Life & Mystery Topic

- Mystery topic
- What is needed for life?

- Test 2 on Tues, Feb 27
  - Large majority on solar system
  - Some question on telescopes & topics covered in test 1
  - Format similar to Test 1
  - Practice test: link on syllabus
  - Life & mystery not on test.

- Missouri “Show Me” Club
  - Today, 7:30-8:30pm, here

51 Pegasi

- Michael Mayor & Didier Queloz discovered something important by studying the star 51 Pegasi.
  - M&Q measured the speed of the star using Doppler effect
  - Doppler effect (p. 116): motion of star or us changes wavelength of light
  - Doppler effect measures only speed toward or away from us.

- Steps
  - Examine the data for the facts. Which clues are important? What is remarkable? What do I need to know? Ask.
  - Brainstorming
  - Developing your idea
  - Testing your idea
Motion of 51 Peg Away & Towards Us

Extrasolar planets

- What did Mayor & Queloz discover?
- Q What key clue says they discovered a planet and not a faint star?
  a. Period is 4 days 5 hr.
  b. Speed of star is 60 m/s.
  c. Motion repeats.
  d. They did not see the companion object.
Other ways to find extrasolar planets

• Observe light of planet
  – Did M&Q see what they discovered? No
  – Light from star overwhelms light from planet.

• Occultation
  – Planet partially blocks light of star
  – Need planet, star, Earth alignment.
  – Can measure size of planet.

Info from extrasolar planets

• Selection bias
  – Massive planets
  – Short periods

• Median distance <1AU

• Mass
  – Most are more massive than Jupiter
  – None are as massive as Earth.

• Density (few known)
  – Like Jupiter

• Orbital eccentricity
  – More eccentric than planets in solar system
### Info from extrasolar planets

- **Selection bias**
  - Massive planets
  - Short periods
- **Median distance $<1$AU**
- **Mass**
  - Most are more massive than Jupiter
  - None are as massive as Earth.
- **Density (few known)**
  - Like Jupiter
- **Orbital eccentricity**
  - More eccentric than planets in solar system

- **Q:** Which observations, when paired together, are surprising?
  a. Mass & density
  b. Mass & distance

---

**Planets close to the star “should” be rocky and not massive.**

**Best idea:**
- Planet did form far from star. Planet migrated close to star.
Life on earth

Evidence for life on the new Earth

- **C12/C13 ratio**
  - Living things have higher ratio of C12 than in non-living things.
  - Carbon in rock from 3.85Byr contain same higher C12/C13 ratio.
  - Carbon-incorporating life existed 3.85Byr ago

- **Stromatolite (mats of bacteria)**
  - Bacteria existed 3.5Byr ago

Fig 18-4 This section of a 3.5-billion-year-old stromatolite shows a structure nearly identical to that of a living mat. Thus, it offers strong evidence of having been made by microbes, including some photosynthetic ones, that lived 3.5 billion years ago.
How did life on Earth start?

- Urey-Miller experiment
  - With lightening, gases assemble into organic molecules
  - Life formed from these organic molecules
- Migration from outside Earth
  - Martian meteorite

Necessities for life

- Water
- Source of energy
- Building material
- Q: What is the source of energy for a tomato plant?
  a. Sunlight
  b. Heat from a volcano
  c. Radioactivity
- Q: What is the primary source of building materials for an oak tree?
  a. Ground
  b. Air
Bare necessities

• Time scale for life
  – Seconds
  – Could be millions of years

• Is sunlight absolutely necessary?
  – No: bacteria live near volcanic vents in the ocean.

• Is liquid water absolutely necessary?
  – An experiment
    • Place bacteria in a cold environment with radioactive nutrients
    • Wait a long time.
    • Did bacteria use the nutrients? Are bacteria radioactive?

Life in the solar system

• Requirements
  – Water
  – Energy
  – Building material
Europa

- *Not* made of ice.
  - Density similar to Moon
- Tidal forces keep it geologically active.
- Covered by layer of water ice.
  - Appears to be “pack ice” on top of an ocean.
  - Water must be warmed by heat from Europa’s interior.

Europa’s surface

- Ice rafts
- Nebraska-sized area showing ice and channels.
- Ice flow cutting across ridge
- The occasional impact crater
Titan

In visible light, from Voyager

- Composition: half ice, half rock.
- Has an atmosphere, with many similarities to Earth’s.

Cassini Satellite:
Radar images

Titan Dunes over Possible Craters
saturn.jpl.nasa.gov
Titan’s atmosphere

- Density about same as Earth’s 1.5 bars
- Primarily N₂, but also:
  - carbon monoxide (CO)
  - methane (CH₄)
  - ethane (C₂H₆)
  - propane (C₃H₈)
  - hydrogen cyanide (HCN)
    - a building block of DNA
  - C₂N₂, HC₃N
- Q: Which life-indicating gas is missing? A: CO₂; B: O₂; C: Neon; D: