Physical Science 100: The BIG Picture

Goals and objectives
What did we try to do?
Did we do it?

1. Gain conceptual understanding of important principles

- Newtonian Synthesis – laws of force & motion
- Conservation Laws (energy, charge, matter, momentum)
- Special Relativity (time dilation, length contraction, motion symmetry)
- Law of Increasing Disorder (spontaneity, ranking of energy according to its order and usefulness)
- Model of the Atom (wave-particle duality of light & matter, uncertainty principle, exclusion principle; periodic properties)
- Model of the Nucleus (strong nuclear force & radioactivity)
- Chemical Bonding (ionic, covalent, metallic; intermolecular: dispersion, polar, hydrogen)
- Chemical & Nuclear Reactions (CR – atoms conserved, NR – mass-energy conserved; Both: energy downhill, entropy uphill)
- Processes on the Earth (plate tectonics, hydrologic system)
- Cosmology (Big Bang Model, Life History of a Star)

more observations explained in terms of principles

- observation: Water is an unusual molecule. For its mass, water has an unusually high melting and boiling point. Solid ice is less dense than liquid water
  explaining principles: Water molecule is polar; strong H-bonds hold ice molecules together in open structure (density); H-bonds make it hard for molecules to break loose from each other (melt & boil).

- observation: Dense, solid planets with thin or no atmospheres are nearest the sun.
  explaining principles: 1) Gravity pulls strongest on dense matter; 2) dense matter has high melting temperatures.

more observations & principles

- observation: nuclear fusion releases tremendous amounts of energy when it occurs in the sun, but it requires tremendous energy to make it occur in the lab
  explaining principles: strong nuclear force, electromagnetic interactions

- observation: cosmic ray-generated muons moving near the speed of light have a different lifetime than do stationary muons generated in a lab.
  explaining principle: special relativity

observations & principles, cont’d

- observation: electrons give predictable diffraction patterns;
  explaining principle: wave-particle duality

- observation: in the early study of nuclear processes involving beta decay, it was found that the mass of the products plus the gamma ray does not equal that of the starting materials. Search found the existence of neutrino
  explaining principle: conservation of mass-energy

more observations & principles

- observation: a moving head continues on through the windshield of an abruptly stopped car.
  explaining principle: Newton’s laws of motion

- observation: Humpty Dumpty could never be put back together again (or, it takes work to bring order out of the chaos of my office!)
  explaining principle: Law of Increasing Disorder
**last examples of the observations & principles**

**Observation:** The oceanic plate is subducted below the continental plate in oceanic-continental convergence zones. Principle of buoyancy (ultimately Newton’s laws of motion)

**Models of Matter – Unit 2 Summary Table**

<table>
<thead>
<tr>
<th>Model</th>
<th>Does Explain</th>
<th>Does NOT Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>appearances</td>
<td>Brownian motion</td>
</tr>
<tr>
<td>Molecular</td>
<td>Brownian motion</td>
<td>charged parts</td>
</tr>
<tr>
<td>Plum Pudding</td>
<td>charged parts</td>
<td>Rutherford’s exp’t</td>
</tr>
<tr>
<td>Nuclear</td>
<td>Rutherford’s exp’t</td>
<td>discrete spectra</td>
</tr>
<tr>
<td>Bohr</td>
<td>discrete spectra</td>
<td>accelerating charges?</td>
</tr>
<tr>
<td>Orbital (Quantum)</td>
<td>no acceleration</td>
<td>Why mercury is a liquid</td>
</tr>
</tbody>
</table>

**Quantum model of the atom connects structure of the Periodic Table & Chemical Reactivities of the Elements**

**Bonding Summary Table**

<table>
<thead>
<tr>
<th>Characteristics of Bonding</th>
<th>COVALENT</th>
<th>IONIC</th>
<th>METALLIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonds arise from electrostatic interactions</td>
<td>true</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>Energy levels are widely spaced</td>
<td>false</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>Interactions are long-range</td>
<td>true</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>Electrons are confined to individual nuclei</td>
<td>false</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>Electrons are shared between pairs of nuclei</td>
<td>false</td>
<td>true</td>
<td>true</td>
</tr>
<tr>
<td>Charge carriers (electrons or ions) are free to move in the solid-state</td>
<td>false</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>Charge carriers (electrons or ions) are free to move in the liquid or solution</td>
<td>true</td>
<td>false</td>
<td>true</td>
</tr>
</tbody>
</table>

**PICTORIAL SUMMARY of PLATE TECTONICS**
Plate Tectonics Summary Table

<table>
<thead>
<tr>
<th>Boundary Type</th>
<th>Earthquakes</th>
<th>Volcanoes</th>
<th>Fold Mt Belts</th>
<th>Trench</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divergent</td>
<td>Yes, Shallow</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td>MOR East Africa</td>
</tr>
<tr>
<td>Convergent Oc-Oc</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (Island arcs)</td>
<td>Yes</td>
<td>Aleutian Is, W.C.N &amp; S.A. Himalayas</td>
</tr>
<tr>
<td>Cont-Cont</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Transform</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td></td>
<td>San Andreas</td>
</tr>
</tbody>
</table>

3. Gain understanding of how science works -- Model 2

Model 2: Formulation of Theory of Plate Tectonics
accumulate masses of observations in diverse fields (Evidence for Pangaea, Seafloor Spreading, Seismic Studies)
but no coherent theory for many years which explains anything;
almost overnight revolution with introduction of simple idea (existence of mobile plates floating on the asthenosphere) which ties apparently unrelated observations together

Scientists Look For Patterns And Ask Why

Newtonian Physics followed this model

Next to Last Clicker Question

My final grade will be calculated _____ way(s). I will get the _____ score. I ____ take the final.

A) two ways, highest, must
B) two ways, lowest, don’t have to
C) one way, only, don’t want to

Last Clicker Question

A) I really liked the clickers.
B) I hated the clickers.
C) I’m neutral on them.
4. See how scientific advances fit into larger scope of human endeavors.

- science/technology
- human needs/wants
- Newtonian Physics → deterministic philosophies
- Quantum physics & special relativity → moral relativism

- John Calvin - religious thought - predestination; explanations existed for all avenues of human behavior; social behavior could be understood on basis of rationality: economics, sociology, psychology

- moral relativism
- there are no absolutes for human behavior, everything is culturally determined

5. See that science and faith are not mutually incompatible

- The LDS perspective: “The glory of God is intelligence.”

- A personal perspective: Filters of faith and science
  1. Look at science through filter of faith:
     - Faith gives me some assurance that there is a point to my science; that there is a rational explanation for things
     - Helps to keep me humble and keep successes and failures in perspective
  2. Look at religion through filter of science:
     “My religion doesn’t ask me to believe anything which isn’t true” (Henry Eyring - prominent LDS scientist, father of President Henry B. Eyring, LDS First Presidency)

And one from Pres. Hinckley

- Study your options.
- Pray to the Lord earnestly for direction.
- Then pursue your course with resolution.

Gordon B. Hinckley
Ensign May 2001

Let’s finish where we began

The eternal mystery of the universe is its comprehensibility.

The most beautiful emotion we have is the mystical. It is the power of all true art and science. He to whom this emotion is a stranger, who can no longer wonder and stand rapt in awe, is as good as dead.

Albert Einstein

Education is the power to think clearly, the power to act well in the world's work, and the power to appreciate life.

Brigham Young

One Last Cartoon....

Published Easter Sunday, 1996
Quotes to Live By

Ad Majorem Dei Glorium – All for the Honor and Glory of God

“In essentials, unity, in doubtful matters, liberty, in all things, charity.”

Pope John XXIII, Ad Petri Cathedram

“If you want peace, work for justice.” Pope Paul VI

In Medio Stat Virtue - Aristotle