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What is science?

- Trying to understand the world (facts, principles)
- Principles, at one time, were revolutionary, but now treated as fact
- Scientific Method
    - 0-Observation
    - 1-Ask questions
    - 2-**Hypothesis**-educated guess, not always the correct answer
        - testable and predictive, does it pass an "if/then" test?
        - Past and future events, both difficult and easy
        - Events that haven't happened yet don't invalidate
    - 3-Data
    - 4-Evaluate: correct/incorrect?
        - Usually wrong (Edison had 200+ failed light bulb designs)
        - Revise hypothesis with collected data
- **Theory**=re tested hypothesis over and over, results all agree, lots of testing and evidence (upgraded hypothesis)
- **Law**=upgraded theory, almost indisputable evidence (99% sure its correct)
- Both are retested and revised!
    - Must have facts, not beliefs, to challenge ideas

What is Geology?

- Early mid 19$^{th}$ century, but questioning the world for longer
- **Catastrophism**: entire world explained by 6 huge catastrophes that occurred in a period of 1000 years (last was Noah's flood)
- James Hutton (1795) naturalist in Scotland, published "Theory of Earth" that became the basis of geology.
- **Principle of Uniformitarianism**: process in nature always had the same effect, consistent year after year
    - Major catastrophe was not needed to shape the earth; only needed small changes over time
    - Things we see now have been happening forever
    - Opposite of catastrophism

History of Geology

- **Actualism**: reformed version of uniformitarianism. Hutton was correct, but there were some catastrophes that did occur
    - Comets & asteroids
    - Meteorite enters the atmosphere, moves at 40 km/s (90,000 mph)
    - 30 m (100 ft) in diameter @ 15 km/s impacts w/ energy of 4 mil tons of TNT

How did the Earth Form?

- 5 BYA=no solar system, just a nebula of H atoms
- 14-15 bil years old – universe
- **Nebula**=cloud of gas
- **Nebular Hypothesis**: starts with a nebula
    - 1. Gravity (attraction between all objects) affects over time. Draws H atoms closer together, confined in center. Temperature rises
    - 2. Cloud starts to flatten out and rotate (Frisbee) – SOLAR DISK MODEL
    - 3. **Protostar**: H forms a distinct body, a prototype star. Temperature continues to rise, not hot enough yet to become a star.
        - 6 GA (BYA)
    - 4. Temperature increases to become an actual star (hot enough for fusion). Fusion atoms combine to create different atom
        - can build ½ of elements on the periodic table
        - starts to cool down and stick together
    - 5. **Planetary Accretion**: particles combine to create planets
        - 4.5 GA, still happens today
        - most of earth's mass is already accreted-age of earth
- **Theia impact**:
    - Something the size of Mars collides with earth
    - Debris forms the moon

- Density is distributed randomly throughout the earth
- Theia melts a bunch of earth material, earth is just magma
    - Higher density rock sinks

Compositional/Chemical Layers

- 4 layers described by composition; earth cooled layers separated
    - 1. **Crust**: 8-45 km, composed of light elements like Si, Al, O
        - continental crust has lower density
        - oceanic crust has higher density
    - 2. **Mantle**: 45-2900 km, composed of denser elements like Fe, Mg
    - 3. **Outer Core**: mostly Fe, Ni, little bit of $SiO_2$
    - 4. **Inner Core**: 94% Fe, 6% Ni

Physical/Mechanical Layers

- 1. **Lithosphere**: crust and uppermost solid mantle (100 km)
    - **brittle**: strong, resistant, but will break into pieces/shatter)
- 2. **Asthenosphere**: plastic/ductile behavior
    - material gives way easily. Will bend or flow out of the way
    - consistency of peanut butter
- 3. **Mesosphere/Lower Mantle**: brittle because temperature acts against pressure

- **Outer Core**: Ductile, consistency of ketchup
- **Inner Core**: brittle, essentially a solid ball of iron

How Do We Know What's Within the Earth?

- Drilling only goes down a few miles at best
  - 1. Volcanoes: eruptions bring material to the surface
  - 2. Earthquakes: seismic waves tell about density
  - 3. Meteorites: earth formed via accretion of meteorites and the composition reflects earth's overall composition