

Chem 108
Introductory Chemistry

Dr. Ron Rusay

CONNECTIONS: Chemistry \rightleftharpoons STEM \rightleftharpoons Applications

STE(A)M
S Science
T Technology < A: Arts & Applications
E Engineering
M Mathematics

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What is the stuff around us? How do things work?
Ancient Questions: in Greece, China, Arabia, Persia

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STEM

RESULTS: Protocols, Explanations, Comparisons, Predictions & Tangible Products: "Ponderables versus Imponderables" (terms used circa 1830)
Additionally: MANY MANY VOCABULARIES in many languages

CHEM 108: Science, Chemistry, Mathematics, & Questions about the World Around Us

- College and career success require broad content knowledge and proficiency in reading, writing, language, communications, science and mathematics.
<http://stradaeducation.gallup.com/reports/225161/2017-strada-gallup-college-student-survey.aspx>
- These skills are building blocks necessary for success in addressing complex problems, in life-long learning, and in individual challenges.

CHEM 108: Science, Chemistry, Mathematics, & Questions about the World Around Us

| Bachelor's degree | % change, 2011–2017 |
|--------------------------------------|---------------------|
| History | -31 |
| Religion | -27 |
| Languages | -22 |
| English | -22 |
| Political science | -15 |
| Anthropology | -14 |
| Sociology | -6 |
| Arts | -5 |
| Art history | 0 |
| Music | 2 |
| Business | 4 |
| Cultural, ethnic, and gender studies | 5 |
| Psychology | 16 |
| Chemistry | 24 |
| Biology | 31 |
| Physics | 36 |
| Engineering | 49 |
| Nursing | 66 |
| Computer science | 67 |
| Exercise science | 74 |

CHEM 108: Science, Chemistry, Mathematics, & Questions about the World Around Us

- What is Science?... What is Chemistry?
 - VOCABULARY: Key Terms → COMMUNICATING
- Comparisons and Conversions :
 - Ratios, Percent, Density, Moles, Masses
- Mathematics / Arithmetic:
 - Adding, Subtracting, Multiplying, Dividing, Powers of Ten, Scientific Notation
- Measurement & Units: (metric)
- Matter & Energy : Classification & Properties
- Periodic Table



Information & Knowledge

<http://chemconnections.org/general/chem108/>

How are they acquired?

Hearing, Seeing (Viewing/Reading), Doing

Which works best for you?

It depends on our individual traits & skills

- Syllabus
- Calendar
- Resources

NY Times Advice on:
Dillydallying



Inside the Brain
A tour of how the mind works



Click Image

Information, Learning & Knowledge

How are they acquired?

Hearing, Seeing (Viewing/Reading), Doing

Which works best for you?

It depends on our individual traits & skills

How can these be discovered?

Various surveys can be used.

Your first assignment ("Metacognition"):

<http://chemconnections.org/general/chem108/learning.html>

- Complete Learning Style survey & submit & apply results



Click Image

What is the stuff in the world around us?

How does stuff work?

[Chemistry]

https://www.youtube.com/watch?v=AEgZOrRlg4&feature=push-sd&attr_tag=sx_IaKyLu0nf2UD%3A6



What is the stuff in the world around us?

How does stuff work?

Ancient Questions: in Greece, China, Egypt & Arabia, Persia

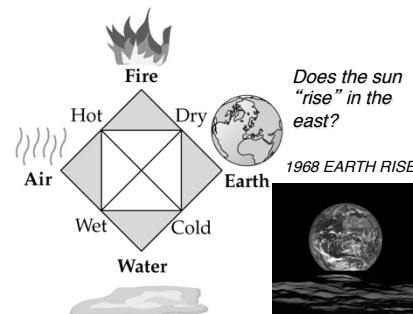


1831 Hokusai (ROUND?)
富嶽三十六景 上総の海路 At Sea off Kazusa
<https://www.metmuseum.org/art/collection/search/36502>

What is the stuff in the world around us?

How does stuff work?

Ancient Questions: in Greece, China, Egypt & Arabia, Persia



Observations: Perception

STEM relies on observations.



- Can more than one observation be correct?
- What do you see?

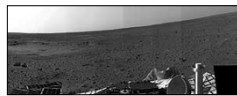
Observations: Perception

STEM relies on observations: SEEING



<http://video.pbs.org/video/2365563172/>

What might this be?



<http://mars.nasa.gov/>
Why is this important?
Would you colonize Mars?
200,000 people have applied!... for a one-way trip?

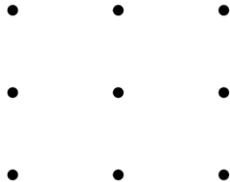
Mars Rover 2020



<https://mars.nasa.gov/mars2020/>
How many frequent flyer miles?
313,586,649 miles
(NO ROUND TRIP)

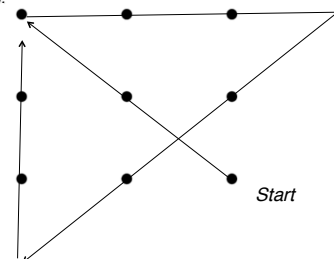
Problem Solving

Connect all of the dots with four straight lines without taking a stylus, pen, or pencil from the surface and passing through each point only once.



Problem Solving

Connect all of the dots with four straight lines without taking a pen or pencil from the surface and passing through each point only once.



Problem Solving

Can there be more than one solution for the same problem?

Of Course!

Problem Solving

An arborist is asked to plan an orchard that has 10 trees arranged in 5 rows having 4 trees in each row.

• Find a pattern that satisfies the plan.

Problem Solving

An arborist is asked to plan an orchard that has 10 trees arranged in 5 rows having 4 trees in each row.

• A pattern that satisfies the plan:

What is the stuff around us? How do things work?

Ancient Questions: in Greece, China, Egypt & Arabia, Persia

Aristarchus
~ 270 B.C.E.

Does the sun "rise" in the east?

Two plausible possibilities.
(Geo-centric model)
Sun moves around the earth.

Cleanthes & Stoics
~ 270 B.C.E.

(Helio-centric model)
Earth rotates and moves around the sun.

The Scientific Method

- STEM discoveries are driven by observing, comparing, asking questions, & then making predictions, but what is true and where does distorted speculation, lies & "fake news" begin?
- Empirical Analysis must not be based on false data for the Method to work.
- It is used to develop logical theories based on data that are truthful, but any method or system can be compromised.

What is the stuff around us? How do things work?

Ancient Questions: in Greece, China, Egypt, Persia

Geo-centric
Until the 16th century:
Copernicus / Galileo

Does the sun "rise" in the east?

Two plausible possibilities.
(Geo-centric model)
Sun moves around the earth.


Cleanthes & Stoics
~ 270 B.C.E.

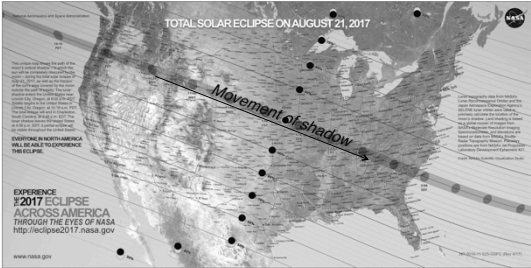
(Helio-centric model)
Earth rotates and moves around the sun.

<https://www.youtube.com/watch?v=4yzraWw8mrc> [1:17-]

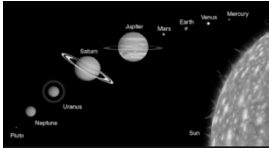
Solar Eclipse

Maximum ~ 75% of Total @ DVC: 10:15 AM
<https://eclipse2017.nasa.gov/>





Question



Does the sun rise in the east, and does the earth rotate clockwise or counter-clockwise? Provide an explanation for your answer.

A) Yes, Clockwise
 B) Yes, Counter-clockwise
 C) No, Clockwise
 D) No, Counter-clockwise

<https://www.youtube.com/watch?v=4yzraWw8mrc> [1:17-]

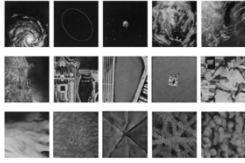
Some Possible Steps in the Scientific Method

1. **Observations**
 - qualitative (generalities)
2. **Science & Empiricism are based on, concerned with, or verified by observation rather than just supported by theory or pure intuition and logic. (It matters!)**
3. **Gathering information & Performing experiments**
 - gather new information to test whether the hypothesis is valid

Quantifying Observations

Measurements & Relative Comparative Scales


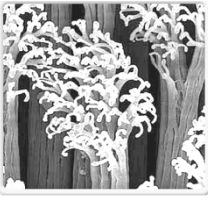
- Macroscopic vs. Microscopic (Large vs. Small)
- Charles & Ray Eames / IBM financed video:




[http://chemconnections.org/general/movies/PowersOfTen\(Charles & Ray Eames\) 1.mp4](http://chemconnections.org/general/movies/PowersOfTen(Charles&RayEames).1.mp4)
<https://www.youtube.com/watch?v=0fKBhvDjuy0>
 Powers of Ten (Images) <http://www.wordwizz.com/imagendx.htm>
<http://www.eamesoffice.com/>


Microscopic Gecko's Toe and Setae


6,000x (6×10^3)
 Magnification using Atomic Force Microscopy (AFM)





Full et. al., Nature (2000)
 5,000 setae / mm²
 600x frictional force;
 10⁻⁷ Newtons per seta (0.0000001)
 Geim, Nature Materials (2003)
 Glue-free Adhesive
 100 x 10⁶ hairs/cm² (100,000,000)
 Yurdumakan, Chem Comm (2005)
 200X Gecko's Force

Focus


Contrast



Brightness


Magnification


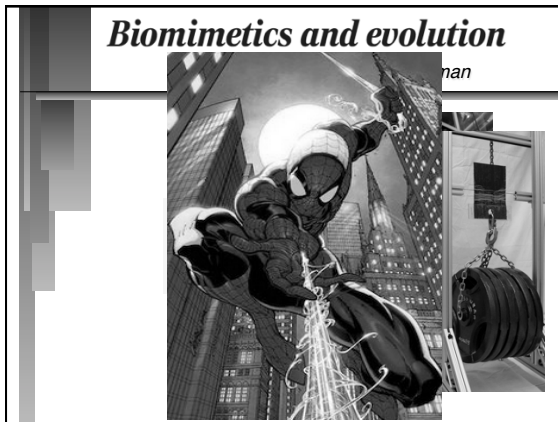
<http://micro.magnet.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

Biomimetics and evolution

<https://www.youtube.com/watch?v=9ZJYbcG0Ts0>



Science 345, 1448 (2014)



Microscopic vs. Macroscopic Relative Scale

Macroscopic stuff is large, and is generally something that is visible to the naked eye.

Microscopic things are very, very small and require magnification to perceive them.

[http://chemconnections.org/general/movies/PowersOfTen\(Charles & Ray Eames\).1.mp4](http://chemconnections.org/general/movies/PowersOfTen(Charles&RayEames).1.mp4)

<https://www.youtube.com/watch?v=0fKBhvDjuy0>

Microscopic vs. Macroscopic Relative Sizes

| MACRO | MICRO |
|--|--|
| <p>Macro-: observable types of molecules in food, e.g. fats, proteins, carbohydrates; needed in large amounts in our diet.</p> | <p>Micro-: the atoms, protons, neutrons & electrons, of the elements' molecules in the food.</p> |

<https://www.youtube.com/watch?v=wlvzfk5ozU>

Macroscopic

<https://phys.org/news/2015-10-big-universe.html>

How big is the observable “macroscopic” universe?

So large that light @ 186,000 miles/second has had barely enough time to travel the distance in 14 billion years.

Macroscopic stuff like the universe is sometimes too large for most of us to really appreciate.

Relative Comparisons

<https://www.youtube.com/watch?v=wlvzfk5ozU>

How does a football compare to the universe?

Some scientists believe that they have similar shapes.

Relative Comparisons

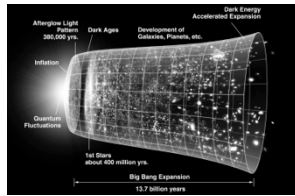
<http://www.space.com/24309-shape-of-the-universe.html>

How does the age of the universe compare to the age of the earth?

The earth is considered to be 4,540,000,000 years old. (4.54×10^9 years)

Relative Comparisons

<https://www.youtube.com/watch?v=Op3AYaJc0Xw>



How does the age of the universe compare to the age of the earth? $\frac{13,700,000,000 \text{ years}}{4,540,000,000 \text{ years}} = 3 \times$
(The earth is considered to be 4,540,000,000 years old.)

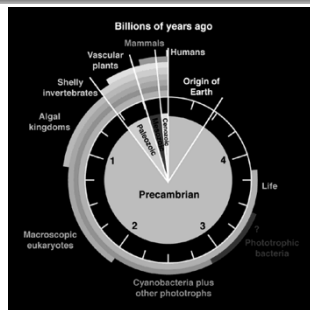
Scientific Notation & Mathematics

- **Short Hand expression:**
Powers of Ten / Exponents of base Ten
- **Count decimal places:** to left (+) and to the right (-)
 $4,540,000,000 \text{ yrs} = 4.54 \times 10^9 \text{ yrs}$
 $0.00000018 \text{ kg} = 1.8 \times 10^{-7} \text{ kg}$
- **Multiplication:** add exponents
- **Division:** subtract exponents

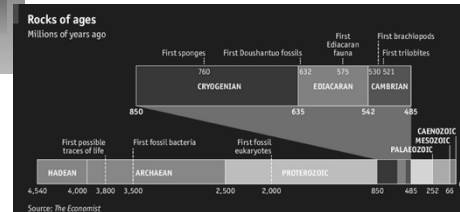
$$\frac{1.37 \times 10^{10} \text{ yrs}}{4.54 \times 10^9 \text{ yrs}} = 0.3017621145 \times 10^1 \times 10^{-1} = 3.02 \quad (\text{Move decimal})$$

<https://ed.ted.com/lessons/the-earth-s-age-in-measurements-you-can-understand-joshua-m-sneideman#watch>

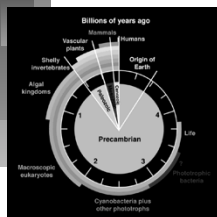
Simple Graphic Comparisons



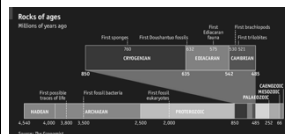
Simple Graphic Comparisons



Simple Graphic Comparison(s)



The earth is 4.54 billion years old and some humans' average lifespan is estimated to be ~80 years.



How does the age of the earth compare to a human's lifespan?

$$\frac{4,540,000,000 \text{ years}}{80 \text{ years}} = 56,750,000 \times$$

$$\frac{1}{56,750,000} = 0.0000000176 = 1.76 \times 10^{-8} \times$$

Scale & Relative Sizes

Macroscopic vs. Microscopic

How would you compare the age of Confucius (Master Kong, 孔夫子) born 551 BC, if he were alive today (551 yrs + 2019 yrs = 2570 yrs), to the age of the earth?...

$$\frac{4,540,000,000 \text{ years}}{2570 \text{ years}} = 1,770,000 \times$$

$$\frac{1}{1,770,000} = 0.000000565 = 5.66 \times 10^{-7} \times$$

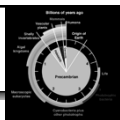
How would the age of mankind compare to the age of all living things?

$$\frac{3,800,000,000 \text{ years}}{200,000 \text{ years}} = 19,000 \times$$

the age of industrialized mankind to the age of mankind?

$$\frac{200 \text{ years}}{200,000 \text{ years}} = 0.001 \times$$

QUESTION



The earth is 4.54 billion years old and assume that our average lifespan will be 80 years. If the total age of the earth is represented by the face of a clock, how much time will 80 years be represented on the clock?

- A) 0.001520 seconds B) 0.00076 seconds
C) 0.0008 seconds D) 7,600,000 seconds
E) 15,200,000,000 seconds

Modern Science & Chemistry



That is:
Ground sloth



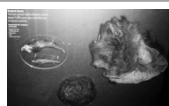
Ancient Sloth Dung Excites Scientists

The rate of species extinction is now ~100 times that of the "normal rate" over geological time.

- Would this excite you enough to pursue a career in science & chemistry?
- What could be a title for the scientist's PhD thesis, and what does dating have to do with it?

"People called my Ph.D thesis my 'Ph.D feces,'" says Hendrik N. Polnar, an American biologist working at the Max-Planck-Institute for Evolutionary Biology in Munich.

How do we know how old things are ? ... like sloth dung



Carbon Dating

Radiocarbon dating allows determining the age of biological artifacts like dung up to about 40,000 years old. This method provides an indirect measurement of age.

- Can this work for anyone, or any plant and animal that ever lived?
- Yes, but it only works for carbon artifacts, that's why we need a birth certificate to attest to our age.

How do we know how old things are ? ... like sloth dung

Carbon Dating ^{14}C life" = 5,730 ± 40 years

Los Alamos National Laboratory Chemistry Division

Periodic Table of the Elements

Representations of Measurements:

An example of a relative comparison using length to represent time

- TIME: 38,000 year old (dung) vs. 20 year old student
- LENGTH: $38,000 \text{ yrs} / 20 \text{ yrs} = 1900 \times$
 - Using lines to represent the respective ages that can be drawn on the classroom's blackboard; Select a scale:
 - 1 inch equals: 1 yr, 10 yr, 100yr, 1,000yr, 10,000yr. (Select an appropriate one.)
 - 38,000 years vs. 20 years
 - Which scale is best?



QUESTION

Which scale is the most practical to graphically represent the age of a 38,000 year old artifact vs. a 20 year old student on the same graph on a 5 meter (~ 15 feet) whiteboard or blackboard?

- A) 1 in= 1 yr B) 1 in= 10 yr
C) 1 in= 100 yr D) 1 in= 1,000 yr
E) 1 in= 10,000 yr

| <i>Match the years in the second column with choices from the first column</i> | |
|--|-------------------------------|
| A. Age of the earth | <u>B</u> 85 years |
| B. Average lifespan of a woman in US | <u>C</u> 195,000,000 years |
| C. Extinction of BIG dinosaurs (Years ago) | <u>E</u> 58 years |
| D. Alchemy (Years ago) | <u>I</u> 13,700,000,000 yrs. |
| E. Average lifespan of a man in Russia | <u>F</u> 2500 yrs. |
| F. Ancient science (Years ago) | <u>L</u> 3,800,000,000 yrs. |
| G. Age of chemistry | <u>K</u> 400 yrs. |
| H. Dr. R's age | <u>G</u> 200-300 yrs. |
| I. Age of the universe | <u>D</u> 1000 yrs. |
| J. Extinction of LITTLE dinosaurs (Years ago) | <u>A</u> 4,540,000,000 yrs. |
| K. Age of Modern Science | <u>H?</u> None of the choices |
| L. First life on earth | <u>J</u> 65,000,000 yrs. |