“The essence of science is to discover identity in difference.” - F.S. Marvin

“You can observe a lot just by watching.” - Yogi Berra

Observations are Qualitative and Quantitative

Chemistry is a Quantitative, Predictive Science --> Observations Are Quantified With Numbers (Measurements)

There Are A LOT of Chemicals

130 million substances (in CAS Registry as of July 2017; 50 millionth substance was registered in 2009)

117 elements, 94 naturally occurring

10^{18} to 10^{200} Possible chemicals (estimated)

Reference: http://www.wisegeek.com/how-many-chemicals-are-there.htm

The most abundant elements in the universe are:
hydrogen (74%), helium (24%), oxygen (10%), carbon (0.46%), neon (0.13%), iron (0.1%), and nitrogen (0.1%)

99% of all living organisms and more than 99% of all chemical compounds contain:
carbon, hydrogen, oxygen, nitrogen, phosphorous, and sulfur

In what compounds are these elements found?

Chemistry is Big Bucks!

World chemical output = $3.7 trillion in 2009
U.S. chemical output = $689 billion in 2009

Products:

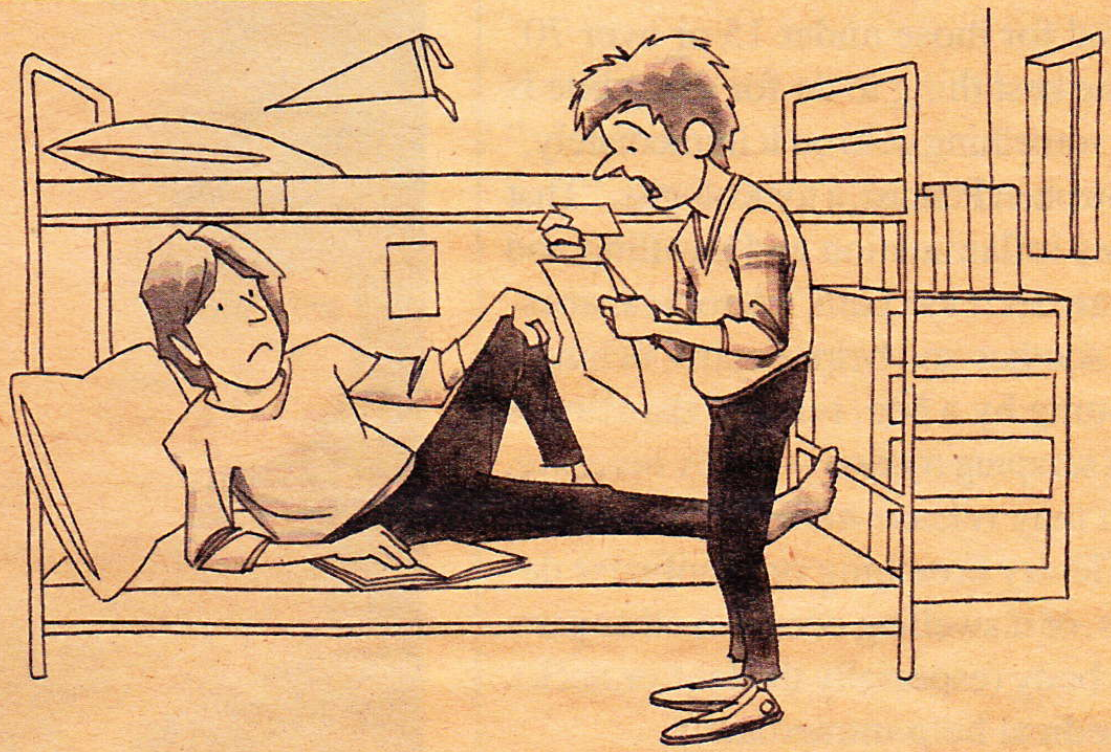
1. Basic chemicals - petrochemicals, plastics, fertilizers
2. Life science chemicals - pharmaceuticals, pesticides
3. Specialty chemicals - electronic chemicals, industrial gases
4. Consumer products - soaps, cosmetics

Largest Chemical Companies:
World = BASF (Germany) = $70 billion in 2010
U.S. = Dow Chemical = $54 billion in 2010
Reference: http://en.wikipedia.org/wiki/Chemical_industry

Most produced chemical in U.S. = sulfuric acid
40 billion kg in 2000

BY BUNNY HOEST AND JOHN REINER

Laugh Parade®



"My dad sent me a new bankcard...He says if I get an A in chemistry, he'll send the PIN number."

Scientists and Engineers Earn Big Bucks

Field	Starting Salary, $ in thousands
Chemistry, BS/MS/PhD	$40/55/76
Chemical Engineering, BS/MS/ PhD	$66/78/90
BiologicalSciences, BS	$33
Petroleum Engineering, BS	$80.8
Computer Engineering, BS	$64.5
Electrical Engineering, BS	$61
Mechanical Engineering, BS	$60.3
Pharmacist	$60
President of US	$400

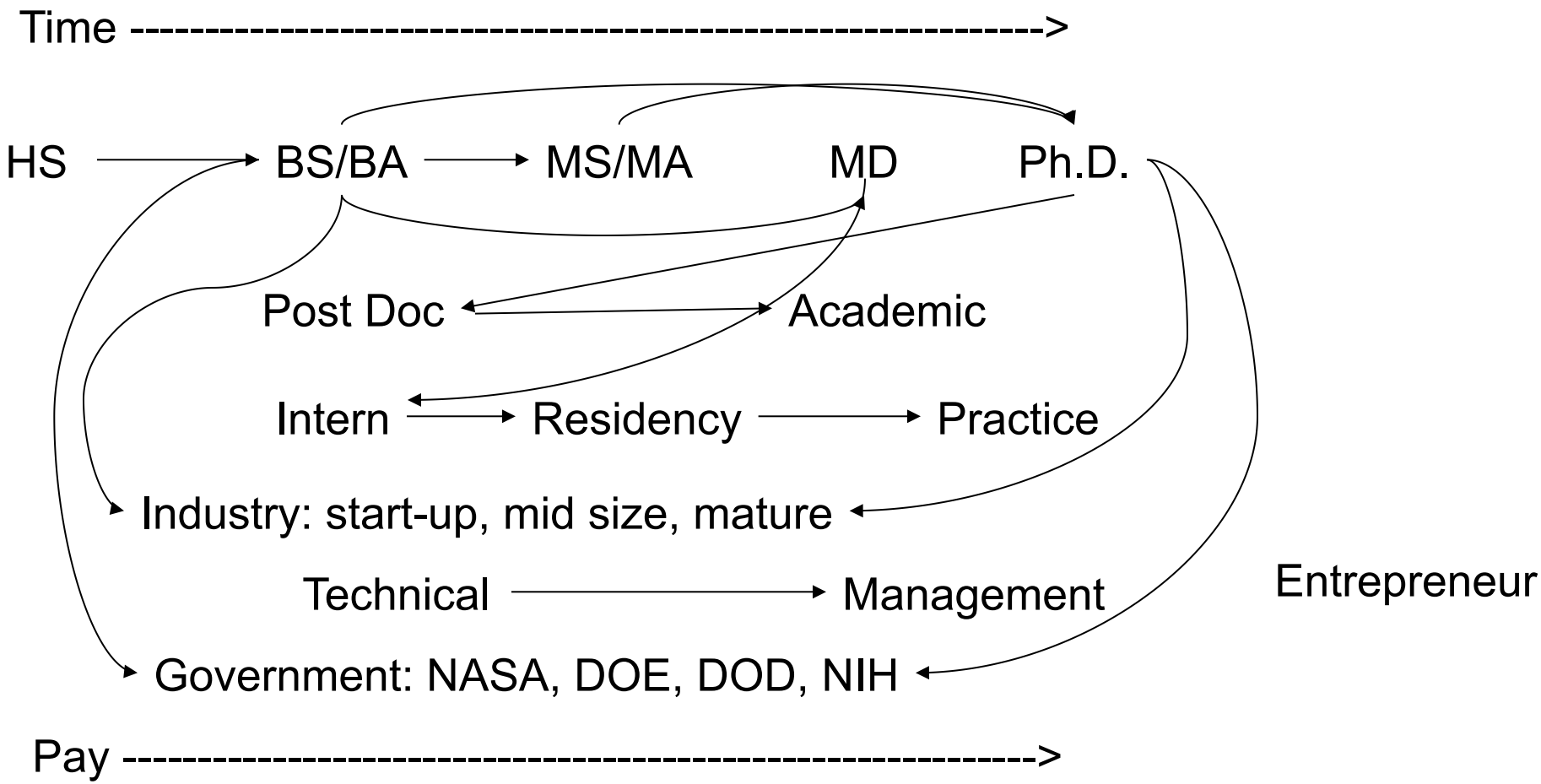
References: C&EN, 6/2/14, p. 28, http://www.bls.gov/oco/ocos047.htm#oes_links, http://www.doe.mtu.edu/news/degree_worth.html, http://www.engineersalary.com/overpaid.asp

22.6 million Scientists and Engineers in 2006

5 million scientists and engineers employed in their field

40% engineers

58% Bachelor's degree, 28% Master's degree, 14% Doctorate



Who said “You can observe a lot just by watching”?

How many substances are there?

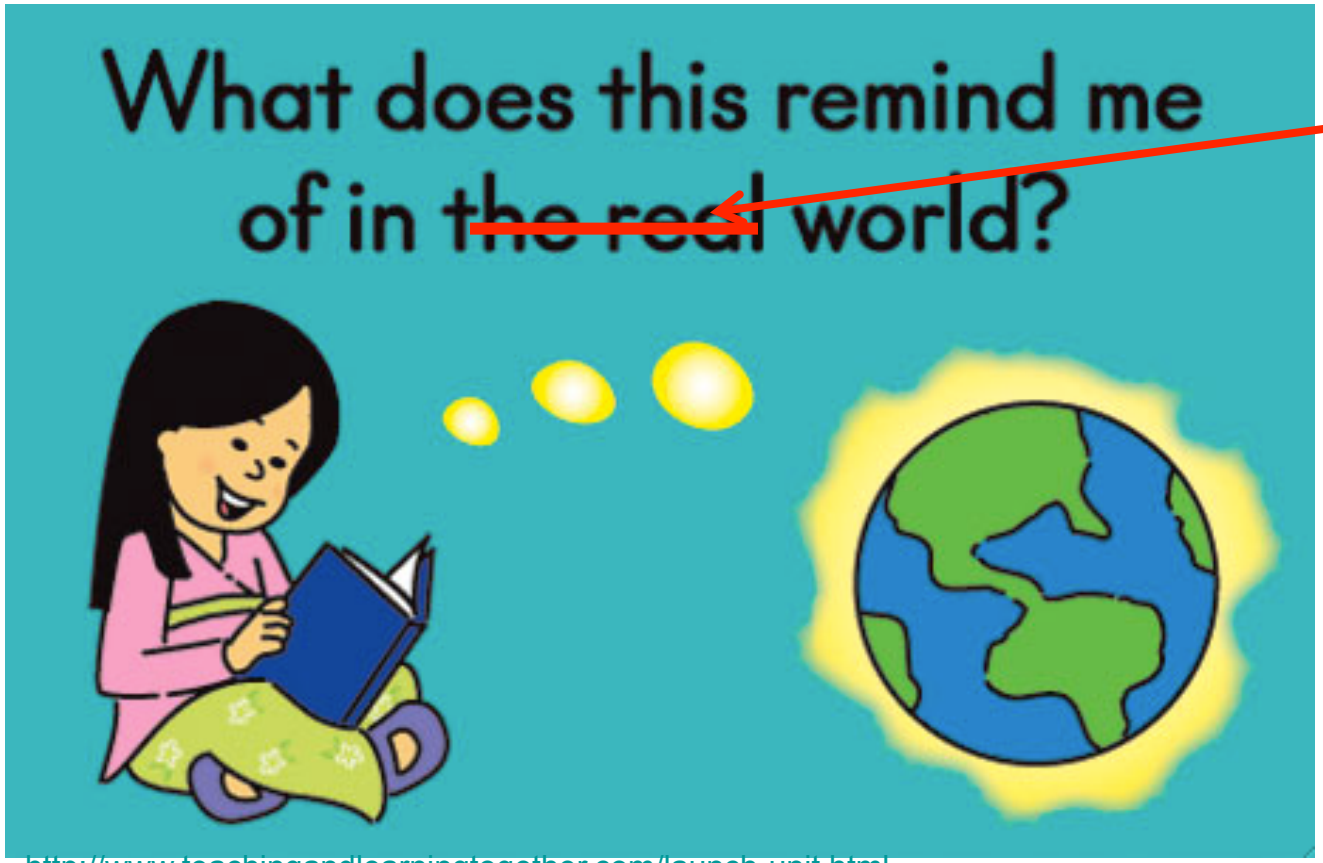
What was the U.S. chemical output in $ in 2009?

What is the starting salary for a biologist with a BS degree?

We Learn:

10%	of what we read
20%	of what we hear
30%	of what we see
50%	of what we see and hear
60%	of what we write
70%	of what we discuss
80%	of what we experience
95%	of what we teach

How Does A Person Learn?



YOUR

http://www.teachingandlearningtogether.com/launch-unit.html

Learning occurs by *ACTIVELY MAKING CONNECTIONS*.
When students interact with other students to clarify, explain, and understand, they are actively building their own minds, making connections, learning.

"*You don't really understand something until you can explain it to your grandmother.*"

- Einstein

What is the best way to learn chemistry?

a) Sit passively in lecture and stay awake

b) Re-write your notes

c) Do experiments in lab and discuss with your lab partner

d) Discuss and try to teach someone what you learned

CEN, 11/2/09, p. 32

1609: Earliest chemistry professorship in Germany

Linen aprons, students allowed to ask questions only "*with modesty and without bothering the teacher*."

2015: Education research and Chem 1A class

- Lectures **don't** work (15 minutes after a fact is presented in a lecture, only 10% of students showed any sign of remembering it)
- Active, not passive, learning
- Put new information to work *immediately* and *repeatedly* (Rule of 7 Marketing adage)
- Work with other students
- Ask questions - ***a lot!***

Work in the SAME Group of 4 to 6

Form your Group by this Friday:

1. your Lab partner
2. Student from another lab section (not your grandmother)
3. At least 1 person with a mobile device with internet

- Studies show students who work in cooperative GROUPS tend to get BETTER GRADES and enjoy course more than students who work individually and competitively.
- Work in teams in industry
- Build and develop social skills (introduce self, listen, encourage, check, accountable)

Coordinator – make sure all group members know their responsibilities and understand problem solution

Recorder – write ideas, possible solutions, and final answer

Checkers – check solution for accuracy before submitting

Develop Good Critical Thinking Skills by:

- Observe and ask good questions
- Hypothesize and predict
- Design an investigation
- Collect, process, and interpret data
- Draw conclusions
- Infer and generalize
- Communicate
- Relate cause and effect
- Recognize assumptions and evaluate
- Apply knowledge to new situations

"Problem solving is what you do when you don't know what to do, otherwise it is not a problem."

http://cen.acs.org/articles/90/i20/Douglas-La-Follette.html

5/13/12, CEN, p. 36 Douglas La Follette: Ph.D. organic Chemist-turned-politician ran low-budget WI gubernatorial campaign in 2012

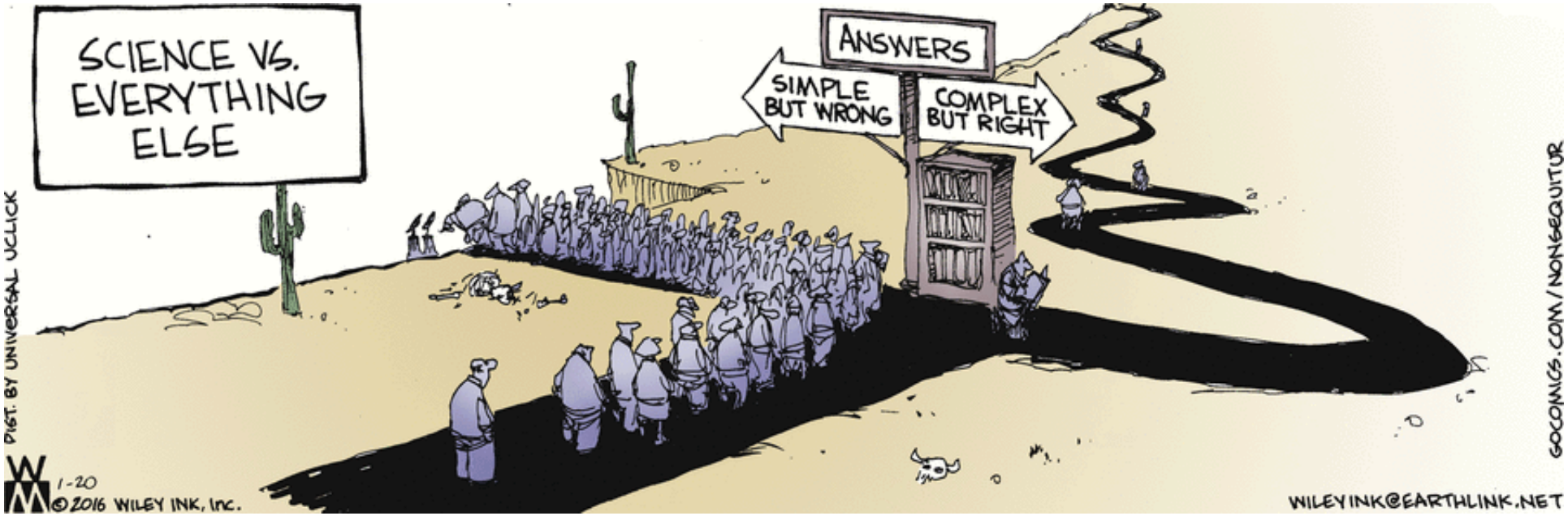
"Our whole society has an antiscience, anti-intellectual attitude"

"Solving problems scares voters because issues are complicated"

"People who are trained in science or have a predisposition toward science tend to be analytical and thoughtful, and they tend to try to solve problems"

Non Sequitur by Wiley Miller, 1/20/16

http://www.gocomics.com/nonsequitur/2016/01/20



"Problem solving is what you do when you don't know what to do, otherwise it is not a problem."

Problem Solving Model 1:

- Understand the Problem
- Devise a Plan
- Carry out the Plan
- Look Back

G. Bodner, “Problem Solving: The Difference Between What We Do and What We Tell Students To Do,” U. Chem. Ed., 2003, **7**, 37.

"Problem solving is what you do when you don't know what to do, otherwise it is not a problem."

Problem Solving Model 2:

- Read the Problem
- Read the Problem AGAIN
- Write down what you think is the relevant information
- Draw a picture, make a list, write an equation or formula to help you begin to understand the problem
- Try Something (*Trial And Error*)
- Try Something ELSE
- *SEE where this gets you*

To be continued …

G. Bodner, "Problem Solving: The Difference Between What We Do and What We Tell Students To Do," U. Chem. Ed., 2003, **7**, 37.

"Problem solving is what you do when you don't know what to do, otherwise it is not a problem."

Problem Solving Model 2: Continued …

- TEST intermediate results to see whether you are making any progress toward an answer
- Read the Problem AGAIN
- When appropriate, strike your forehead and say, "Son of a …"
- Write down "an" answer (not necessarily "**the**" answer)
- TEST the answer to see if it makes sense
- Start over if you have to, *CELEBRATE* if you don't

G. Bodner, "Problem Solving: The Difference Between What We Do and What We Tell Students To Do," U. Chem. Ed., 2003, **7**, 37.

Chem 1A Problem Solving Example

You are given a liquid.
What is the identity of the liquid?

Collect DATA – make observations

qualitative – color

quantitative – measure properties (pH)

Analyze DATA to calculate RESULTS

Interpret RESULTS – compare properties of liquid to properties of known liquids

Draw CONCLUSIONS – identify the liquid