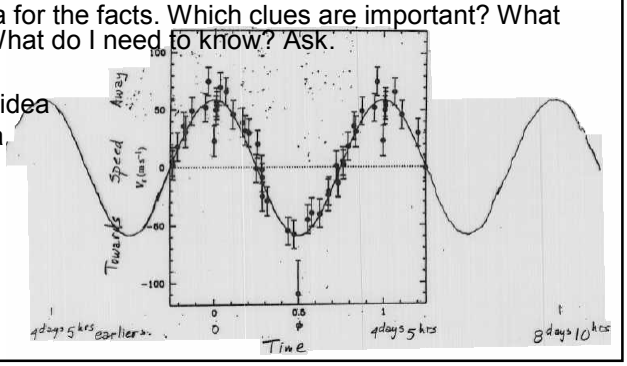
Life & Mystery Topic

- Mystery topic
- What is needed for life?

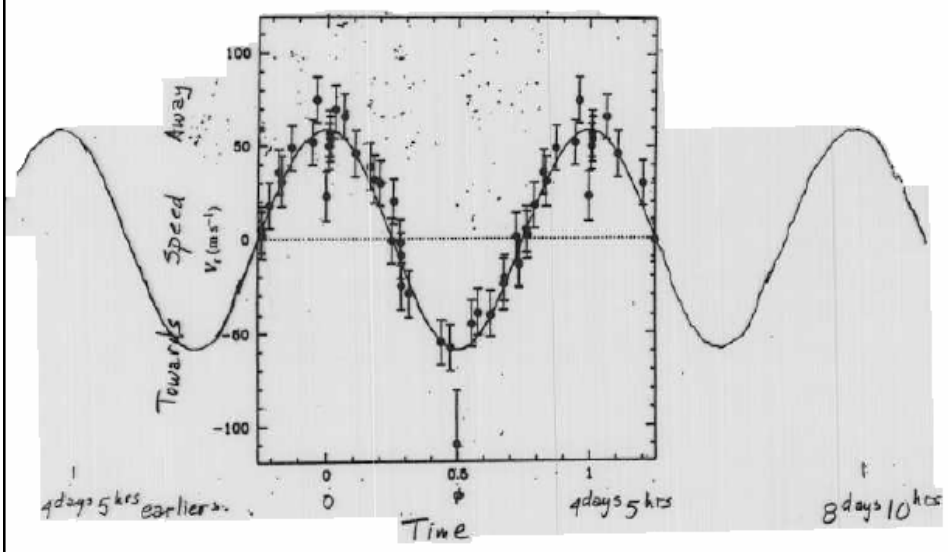
- Test 2 on Tues, Feb 27
  - Large majority on solar system
  - Some question on telescopes & topics covered in test 1
  - Format similar to Test 1
  - Practice test: link on syllabus
  - Life & mystery not on test.
- Missouri “Show Me” Club
  - Today, 7:30-8:30pm, here

51 Pegasi

- Michael Mayor & Didler 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



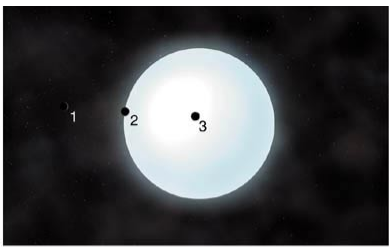
Motion of 51 Peg Away & Towards Us



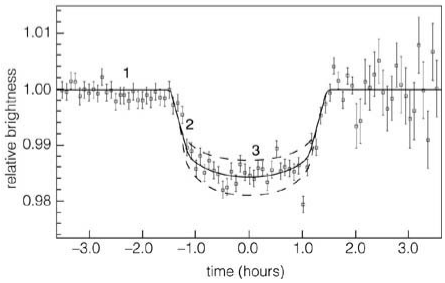
Extrasolar planets

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

Other ways to find extrasolar planets

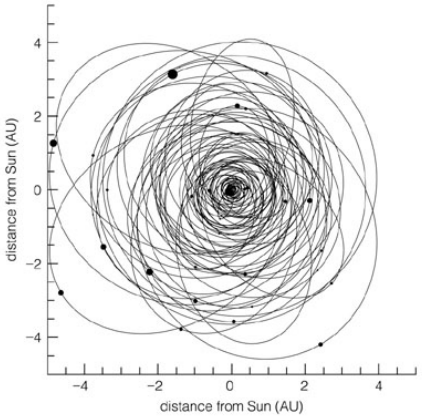


- Observe light of planet
  - Did M&Q see what they discovered? No
  - Light from star overwhelms light from planet.
- Occultation
  - Planet partially blocks light of star
  - Need planet, star, Earth alignment.
  - Can measure size of planet.



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



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- Q: Which observations, when paired together, are surprising?
  a. Mass & density
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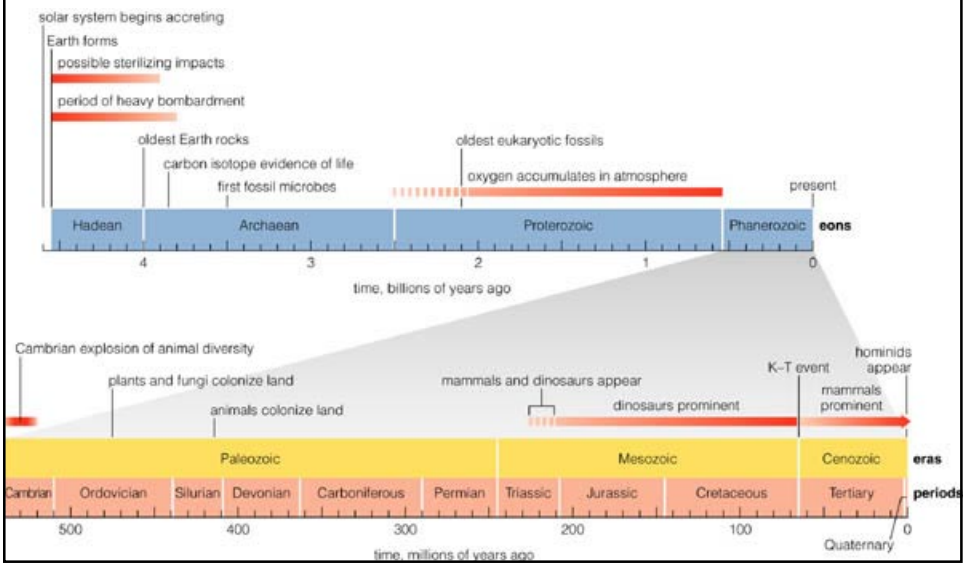
- Q: Which observations, when paired together, are surprising?
  a. Mass & density
  b. Mass & distance
- Planets close to the star "should" be rocky and not massive.
- Best idea:
  - Planet did form far from star. Planet migrated close to star.

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?

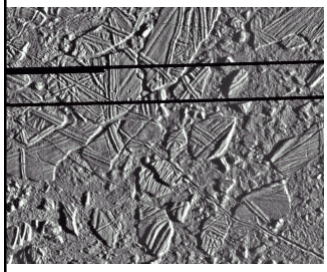
Life in the solar system

- Requirements
  - Water
  - Energy
  - Building material

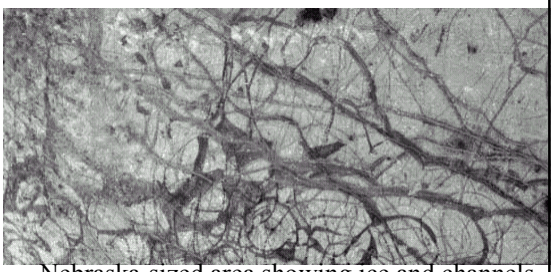
Europa

- *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.

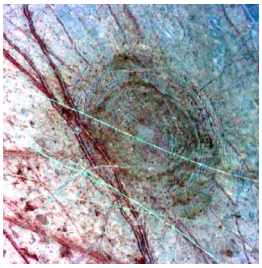
Europa’s surface



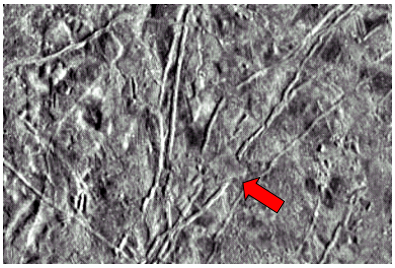
Ice rafts



Nebraska-sized area showing ice and channels.

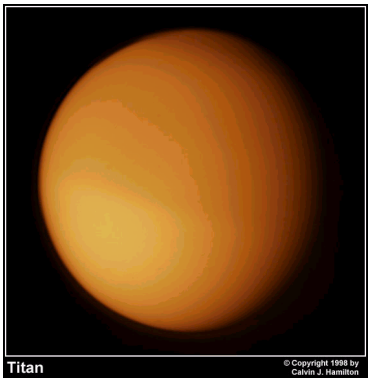


+ the occasional impact crater

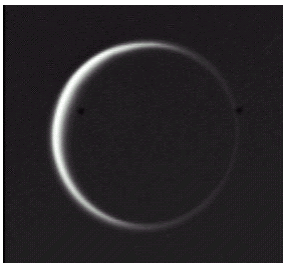


Ice flow cutting across ridge

Titan

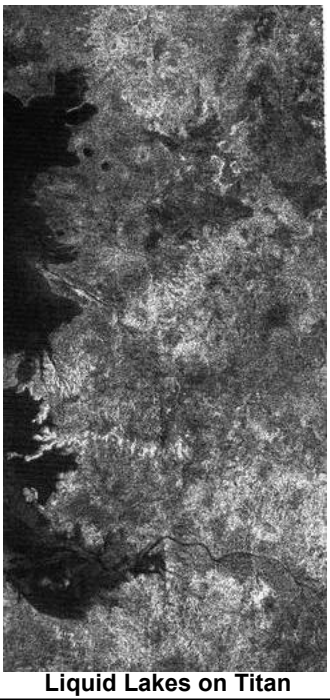


In visible light, from Voyager

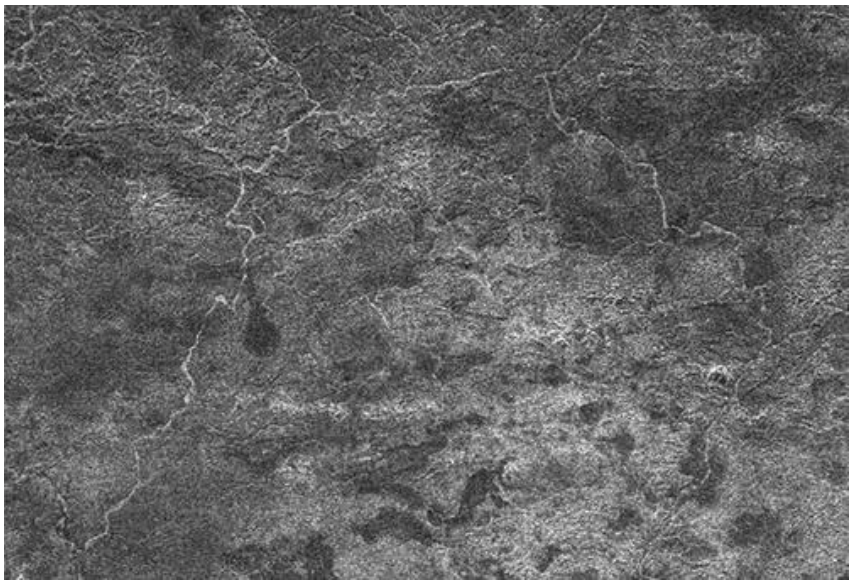

Looking back at Titan

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

Cassini Satellite: Radar images

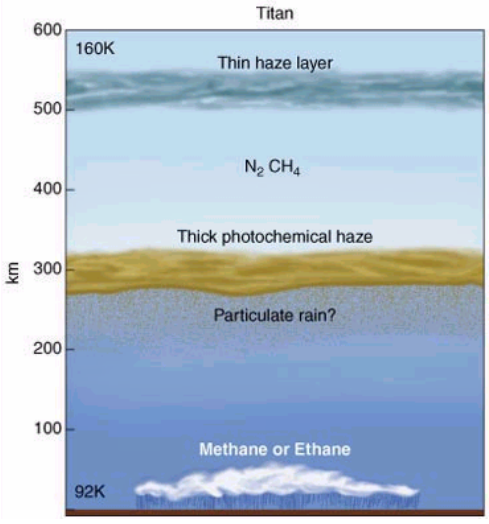

Liquid Lakes on Titan


Titan Dunes over Possible Craters
saturn.jpl.nasa.gov



Meandering Rivers

Titan's atmosphere



- Density about same as Earth's 1.5 bars
- Primarily N_2, but also:
  - carbon monoxide (CO)
  - methane (CH_4)
  - ethane (C_2H_6)
  - propane (C_3H_8)
  - hydrogen cyanide (HCN)
    - a building block of DNA
  - C_2N_2, HC_3N
- Q: Which life-indicating gas is missing? A: CO2; B: O2; C: Neon; D: