WATER AND ORGANICS: ASTEROID DELIVERY?

T.OWEN
U. HAWAII

- **WE DON’T KNOW!!**

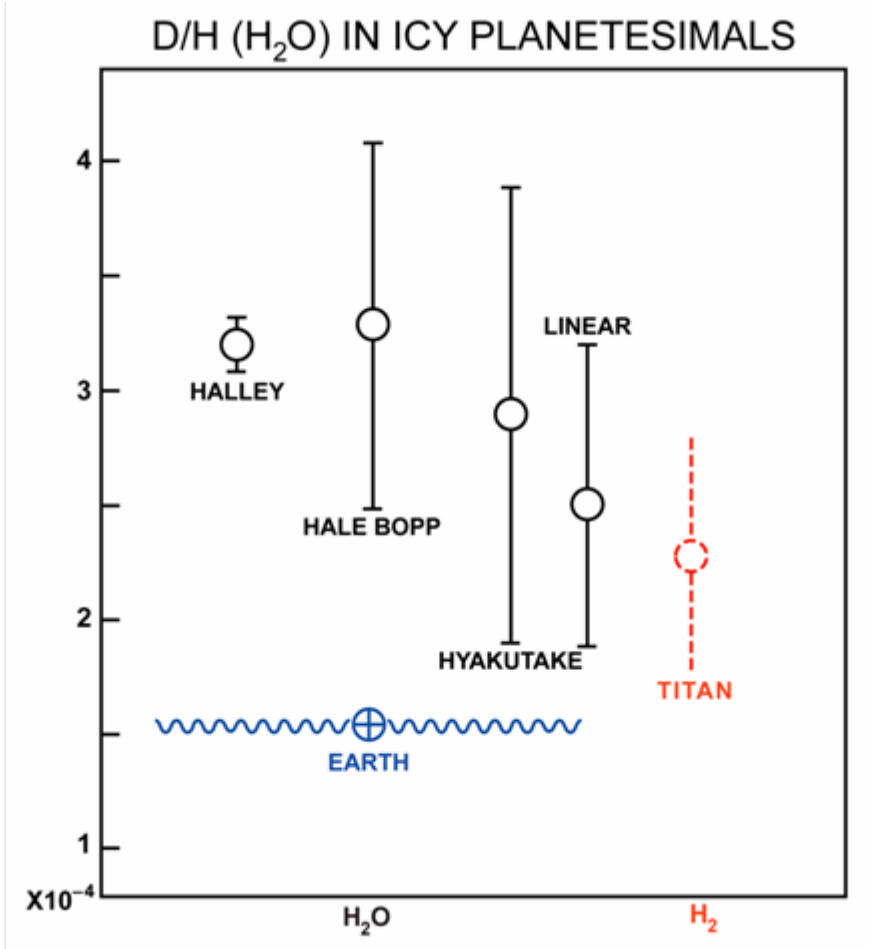
- 1.WATER

- 2. MAIN BELT “COMETS”

- 3. ORGANICS

WATER

(HYDROGEN—D/H)


D/H (H_2O) IN ICY PLANETESIMALS
4
3
2
1
X10^{-4}
HALLEY
HALE BOPP
HYAKUTAKE
LINEAR
TITAN
EARTH
H_2O
H_2

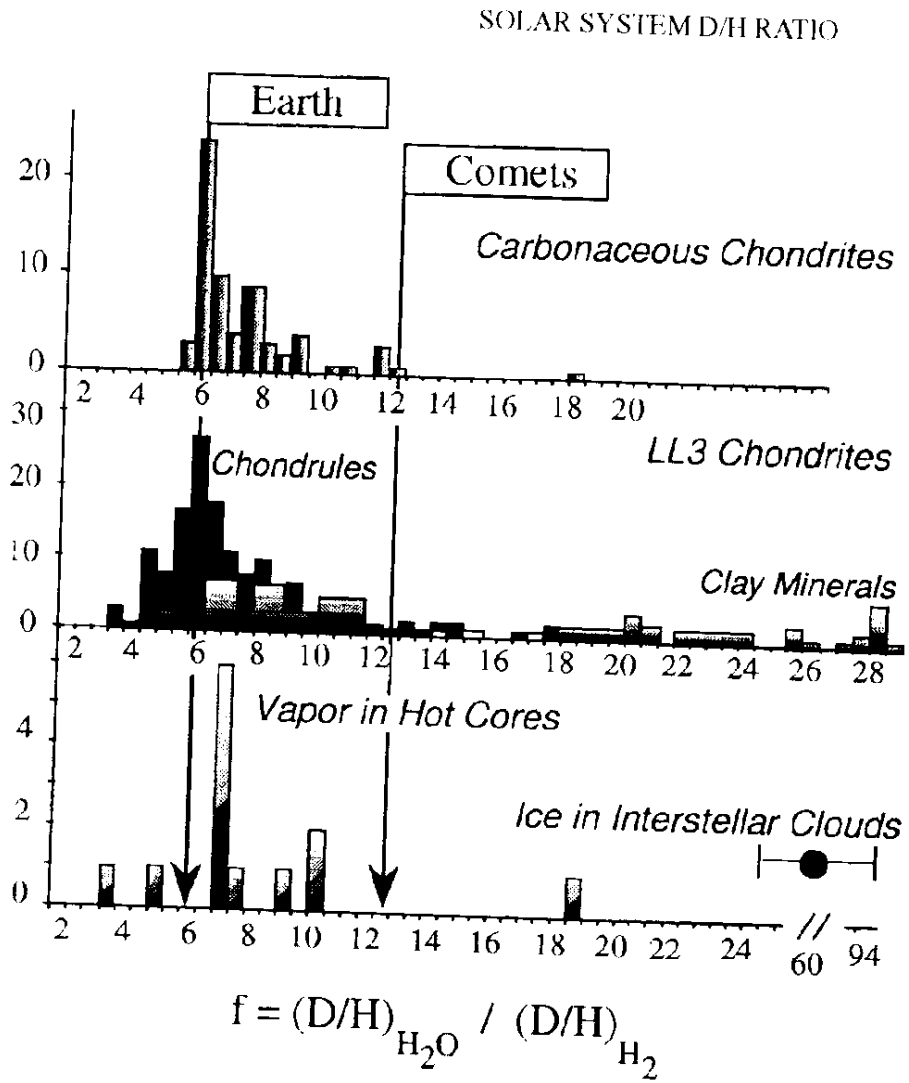
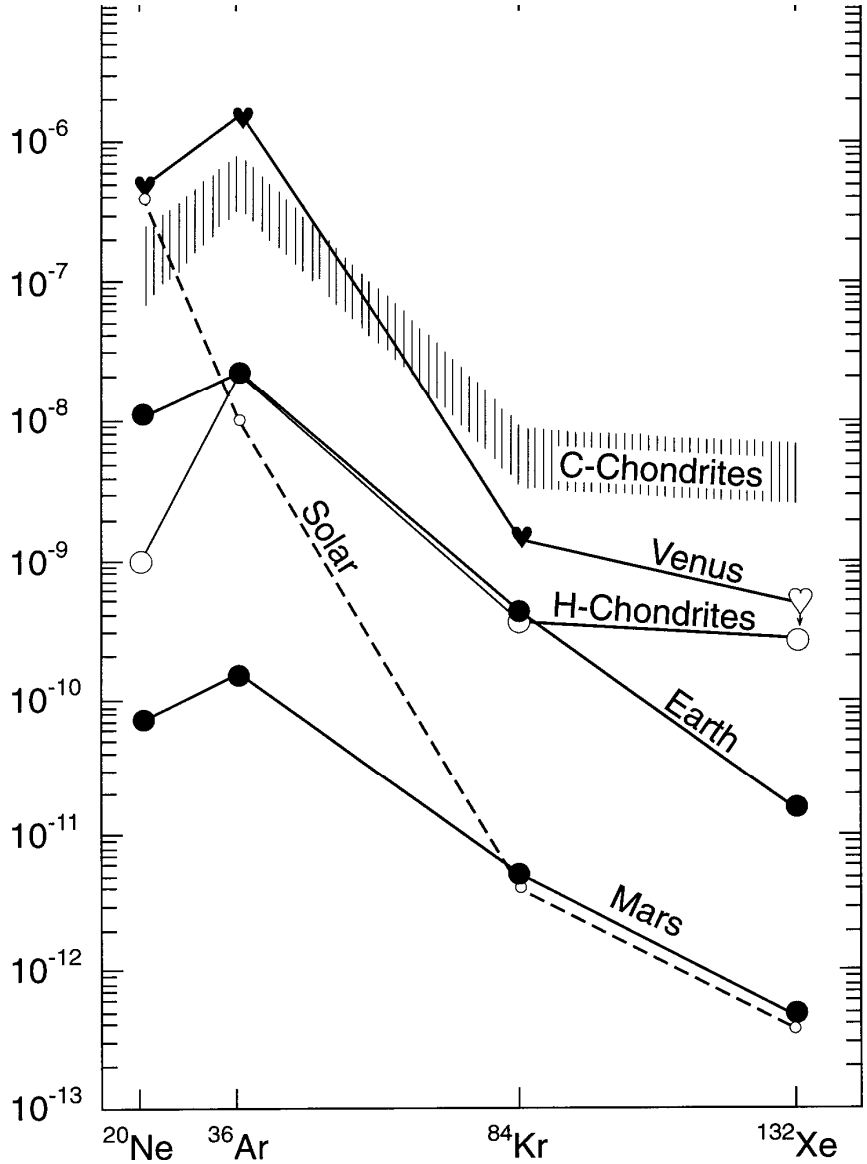
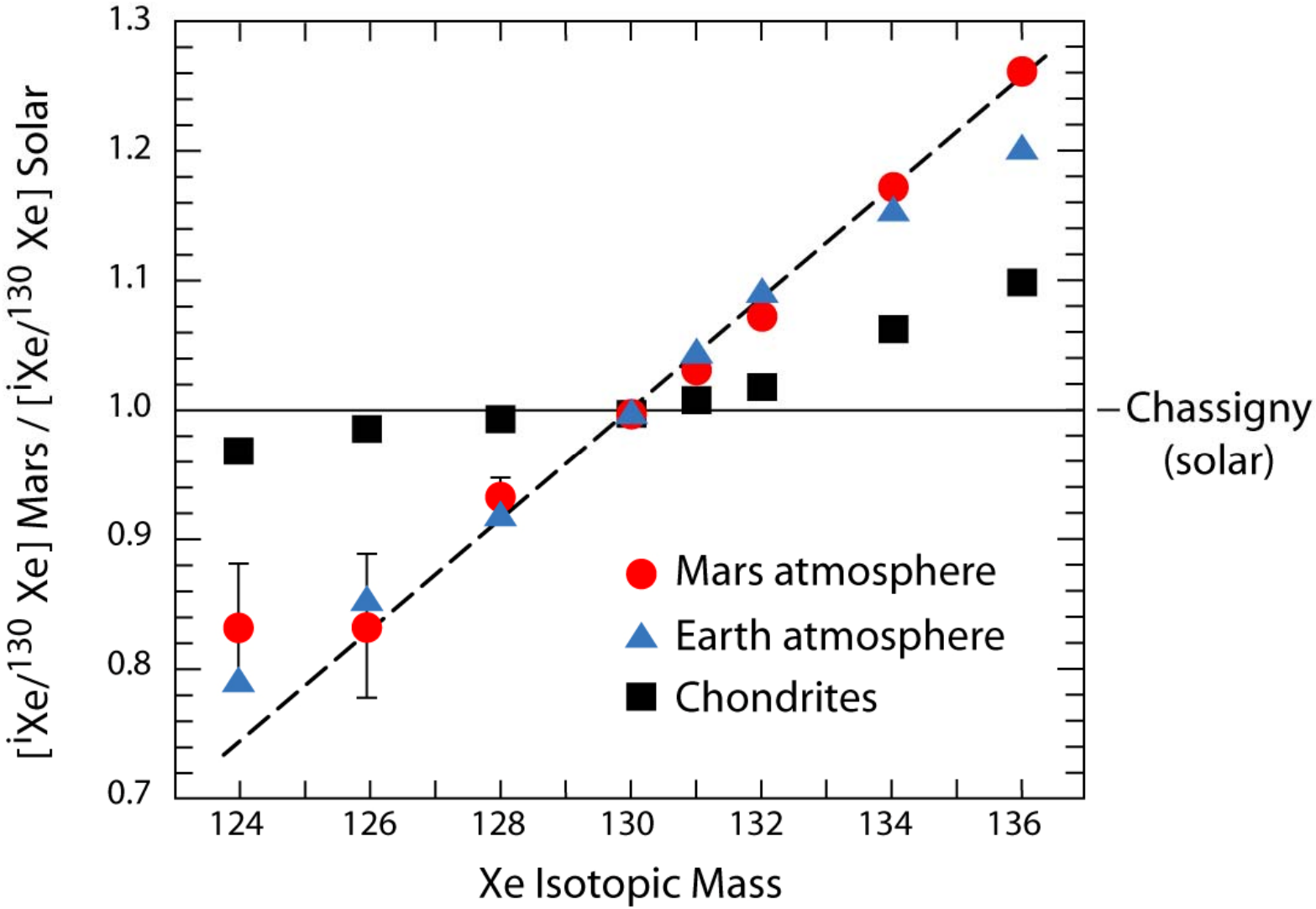


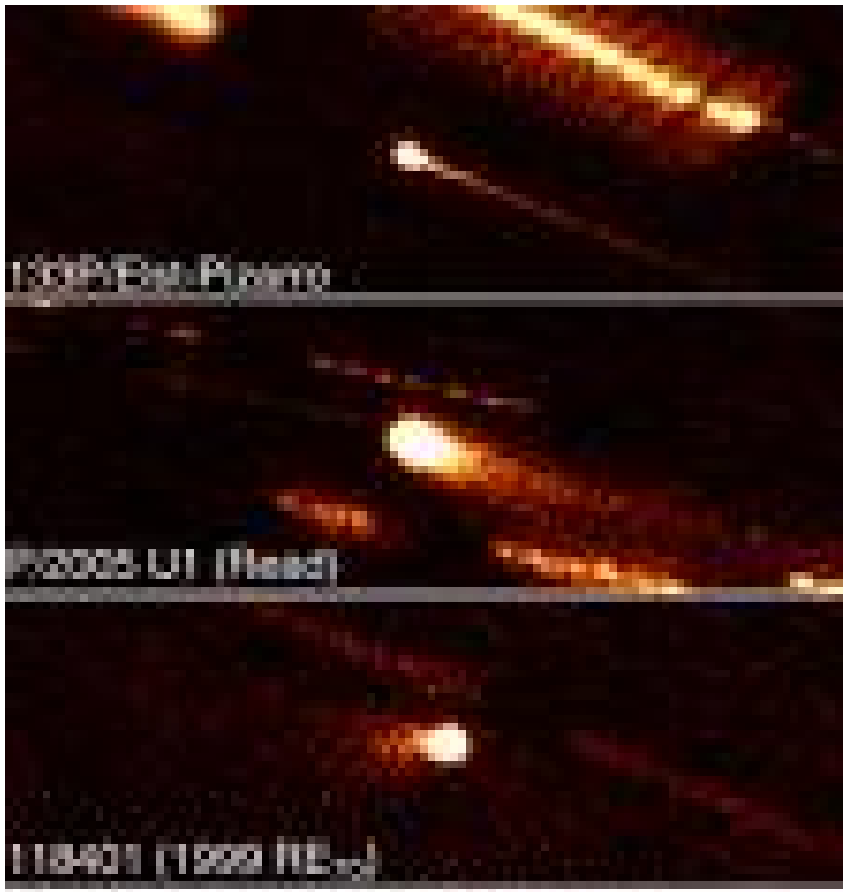
Figure 2. Histograms of distributions of the water D/H ratio in Carbonaceous Chondrites, in LL3 chondrules and clays, in Hot Cores and in interstellar ice (personal compilation of published data). According to this diagram, LL3 chondrites exhibit the best preserved record of the primordial isotopic heterogeneity of the solar system water. Note the similarity between the high D/H values in LL3 chondrites and in interstellar ices.


10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
C-Chondrites
Venus
H-Chondrites
Solar
Earth
Mars
^{20}Ne
^{36}Ar
^{84}Kr
^{132}Xe

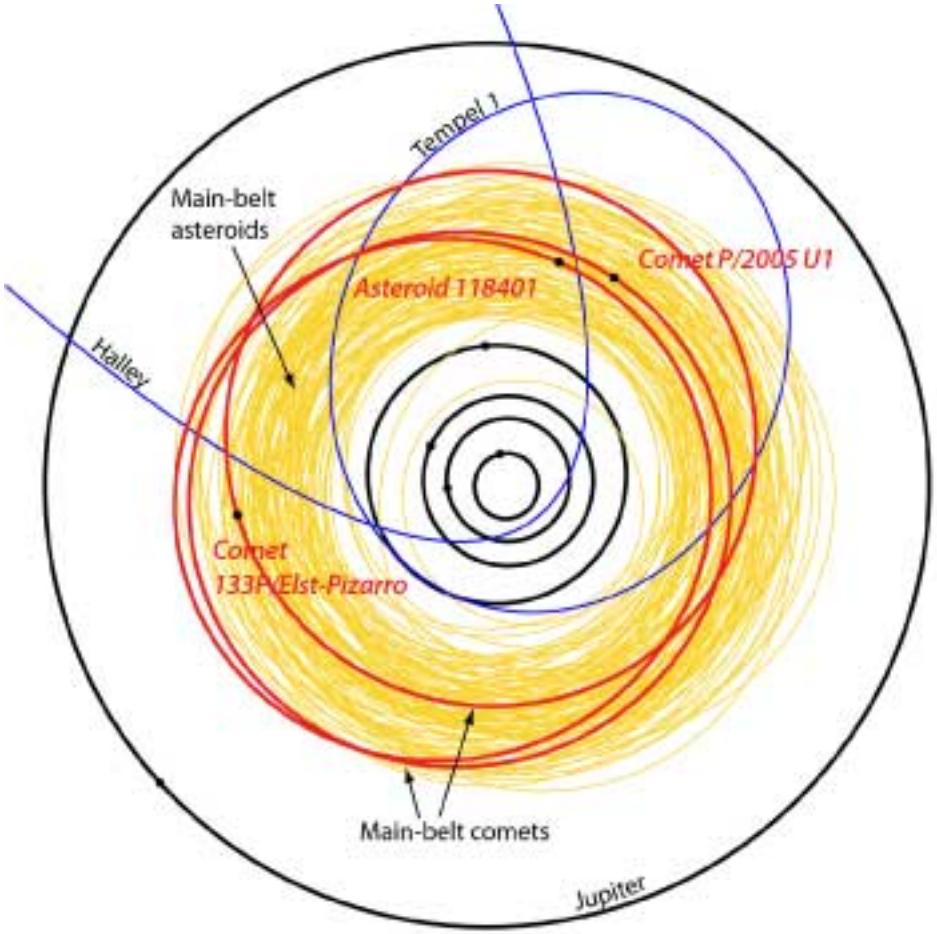
Xenon Isotopes – II
Mars = Earth!



● – EETA 79001 Glass Inclusions


(109P/Swift-Tuttle)
(P/2005 U1 (Read)
(118401 (1999 RE70)

MAIN BELTCOMETS



MBC: COMET OR ASTEROID?

BOTH?

TEST

D/H IN H_2O: 3.2×10^{-4} => COMET

1.6×10^{-4} => ASTEROID

2.4×10^{-4} => ASTERCOM

MBC: SOURCE OF EARTH WATER?

REQUIRES:

- $D/H = 1.6 \times 10^{-4}$

- **NOBLE GAS ABUNDANCES (AND XENON ISOTOPES)**

MATCH EARTH ATMOSPHERE

TOTAL ORGANIC MATTER DELIVERED BY METEORITES/ASTEROIDS/COMETS

COMPARABLE TO TOTAL MASS OF BIOSPHERE
--(CHYBA, SAGAN ET AL. 1989, 1990.)

BUT THIS ESTIMATE

IGNORES LIMIT SET ON METEORITIC CONTRIBUTIONS BY MIS-MATCH OF NOBLE GASES.

{SIMILAR LIMIT MAY APPLY TO COMETS}

AND THUS

INVITES NEW ESTIMATE, ALSO USING NEWER DATA ON IMPACT HISTORY OF EARLY EARTH.

FROM WHENCE CAME CARBON AND IN WHAT GUISE?

ORGANIC COMPOUNDS IN METEORITES

IOM

INSOLUBLE ORGANIC MATTER

90 TO 99% of carbon in meteorites

SOM

SOLUBLE ORGANIC MATTER

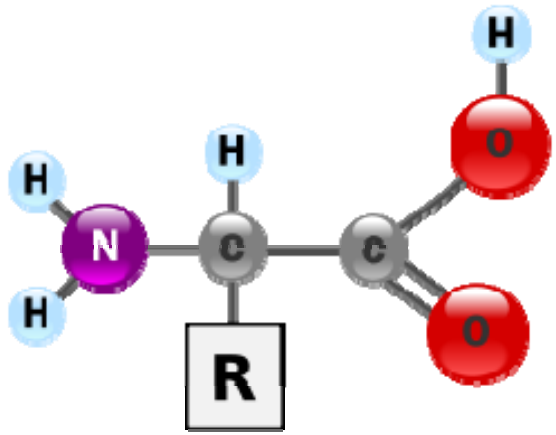
~10% of carbon

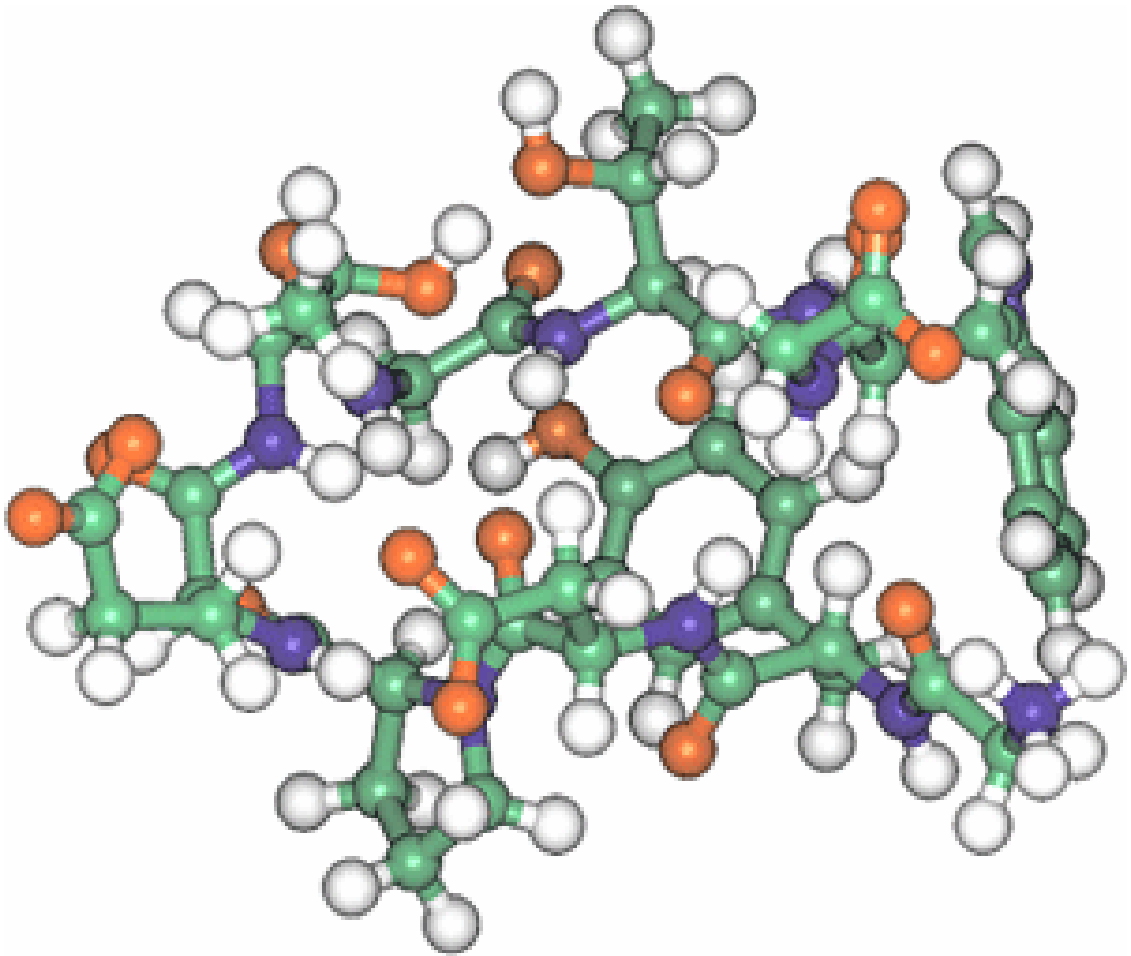
~0.1% is Amino Acids:

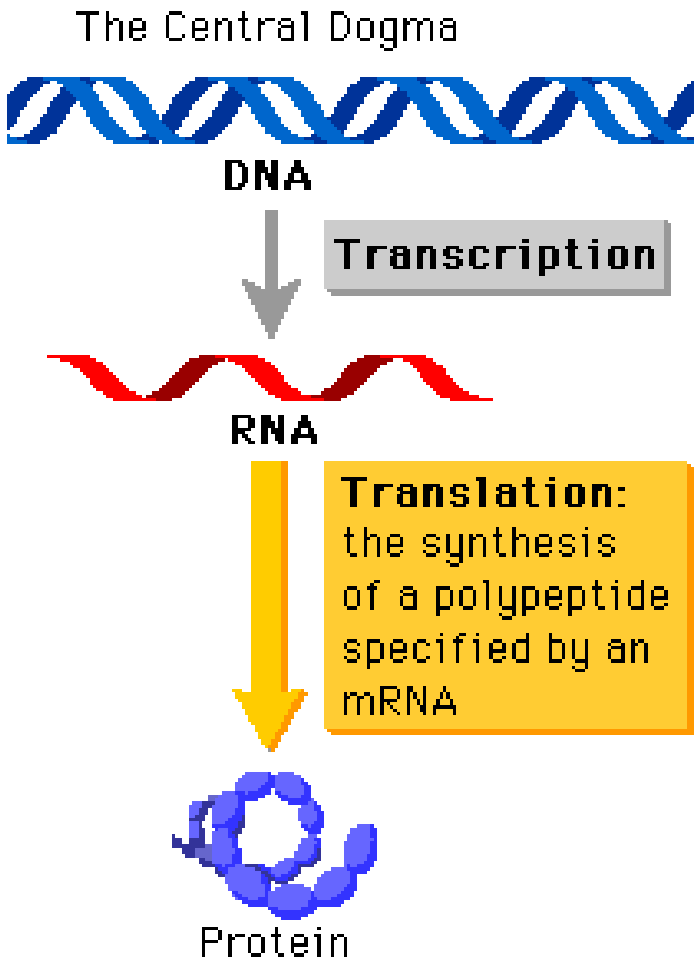
70 identified—J. Cronin

All Life on Earth uses 20

"Building Blocks" of Protein


H
O
H
H
N
C
C
O
R




The Central Dogma
DNA
Transcription
RNA
Translation: the synthesis of a polypeptide specified by an mRNA
Protein

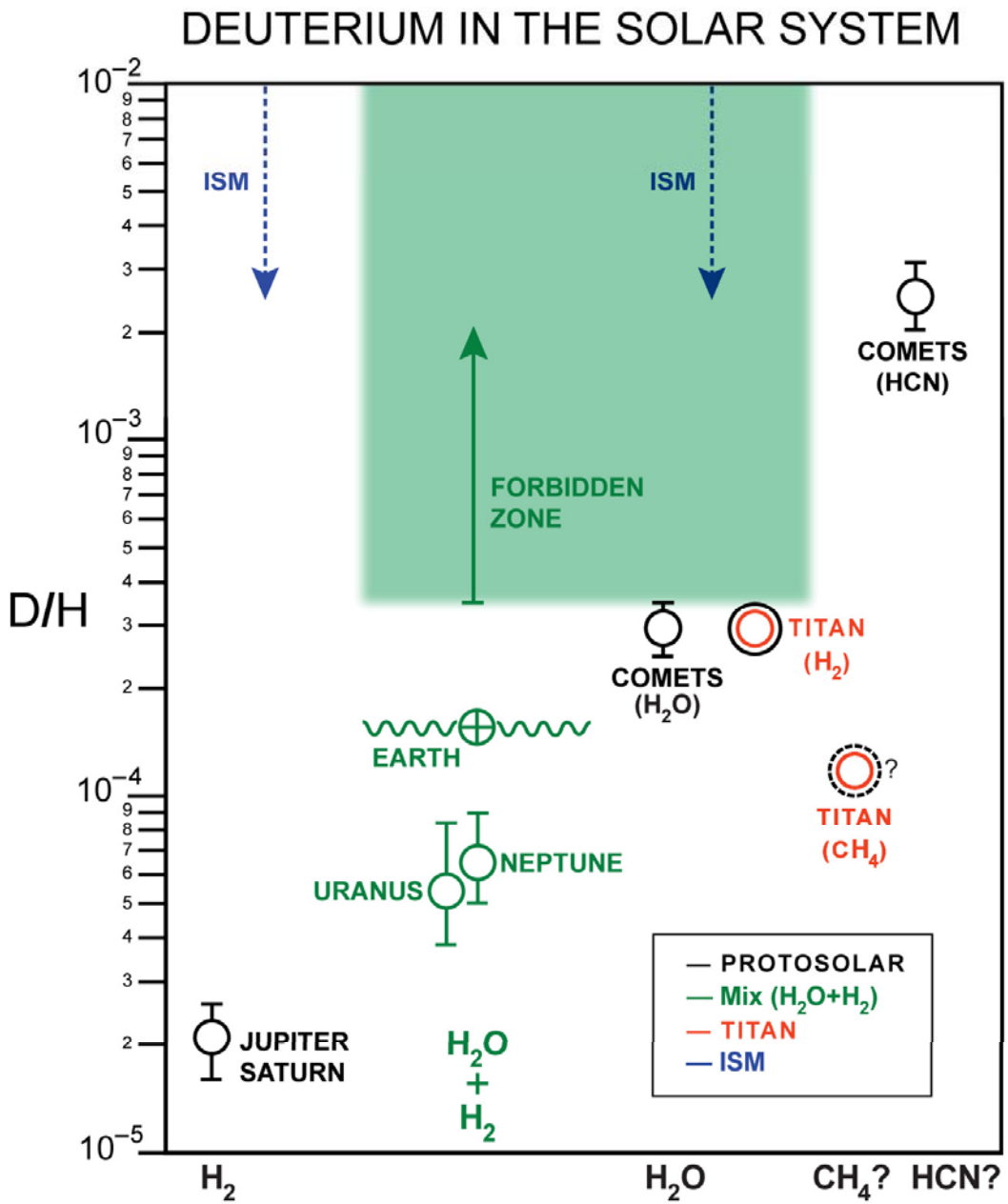
CONCLUSIONS: DELIVERIES?

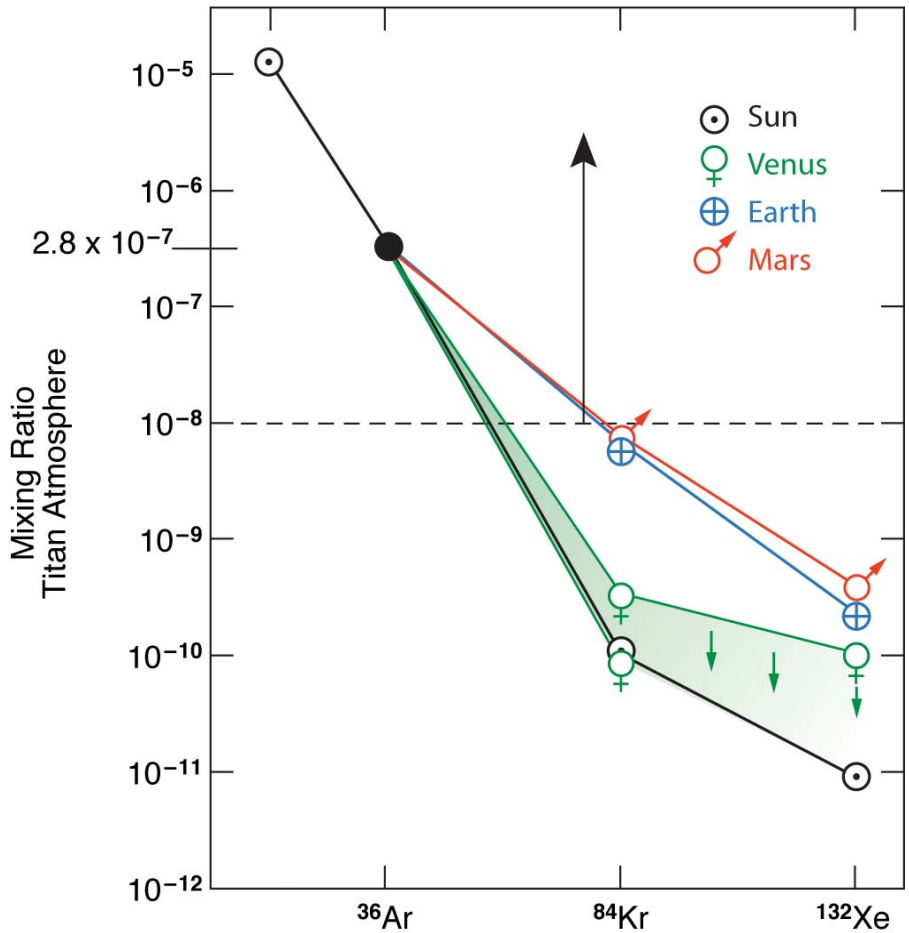
Some water—How Much?

Some Organics— How Much? Which?

Noble Gases and Isotopes Will Provide References.

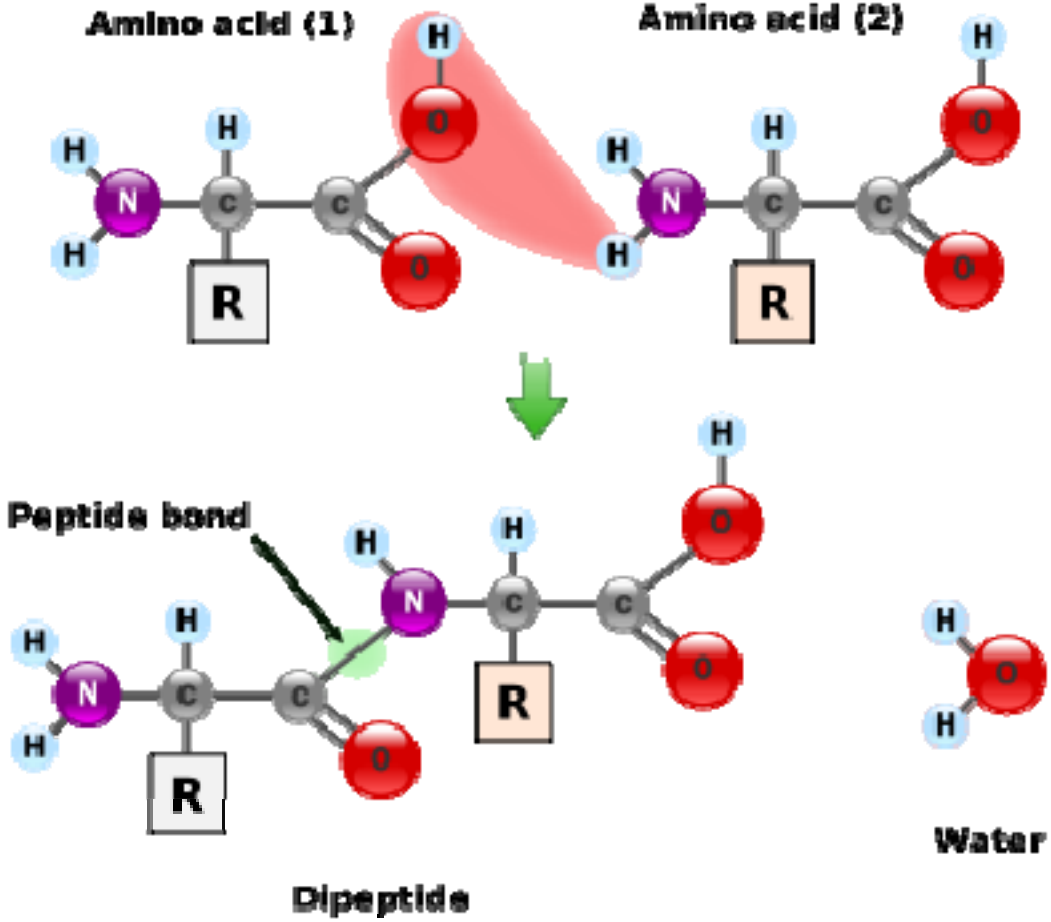
THIS PAGE IS DELIBERATELY LEFT BLANK


DEUTERIUM IN THE SOLAR SYSTEM
D/H
10^{-2}
10^{-3}
10^{-4}
10^{-5}
ISM
ISM
FORBIDDEN ZONE
COMETS (HCN)
COMETS (H_2O)
TITAN (H_2)
EARTH
TITAN (CH_4)?
NEPTUNE
URANUS
JUPITER
SATURN
H_2O + H_2
PROTOSOLAR
Mix (H_2O+H_2)
TITAN
ISM
H_2
H_2O
CH_4? HCN?

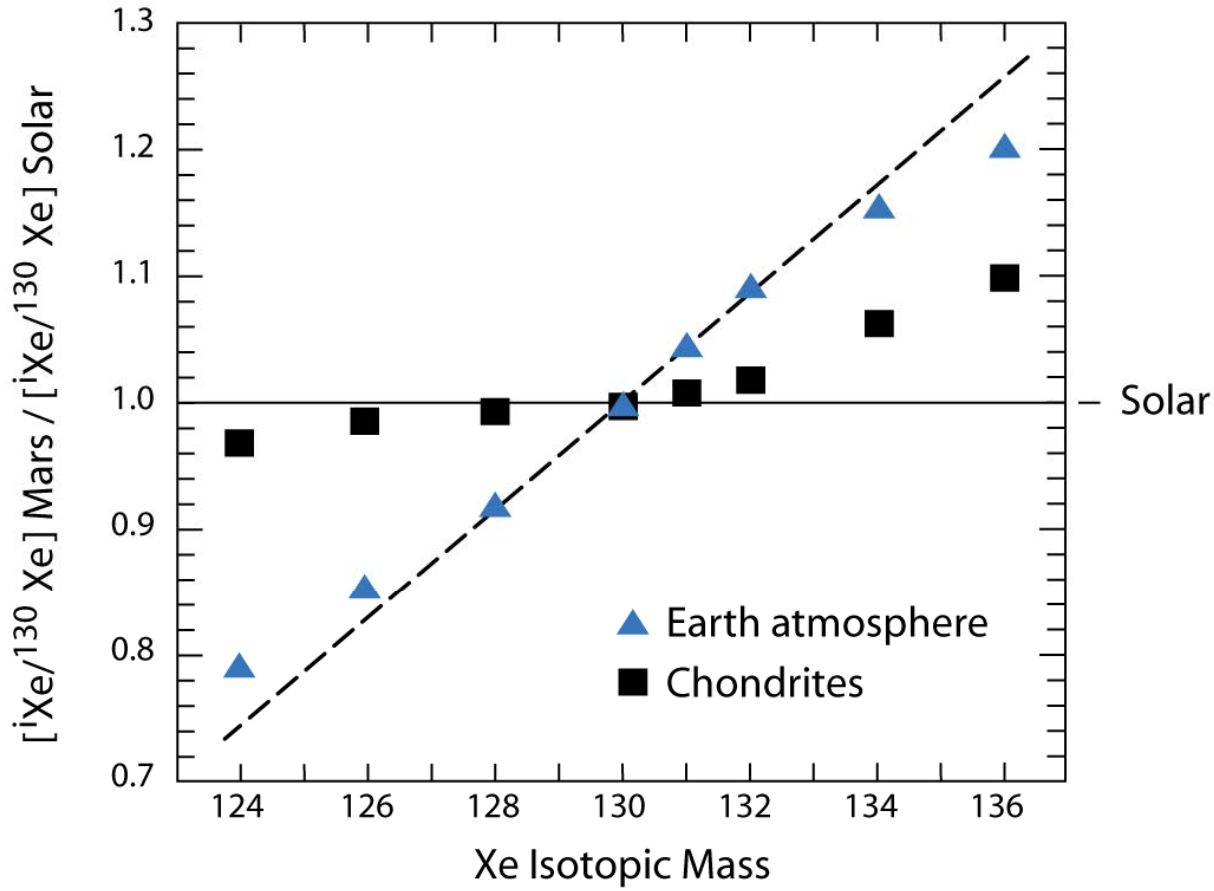

Mixing Ratio
Titan Atmosphere
10−5
10−6
2.8 x 10−7
10−7
10−8
10−9
10−10
10−11
10−12
36Ar
84Kr
132Xe
Sun
Venus
Earth
Mars

• Science 1 December 2006: Vol. 314. no. 5804, pp. 1439 - 1442 DOI: 10.1126/science.1132175

- REPORTS**Organic Globules in the Tagish Lake Meteorite: Remnants of the Protosolar Disk****Keiko Nakamura-Messenger,[1,2*] Scott Messenger,[1] Lindsay P. Keller,[1] Simon J. Clemett,[1,3] Michael E. Zolensky[1]****Coordinated transmission electron microscopy and isotopic**


Amino acid (1)
Amino acid (2)
Peptide bond
Dipeptide
Water

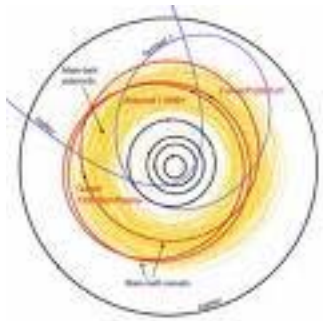
Xenon Isotopes – I

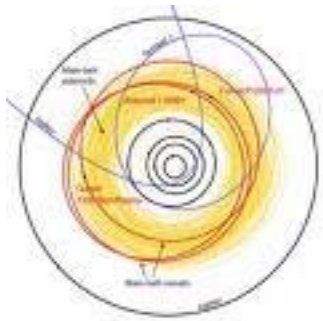


The Wrong Xenon Problem:

Atmosphere exhibits the wrong isotope architecture for xenon — compared to meteorites

"Planetary component" of meteoritic noble gases is misnomer!





MBC: COMET OR ASTEROID?

BOTH?

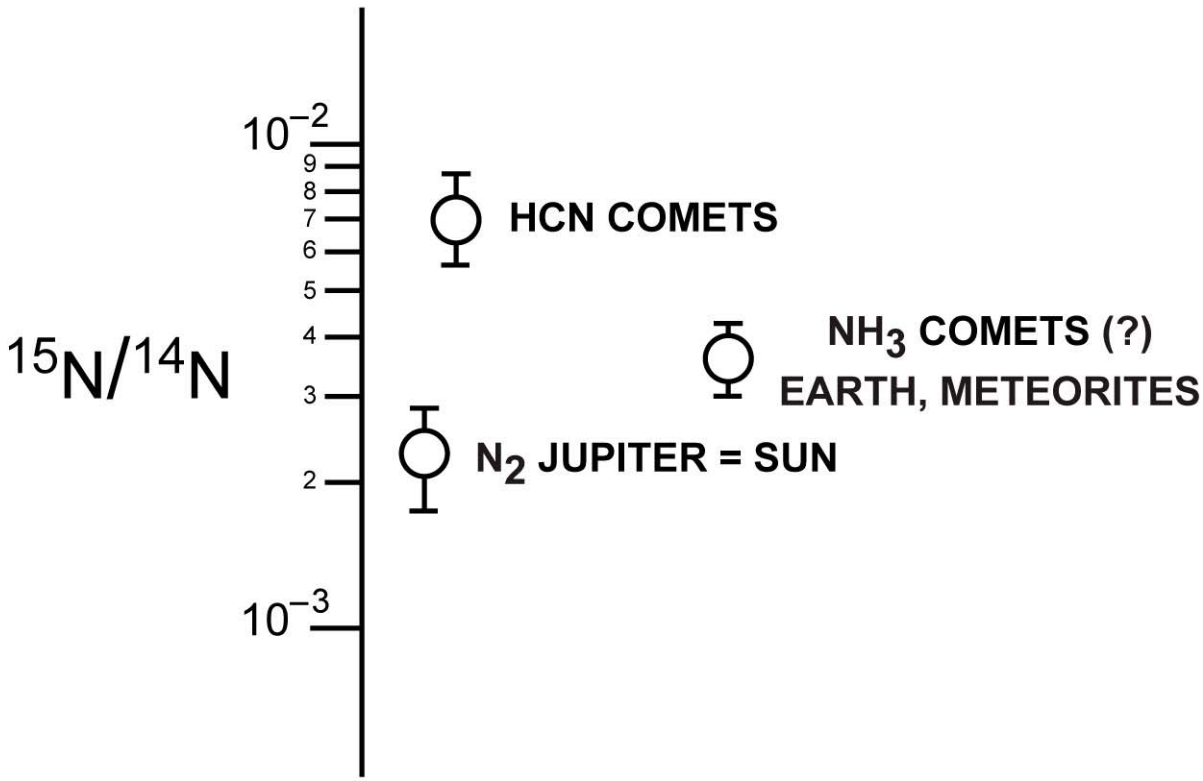
TEST

D/H IN H_2O: 3.2×10^{-4} => COMET

1.6×10^{-4} => ASTEROID

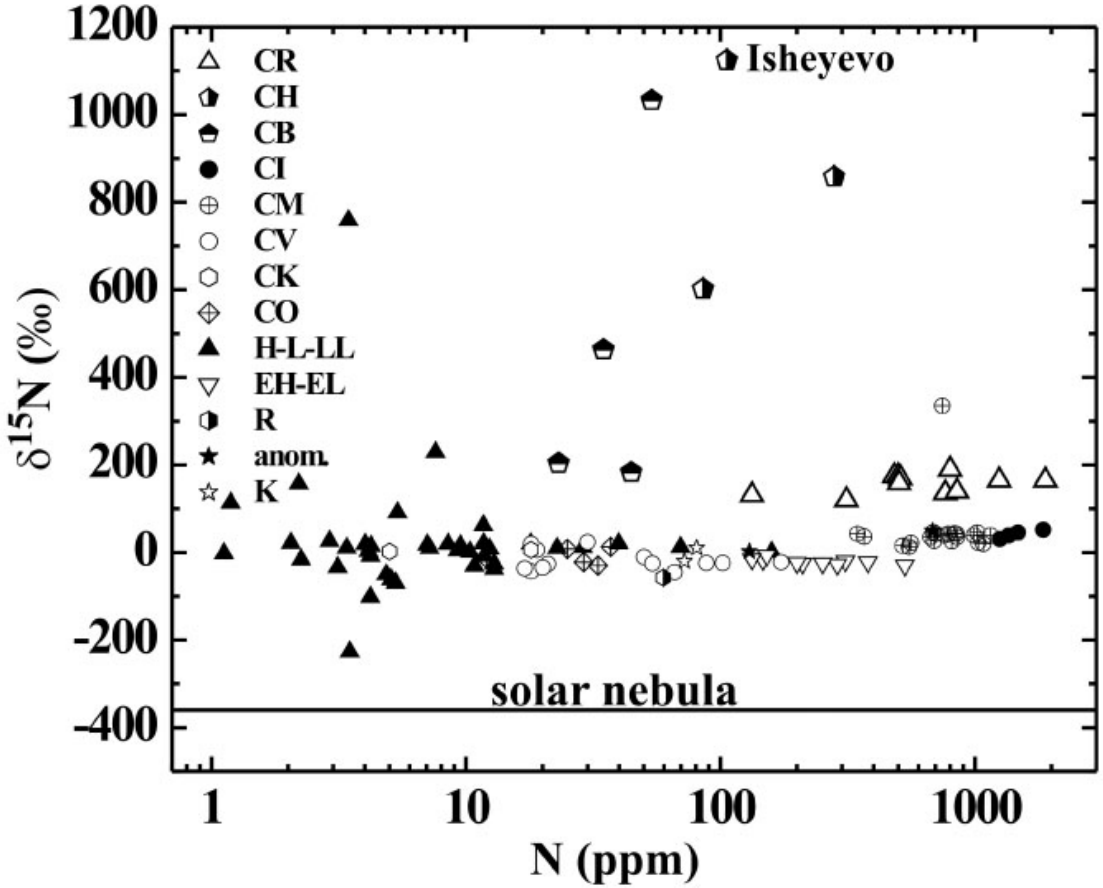
2.4×10^{-4} => ASTROCOM

PROTOSOLAR NITROGEN



WATER

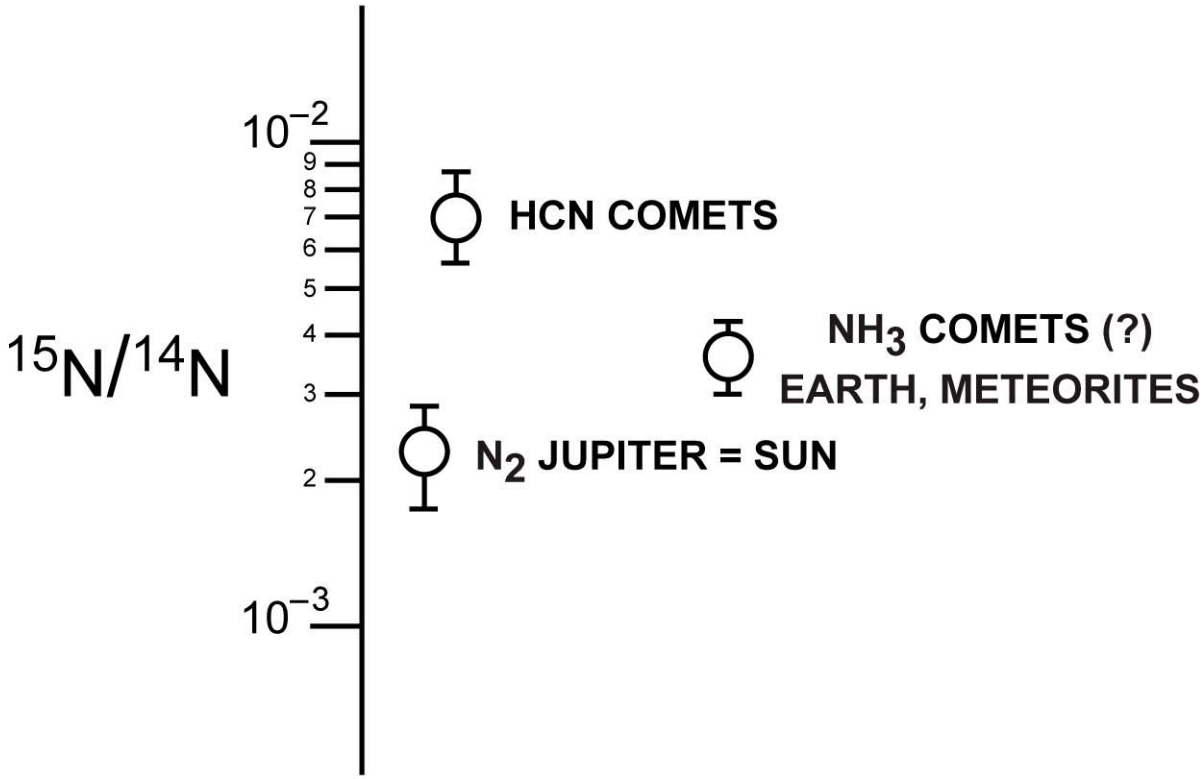
(HYDROGEN—D/H)



Bulk N contents and N-isotopic compositions of meteorites.

Krot et al. (2003), Ivanova et al. (2006)

PROTOSOLAR NITROGEN



MBC: COMET OR ASTEROID?

BOTH?

TEST

D/H IN H_2O: 3.2 X 10-4 => COMET
1.6 X 10-4 => ASTEROID

2.4 X 10-4 => ASTROCOM

MBC: SOURCE OF EARTH WATER?

REQUIRES:

- $D/H = 1.6 \times 10^{-4}$

- NOBLE GAS ABUNDANCES (AND XENON ISOTOPES)

MATCH EARTH ATMOSPHERE

MBC: SOURCE OF EARTH WATER?

REQUIRES:

- **D/H = 1.6×10^{-4}**

- **NOBLE GAS ABUNDANCES (AND XENON ISOTOPES)**

MATCH EARTH ATMOSPHERE

ORGANICS

NITROGEN---$^{15}N/^{14}N$

NH_3 HCN

{WE SEE N_2, Nxx=> amino acids}

ORGANIC COMPOUNDS

IOM

INSOLUBLE ORGANIC MATTER

90 TO 99% of carbon in meteorites

SOM

SOLUBLE ORGANIC MATTER

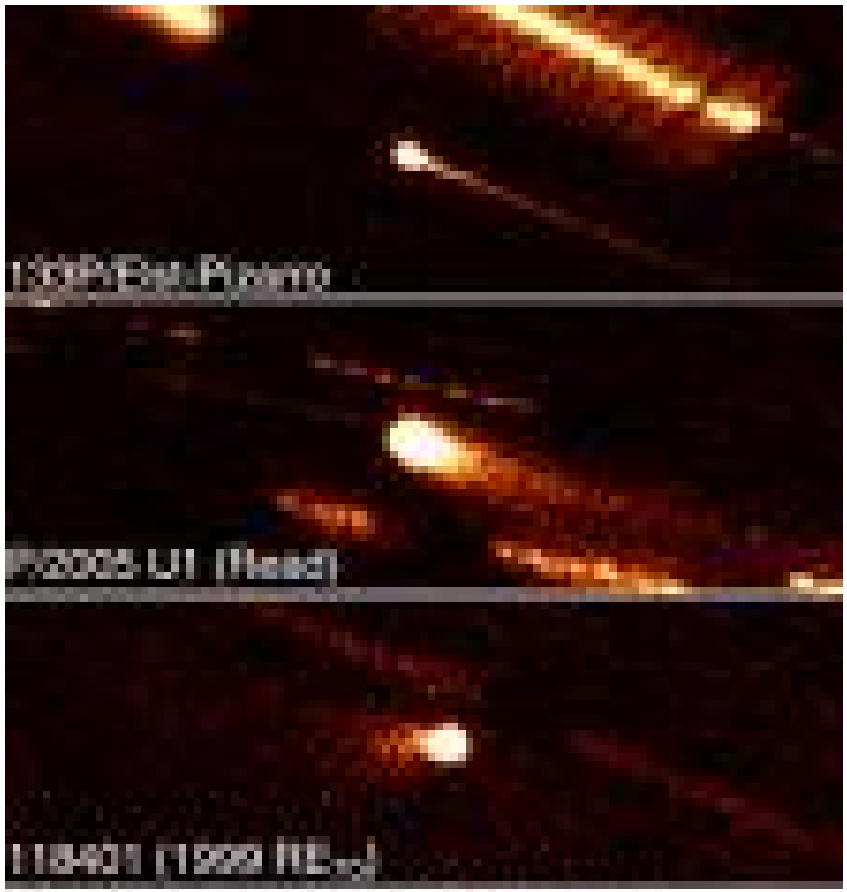
10% of carbon

0.1% is Amino Acids:

70 identified—J. Cronin

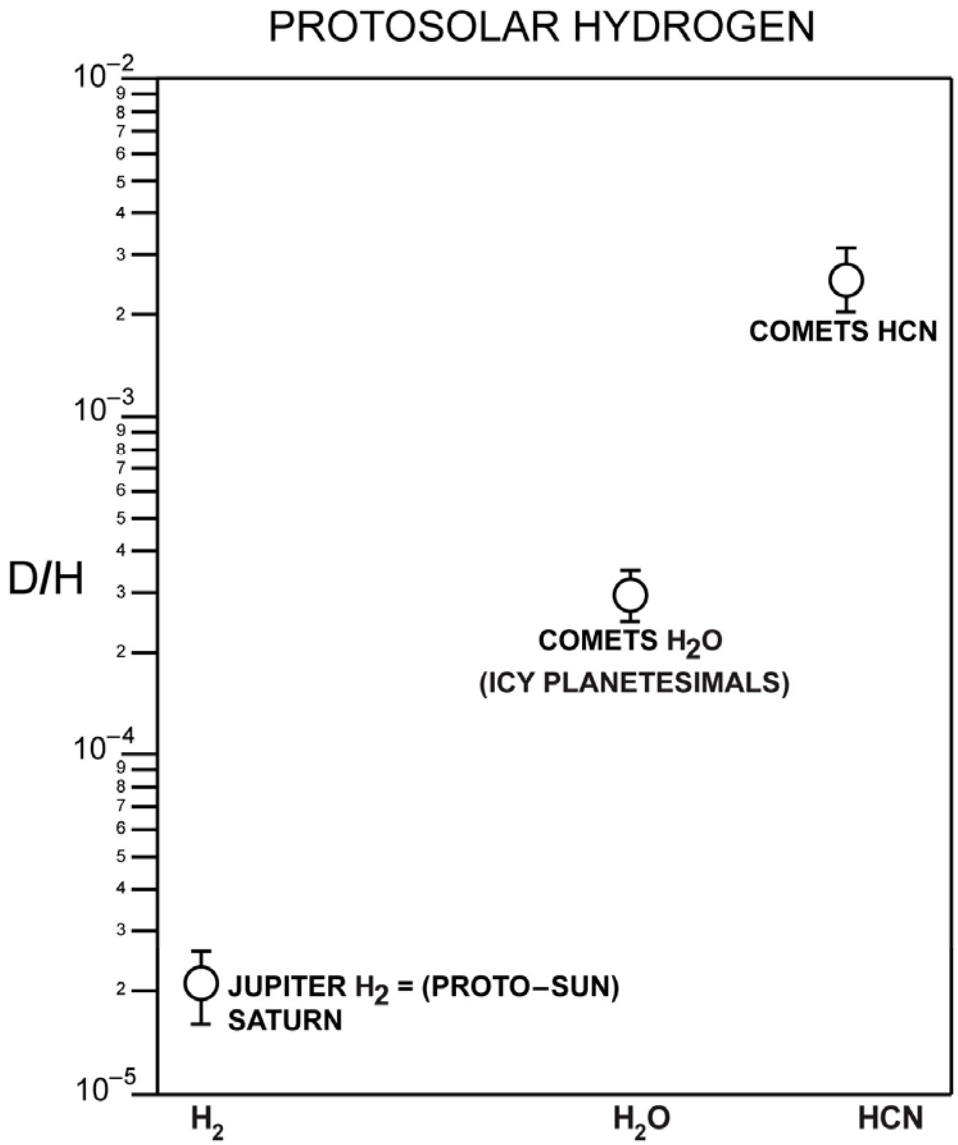
All Life on Earth uses 20

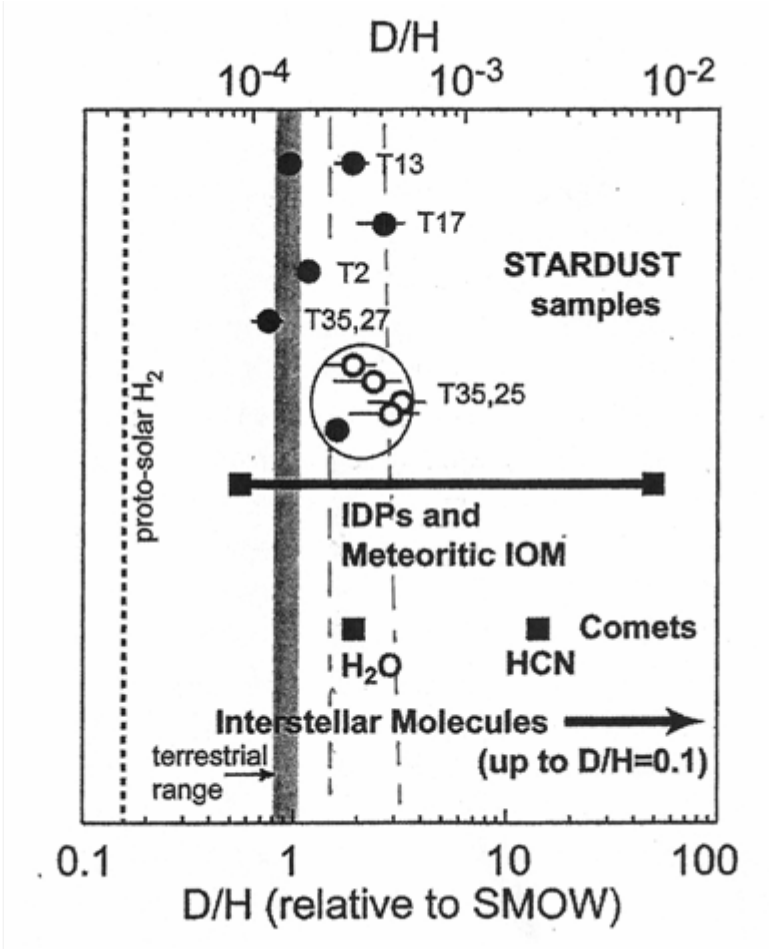
"Building Blocks" of Protein


(109P/Swift-Tuttle)
(P/2005 U1 (Read)
(118401 (1999 RE70)

RULES:

- 1.The Angels Are in the Global View
- 2.There is no Isotope Exchange Between a Solid and a Gas
- 3.There are Two Stable Isotopes of Hydrogen: D and H
  Nitrogen: ^{14}N and ^{15}N
- 4. $N_2 \not\Rightarrow NH_3$
- 5. Never Forget Einstein:


PROTOSOLAR HYDROGEN
D/H
10^{-2}
9
8
7
6
5
4
3
2
10^{-3}
9
8
7
6
5
4
3
2
10^{-4}
9
8
7
6
5
4
3
2
10^{-5}
COMETS HCN
COMETS H_2O
(ICY PLANETESIMALS)
JUPITER H_2 = (PROTO–SUN)
SATURN
H_2
H_2O
HCN


D/H
10-4
10-3
10-2
T13
T17
T2
T35,27
T35,25
STARDUST
samples
proto-solar H2
IDPs and
Meteoritic IOM
Comets
HCN
H2O
Interstellar Molecules
(up to D/H=0.1)
terrestrial
range
0.1
1
10
100
D/H (relative to SMOW)

- **Physical Properties of Main-Belt Comet P/2005 U1 (Read)**
- **The main-belt comets occupy dynamically asteroidal orbits in the main asteroid belt.**

- **Henry H. Hsieh (1 and 2), David Jewitt (1), Masateru Ishiguro (3) ((1) University of Hawaii, (2) Queen's University Belfast, (3) Seoul National University)**

Alles sollte so einfach wie möglich gemacht werden, aber nicht einfacher.

Albert Einstein