to-rubber bonding.
- Interfacial copper sulfide chemistry at the interface.



QUESTIONS

- What do we know?
- How do we know it?
- Why is it important?
- Who cares?



Rabi Questions



Set aside general questions in favor of more limited questions...the answers to which can lead to more general understanding.

- Isidor I. Rabi, Columbia University

Nobel prize for physics, 1944

Scientific World View

Early Insights

- Unification of celestial and terrestrial mechanics
- Existence of atomic species
- Heat as atomic random motion
- The electromagnetic field
- Evolution of living species

Scientific World View

Twentieth Century Insights

- Theory of relativity
- Quantum Theory
- Molecular/Cell Biology
- Cosmological Theories of the Universe
- The Local Environment of Planet Earth

QUESTIONS

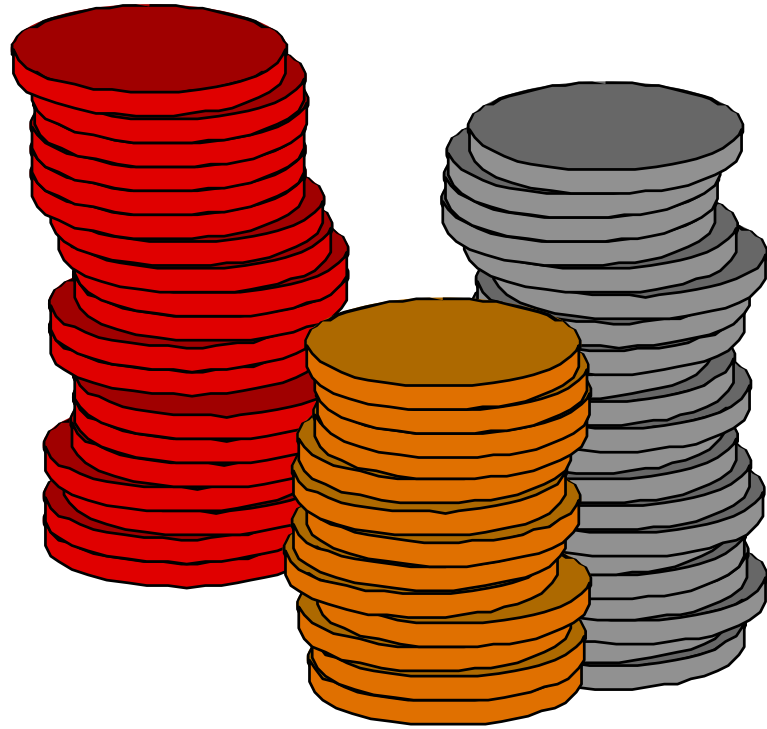
- What do we know?
- How do we know it?
- Why is it important?
- Who cares?

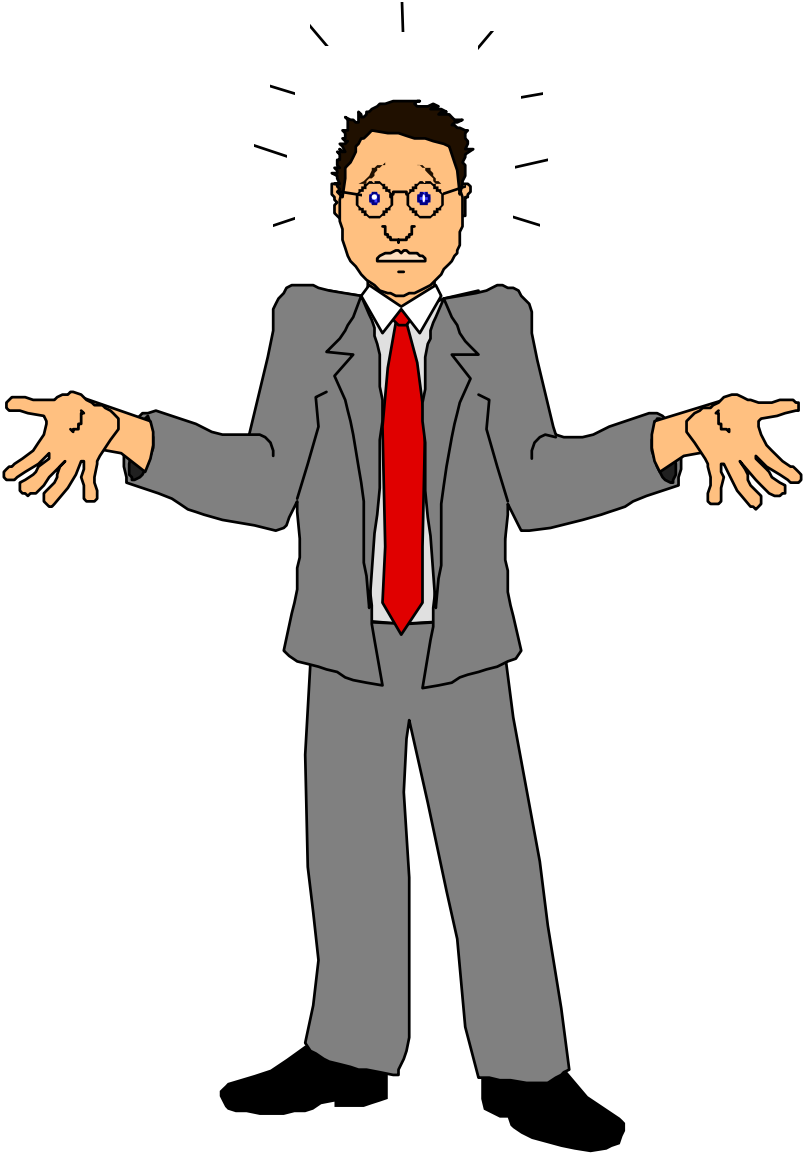
President Ronald Reagan

- said in 1985.... “A trillion dollars is so much money that it is hard to grasp the idea.”
- “..... So I want to tell you how to make [a trillion dollars] a little more real.”

President Ronald Reagan

- “If you took a trillion dollars and stacked them on top of each other, the pile would reach halfway to the moon.”





Counting

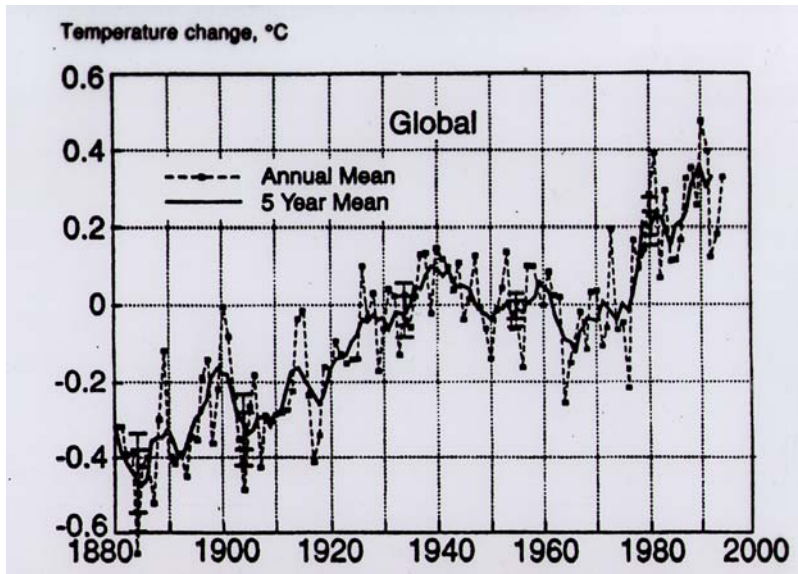
- The census bureau has recently reported the U.S. population as 281,421,906.
 - Do you believe this enumeration of people?
- The last time I checked (the U.S. Treasury website), the public debt was \$5,719,452,925,490.54.
 - Does this to-the-penny accuracy match its precision?

Counting... all those Chads

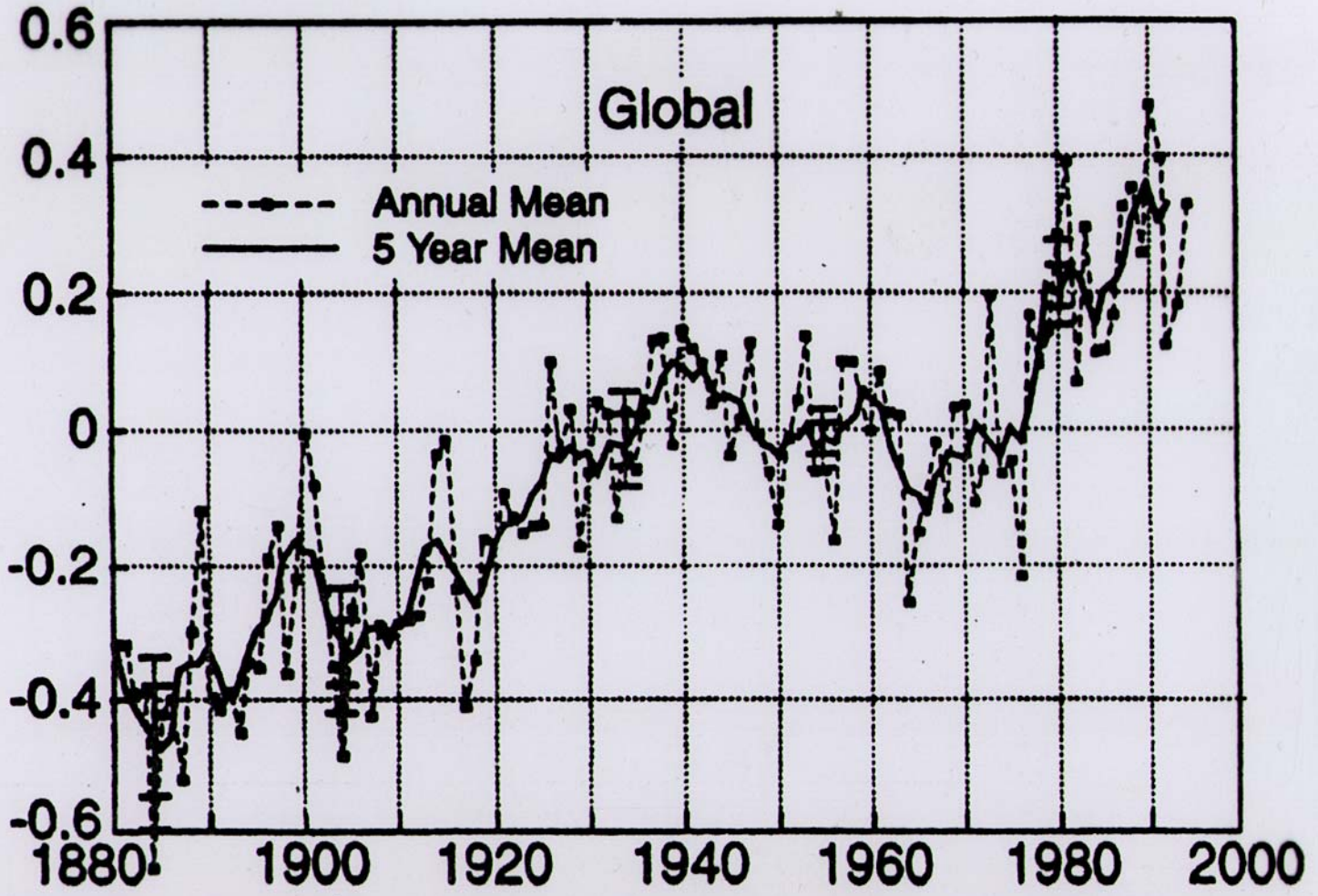
- Although most of the vote-counting of the last election concerned what to count, not how to count, the counting process proved unreliable and imprecise.

Global Mean Temperature

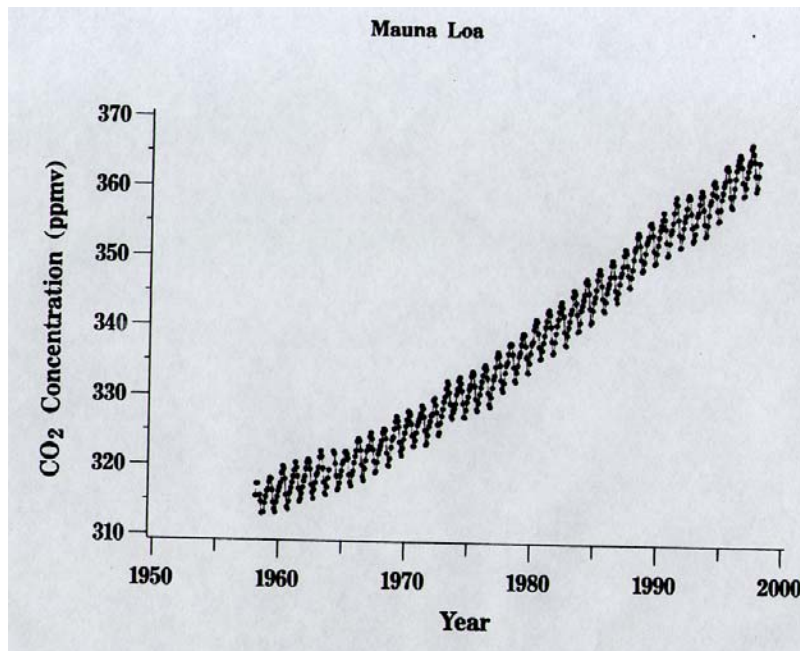
- Global mean temperature has been on the rise since 1880.
- Note fluctuations!



Temperature change, °C

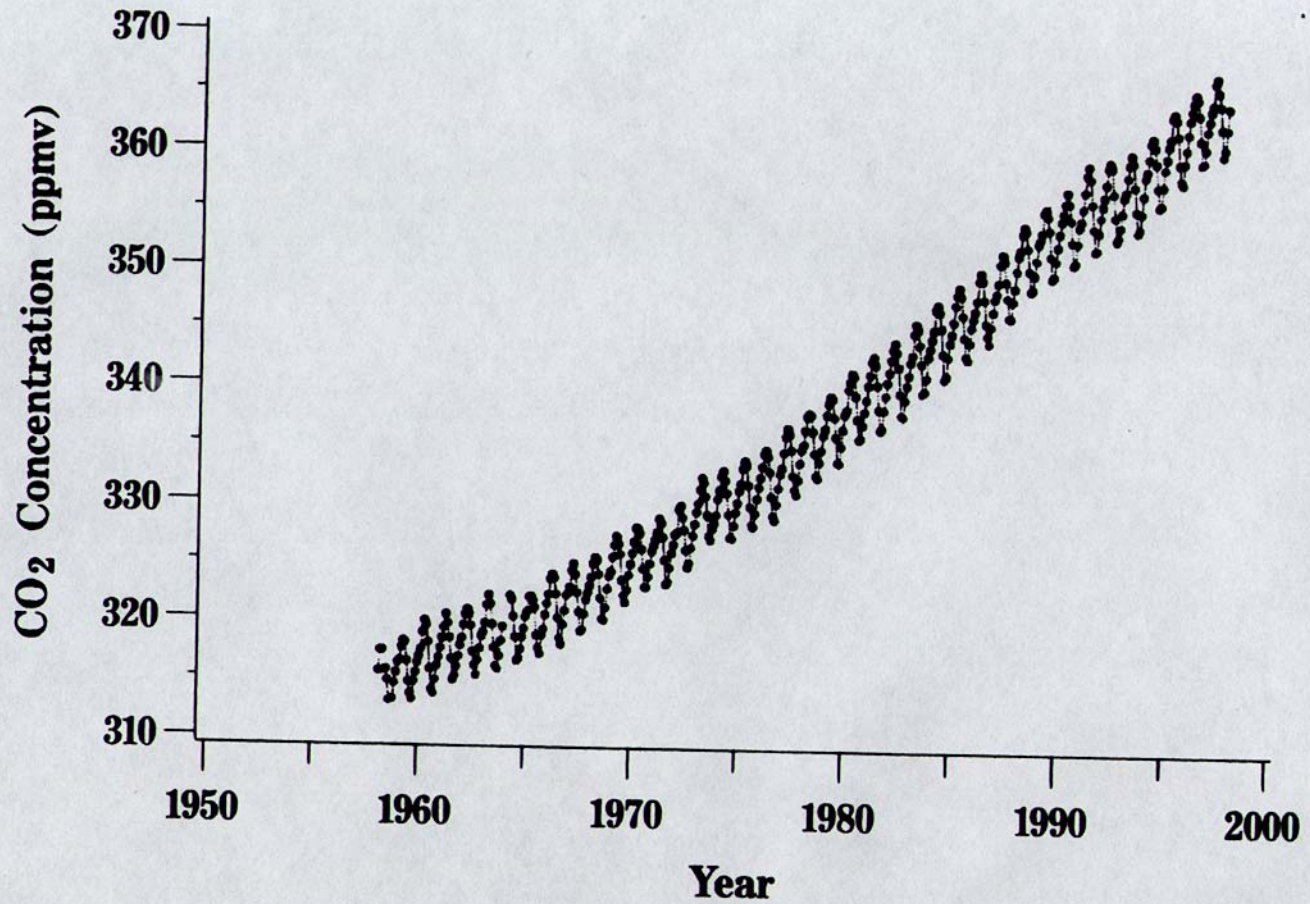


Keeling Curve



- Keeling curve showing increasing atmospheric CO₂ at the Mauna Loa Observatory in Hawaii.
- Keeling and Whorf, 1998.

Mauna Loa



CHEMISTRY. Science of molecules and bonds.

Observation: Sensory experience.

Measurement: accuracy/precision.

International System

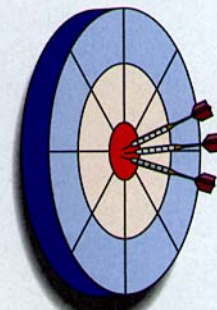
Tools extend experience

Hardware/Software

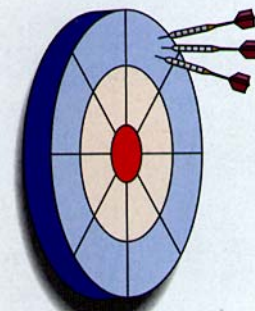
Seeing/weighing atoms/molecules

Scanning Tunneling Microscopy

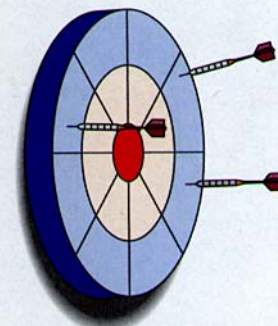
Mass Spectrometry



Good accuracy
Good precision

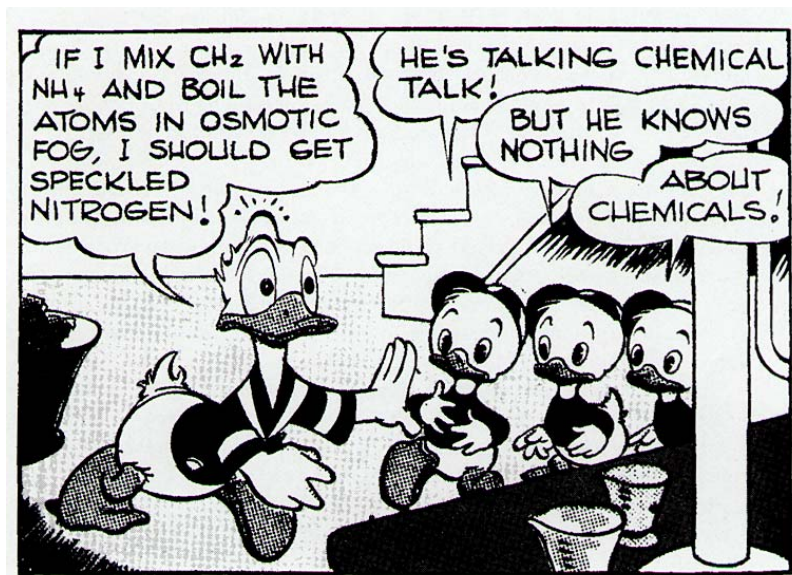


Poor accuracy
Good precision



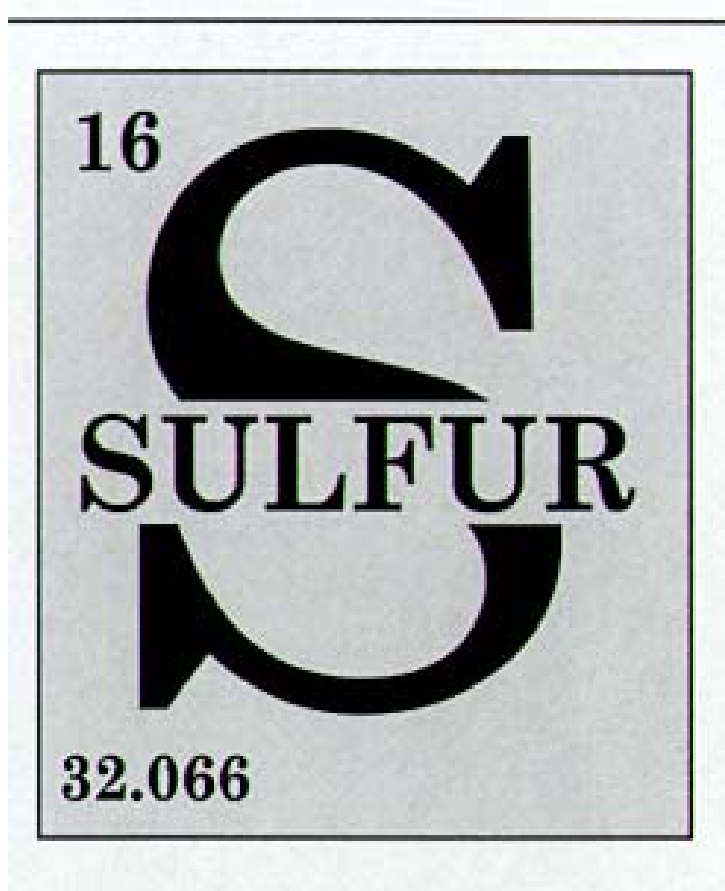
Poor accuracy
Poor precision

Chemical Formula

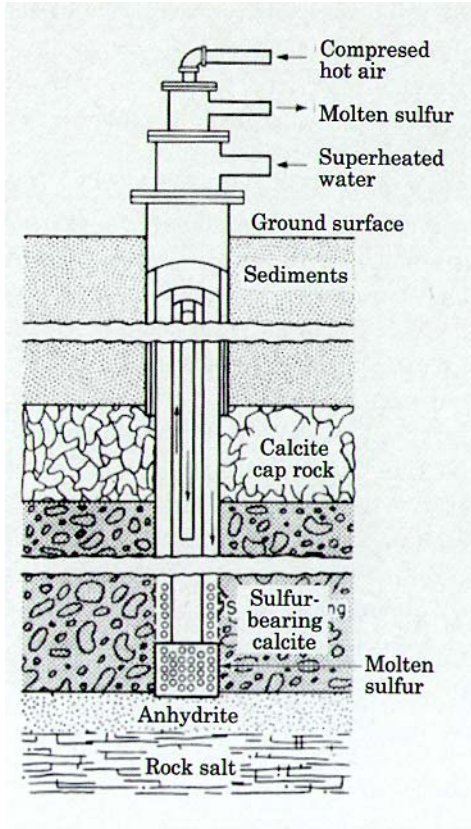


- Talking chemical talk
- Chemical formula
 - CH₂ (methylene)
 - NH₄⁺ (ammonium ion)

Chemical Formula



- Atomic number 16
- Atomic weight 32
- Formula weight
 - 32 grams
 - 1 mole
 - 6.022×10^{23} atoms

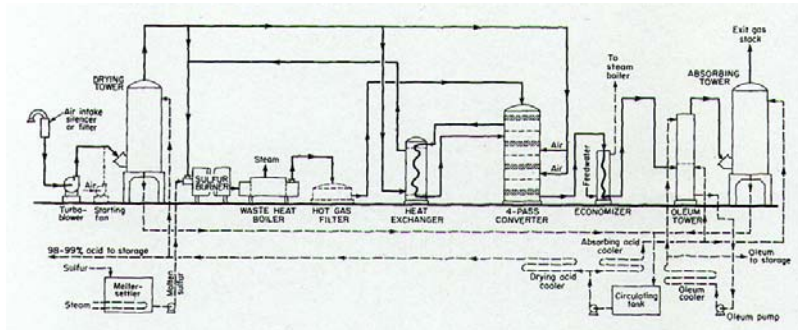


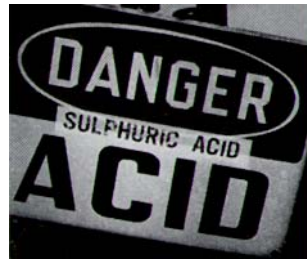
Recovering sulfur

- Extraction with ethanolamine as the water-soluble salt, $\text{HOCH}_2\text{CH}_2\text{NH}_3^+, \text{HS}^-$
- Then, recover sulfur as H_2S by adding strong acid
- Finally, oxidize H_2S in two-step process involving oxygen and sulfur dioxide

Chemical Processes

- Engineering diagram for industrial scale production of sulfuric acid from sulfur.







Rembrandt's Danae

- Destroyed by an acid attack.
- Sulfuric acid, a dehydrating agent.
- $$\text{H}_2\text{SO}_4 + \text{C}_{12}\text{H}_{22}\text{O}_{11} = \text{H}_2\text{O} + \text{SO}_2 + \text{C}$$

QuickTime™ and a
TIFF decompressor
are needed to see this picture.

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