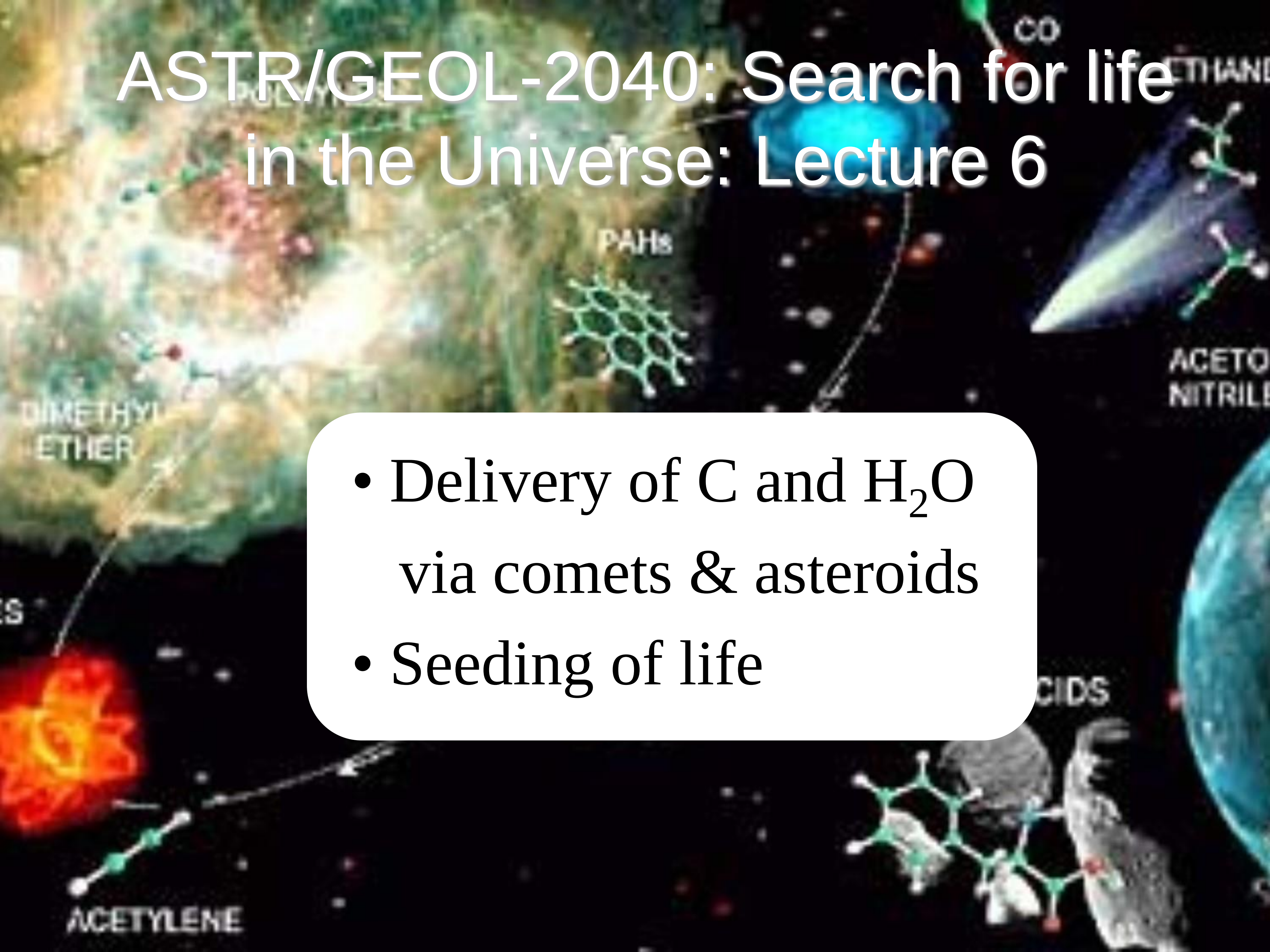
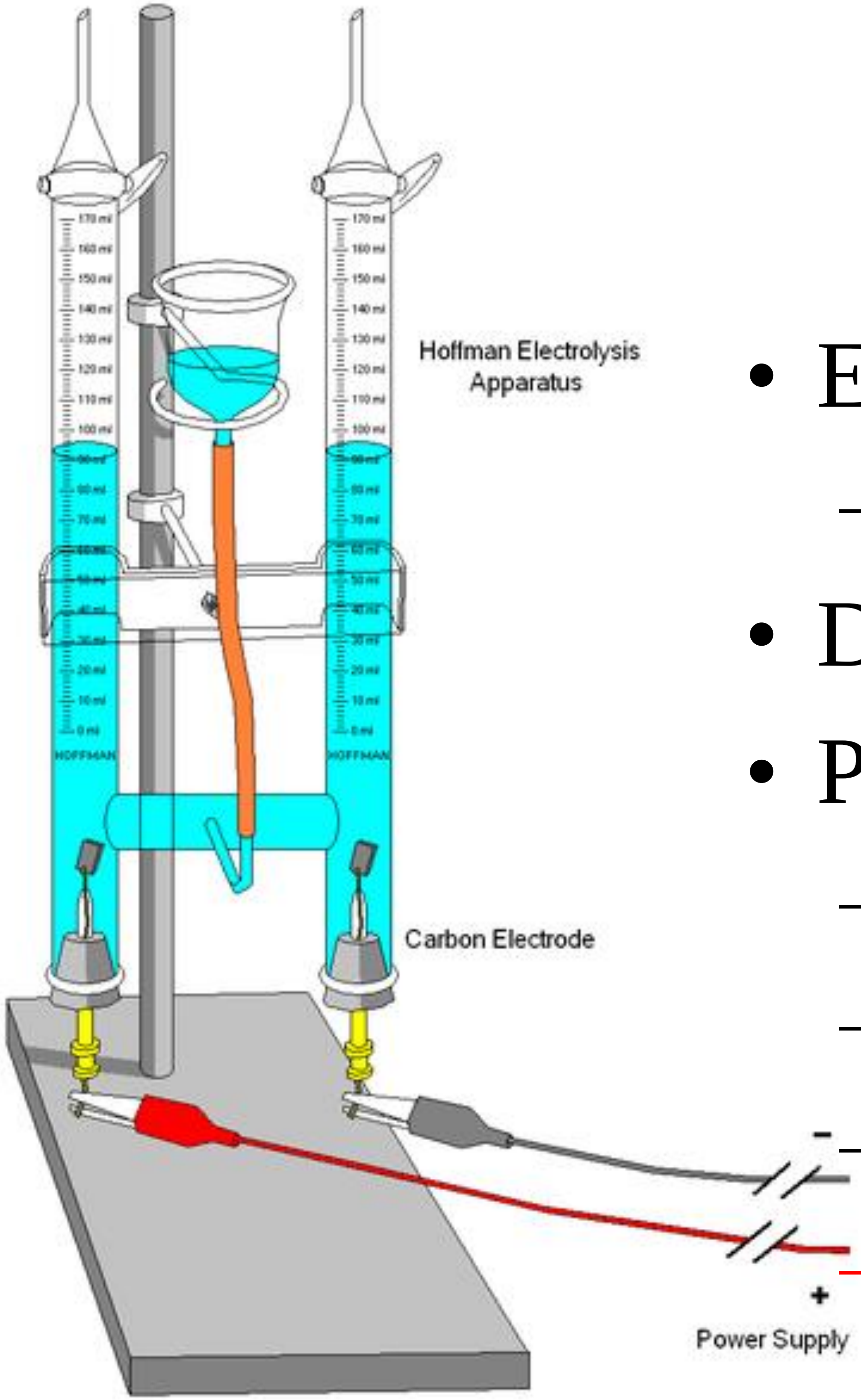
ASTR/GEOL-2040: Search for life in the Universe: Lecture 6

- Delivery of C and H_2O via comets & asteroids
- Seeding of life




Cassini dead since
5:55 this morning
EXIT



Today

- Electrolysis experiment
  - $2H_2O \rightarrow 2H_2 + O_2$
- Delivery by comets
- Panspermia Reading:
  - RGS pp. 22-24, 28-29
  - Lon pp. 383-384
  - BS pp. 121-125
  - also: BS pp 210-212

Power input?

- 200 Volts
- 0.1 Amps
- Power: 200V * 0.1A = 20 W

= 20 Joule/sec

Comparison

- 2500 calories/day = 10^7 J/day
  = 10^7 J/(24*3600s) = 120 W

Solar energy: 10 W from 13x10 inches

Mighty Max Battery

10 Watt Polycrystalline Solar Panel Charger for Deep Cycle Battery - Mighty Max Battery brand product

11 customer reviews | 13 answered questions

Price: $37.95 & **FREE Shipping**. Details

In Stock.

Want it tomorrow, Sept. 16? Order within 4 hrs 4 mins and choose **Saturday Delivery** at checkout. Details

Sold by Mighty Max Battery and Fulfilled by Amazon. Gift-wrap available.

- MLS-10WP is 12v 10 watt polycrystaline solar panel
- Dimensions: 13.75 inches x 10 inches x .75 inches. Pre drilled diodes in junction box and a pair of 6.5 foot cables with alligator clips already attached to the panel
- Strong aluminum frame and high efficiency solar cells bade on photvoltaic technology

- Power per square meter?
- $10W/[(13*0.0254m)*(10*0.0254m)$
  $= 120\ W/m^2$

How many Joules per year?

- 1 yr = $3x10^7$ sec

So 120 W = 120 J/s in 1 yr gives:

$120*3x10^7$ J = $360x10^7$ J = $3.6x10^9$ J

Source	Energy /J m^{-2} yr^{-1}
total radiation from the Sun	1 090 000.0
ultraviolet light	1 680.0
electric discharges (lightning)	1.68
cosmic rays	0.000 6
radioactivity (to 1 km depth)	0.33
volcanoes	0.05
shock waves (atmospheric entry)	0.46

Corrected in 2011 issue of RGS

Table 1.4 Present-day sources of energy averaged over the Earth.

Source	Power/W m^{-2}	$J/m^2 yr$
total solar radiation	360	$1.1 \cdot 10^{10}$
geothermal heat flow	8.1×10^{-2}	$2.6 \cdot 10^{6}$
electrical discharges (lightning)	5.4×10^{-8}	1.7
cosmic rays	2×10^{-11}	$6.3 \cdot 10^{-4}$
shock waves (atmospheric entry)	1.5×10^{-8}	0.47

- Efficiency of solar panels with 120 W/m^2 ?

1/3 or ~0.3 = 30%

Other numbers were ok

Source	$J\ m^{-2}\ s^{-1}$	Energy / $J\ m^{-2}\ yr^{-1}$
total radiation from the Sun	1.1×10^{10}	~~1 090 000.0~~
ultraviolet light		1 680.0
electric discharges (lightning)	1.7	1.68
cosmic rays	6.3×10^{-4}	0.0006
radioactivity (to 1 km depth)		0.33
volcanoes		0.05
shock waves (atmospheric entry)	0.47	0.46

Putting the right molecules together

- Need to produce order
  - → drive away from equilibrium
- Energy required to generate & sustain order

Source		Energy /J m^{-2} yr^{-1}
total radiation from the Sun	$1.1x10^{10}$	1 090 000.0
ultraviolet light		1 680.0
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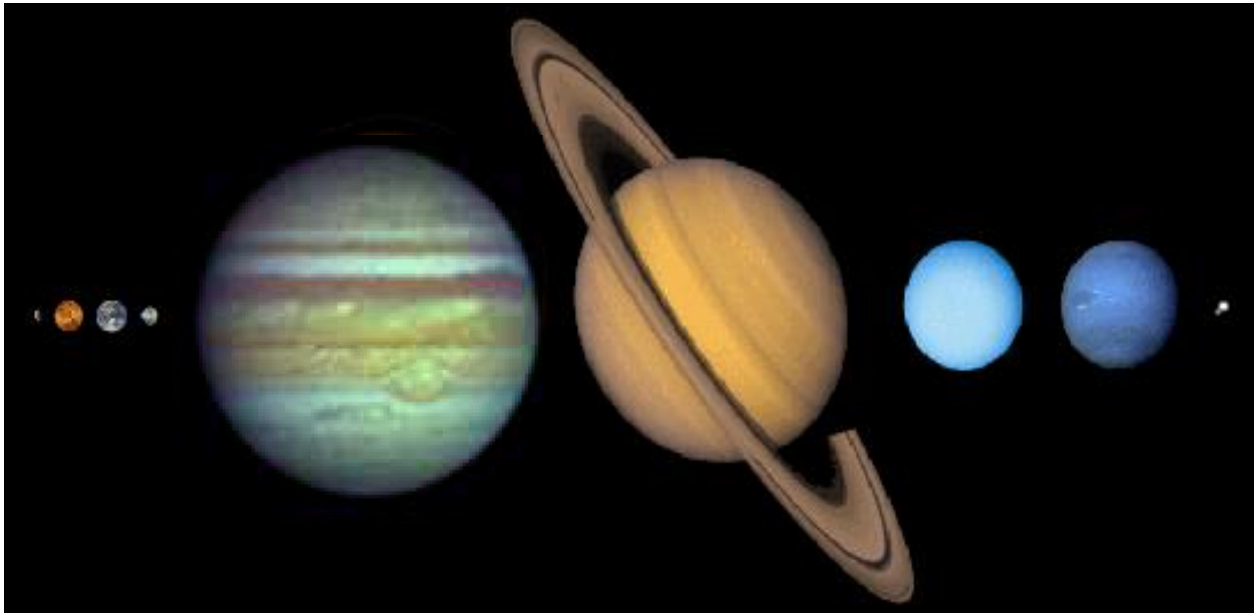
Conclusion from this

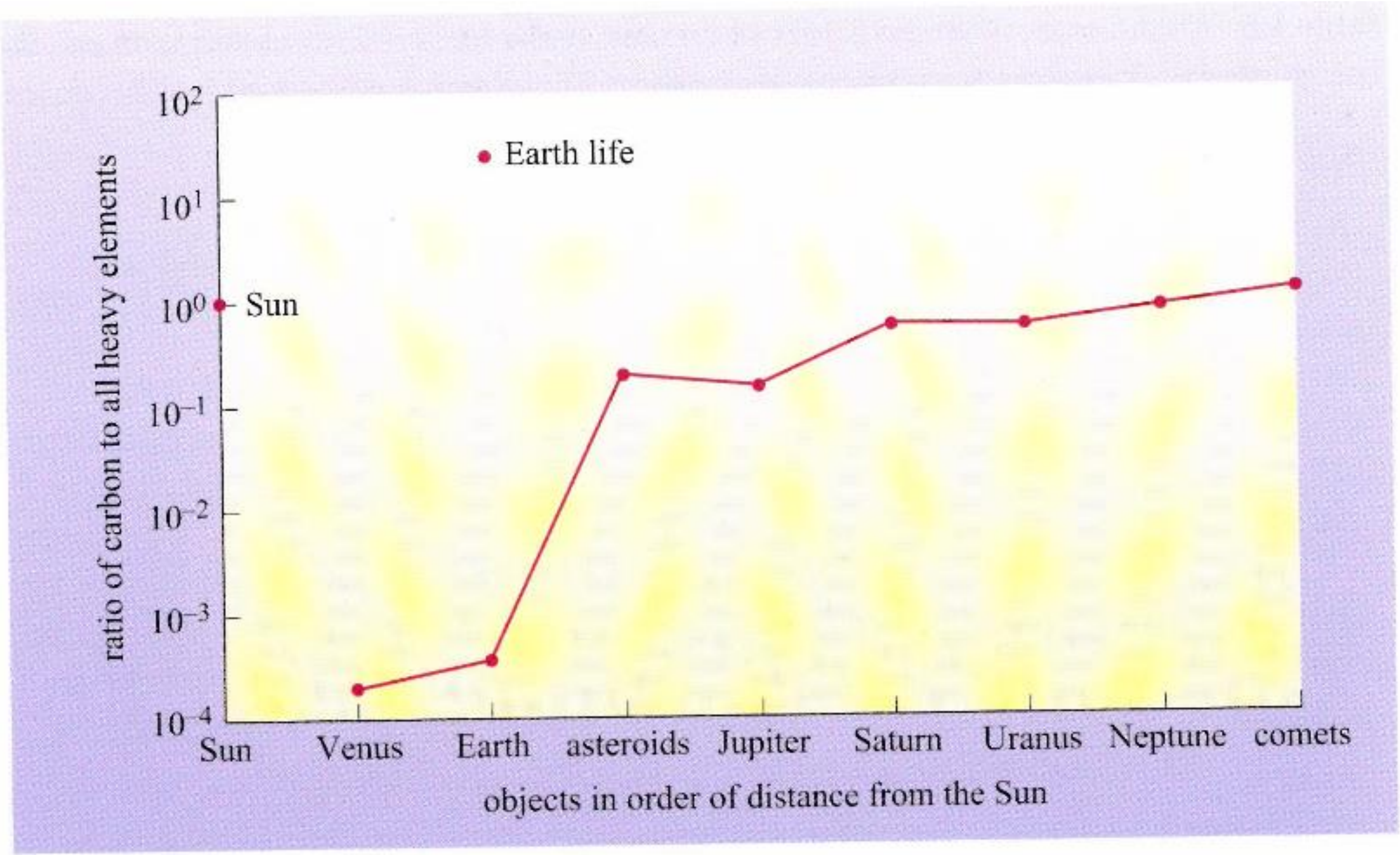
- Electrolysis experiment turned electric energy into chemical energy
- Hydrogen can be stored & used later
- Enery much higher than other non-solar energy sources
- Some biological metabolisms operate at much lower energies

Where in the solar system did it start?

- Where is the carbon?
- Where is the water?



Enough carbon in inner parts?



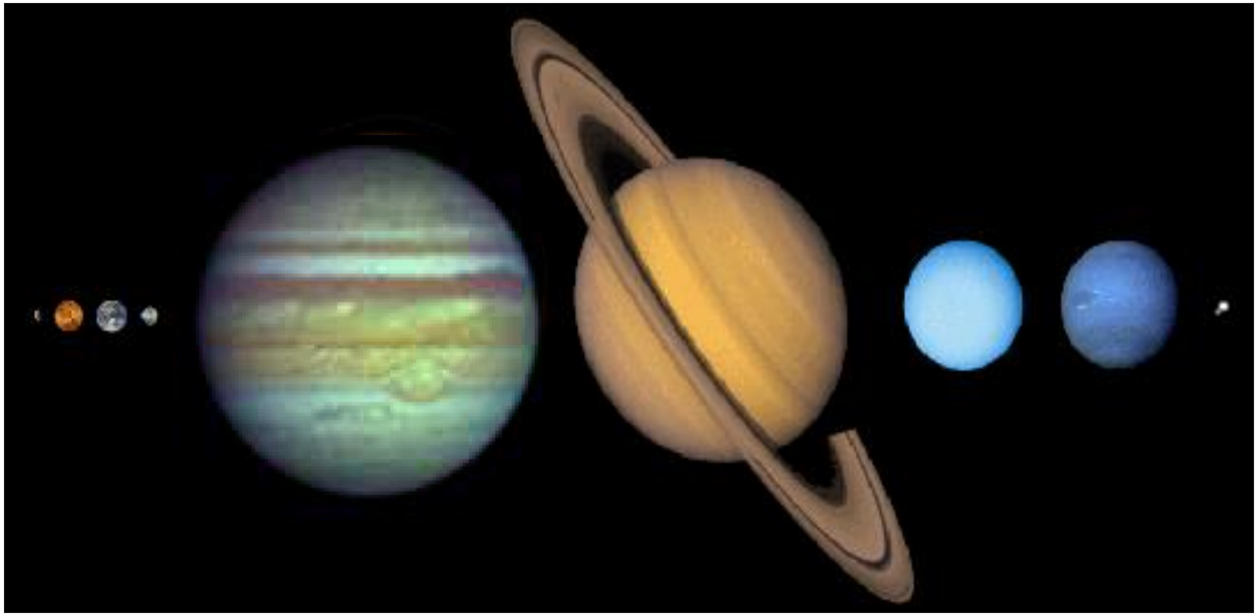
Noticed in 1961 (J. Oro)

RGS p.22

Puzzle

- Not much Carbon where liquid water
- A lot of carbon where water is frozen

What is the reason?



Carbon delivery (present rates)

Table 1.7 Accretion rates on Earth today.

Sources	Mass range /kg	Mass accretion rate (estimated) /10^6 kg yr^{-1}	Carbon %	Carbon accretion rate /10^6 kg yr^{-1}
meteoritic matter				
meteors (from comets)	10^{-17} to 10^{-1}	16.0	10.0	
meteorites	10^{-2} to 10^{5}	0.058	1.3	
crater-forming bodies	10^{5} to 10^{15}	62.0	4.2	
unmelted material contributing organic matter				
meteors (from comets)	10^{-15} to 10^{-9}	3.2	10.0	
meteorites, non-carbonaceous	10^{-2} to 10^{5}	2.9×10^{-3}	0.1	
meteorites, carbonaceous	10^{-2} to 10^{5}	1.9×10^{-4}	2.5	

- Which type is the greatest C source?

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meteorites	10^{-2} to 10^{5}	0.058	1.3	<0.001
crater-forming bodies	10^{5} to 10^{15}	62.0	4.2	**2.6**
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- Which type is the greatest C source?
  - Crater-forming bodies
  - Arrive intermittently

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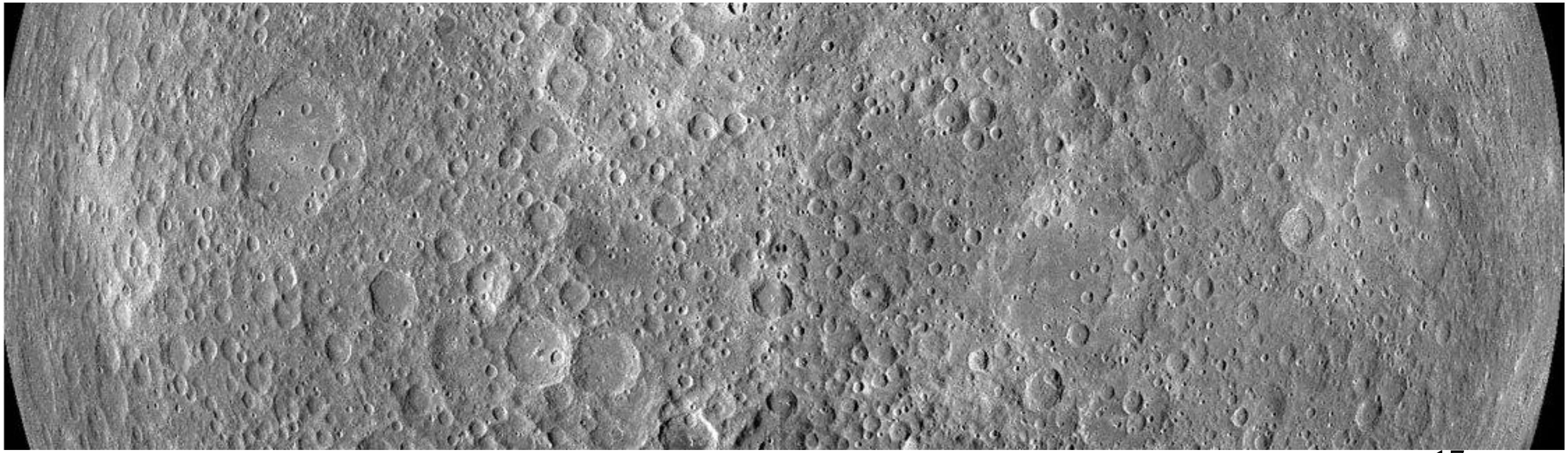
- Greatest organic C source?
- Compare with C of biomass: $6\text{x}10^{14}$ kg
  - $6\text{x}10^{14}$ kg / $0.3\text{x}10^{6}$ kg/yr = 20 x 10^{8} yr = 2Gyr

Carbon delivery

- Somewhat more anorganic than organic C
  - Organic C delivery continuous
- Enough to produce all C in biomass
  - Early rates likely much higher; see moon



Also water is volatile

- Not much water during formation
  - temperatures too high → dry accretion
- Possible solution:
  - Late delivery from beyond ”snowline”
  - Evidence: depletion wrt meteorites
- Low K/U (potassium to uranium ratio)
  - Indicator of relative depletion of volatiles

Is wet accretion possible?

- Yes, by later inward migration
  - Need to look at orbital dynamics
- Many body problem
  - Can easily become unstable

Water on terrestrial planets

- Not much on Venus and Mars
  - either acquired less than Earth,
  - or lost more
- Earth: much is in the mantle (2-10 times)
  - Venus: unclear (losses by impact & sol wind)
  - Mars: loss by solar wind (MAVEN)

Alternative: late delivery

- Also known as: late veneer
  - comets & asteroids
  - Formed beyond snow line
- Potential problem D/H ~ 3×10^{-4}
  - Ocean water D/H = 1.56×10^{-4}
- But 103P/Hartley 2 (IR): comp. w/ Earth
- For the coma: core could be enriched

Different types of comets

LETTER

doi:10.1038/nature105

Ocean-like water in the Jupiter-family comet 103P/Hartley 2

Paul Hartogh[1], Dariusz C. Lis[2], Dominique Bockelée-Morvan[3], Miguel de Val-Borro[1], Nicolas Biver[3], Michael Küppers[4], Martin Emprechtinger[2], Edwin A. Bergin[5], Jacques Crovisier[3], Miriam Rengel[1], Raphael Moreno[3], Slawomira Szutowicz[6] & Geoffrey A. Blake[2]

For decades, the source of Earth's volatiles, especially water with a deuterium-to-hydrogen ratio (D/H) of $(1.558 \pm 0.001) \times 10^{-4}$, has been a subject of debate. The similarity of Earth's bulk composition to that of meteorites known as enstatite chondrites[1] suggests a dry proto-Earth[2] with subsequent delivery of volatiles[3] by local accre-

Our measured D/H value is substantially larger than that whi characterized the young Sun (4.5 Gyr ago; the protosolar rati believed to be about 2.1×10^{-5}, which in turn is slightly higher th the value found in the local interstellar medium today (1.6×10^{-5}) a

Panspermia

- Arrhenius (1859-1927): spores survived
- Lord Kelvin (1824-1907): via meteorites
- Allan Hills meteorite (ALH 84001)
  - 4.5 Gyr: crystallized magma from Mars
  - 4.0 Gyr: battered, but not ejected
  - 3.6-1.8 Gyr: altered by water
  - 1984: discovered in Antarctica
  - 1996: NASA press conference

Why not Panspermia Earth → Mars?

A. Because of Earth's atmosphere
B. Because Earth is too massive
C. Because Earth is closer to the Sun
D. Because of either B or C
E. Because of both B and C

There are several good answers!

Why not Panspermia Earth → Mars?

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Panspermia

- Not a hypothesis for origin of life
  - We could be related to Martian life (think)
  - Other way unlikely (against Sun, heavier)
- Bacteria → suspended animation
  - Virtually no metabolism (bact spores)
  - Hardy to heat, desiccation, radiation, chem.
- Record so far 250 Myr (Lon 384)
  - Isolated bubbles, lake bed Salado in NM

Next week's material

- Domains of life & extremophiles
  - Bacteria in antarctica survived -50 C (-58 F)
  - LUCA, the last common ancestor
- RNA world
  - It can also act as catalyst
  - No proteins necessary

Preparation for quiz #1

- Next week Thursday
- Check all lectures: def of life, order/disorder,
- Away from equilibrium
- Natural selection
- Carbon & Water, polar molecules
- Lipids and other building blocks
- Genetic code, A-T, G-C
- Biomarkers, meteorites, Miller/Urey, ...