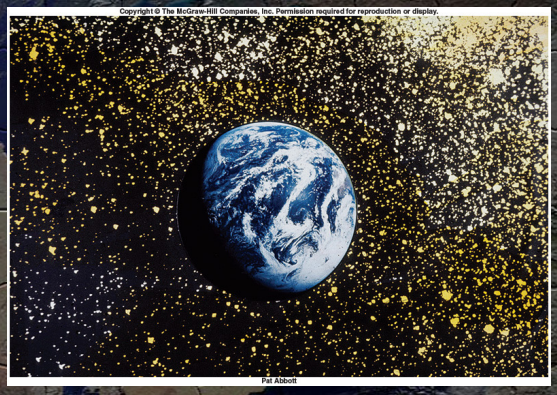
Topic 3: The Solar System

https://geowiki.ucsd.edu/sio15



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1

Homework 1- Gradescope

geowiki.ucsd.edu/sio15

- Watch Gradescope video
- Watch homework 1 video

Lecture Schedule and Material
Homeworks/Tests
Field Trips
other links
Earthwatch/News Clips

Students will submit their hon
Homeworks
Tests
Code of Conduct
• discuss your homework
• working in groups to sh

the Google Earth icon
• When downloading our kml/kmz files, some web browsers may open kml files automatically instead of downloading them. Try "save as" in your browse choose a name you like. If there is also a zip file offered, download the zip file instead and unzip it before you open it in Google Earth.

HW #	Date Distributed	Topics Covered	Date Due	Downloadable Assignment	Auxiliary Links	Homework video	Answer Keys	Grade Appeal Deadline
	Oct 02					Gradescope video		-
1	Oct 01	1-4	Oct 08	homework 1		HW1 video		10/18
2	Oct 08	5-7	Oct 15					10/25
3	Oct 15	8-10	Oct 22					11/01

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2

Latent Heat

"hidden heat"

Heat Capacity: ability to absorb heat while temperature rises slowly

Air:	0.00031
cal/cm^3/°C	
Quartz Sand:	0.31
Granite:	0.51
Water:	1.0
Aluminum:	0.215
Copper:	0.0924
Glass:	0.20
Human body:	0.83

Table 2.1

- water has high heat capacity!
- serves as moderator

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The 3 Phases of H_2O

any substance

- ice
- water
- water vapor

solid

liquid

gas

any phase change costs or releases energy

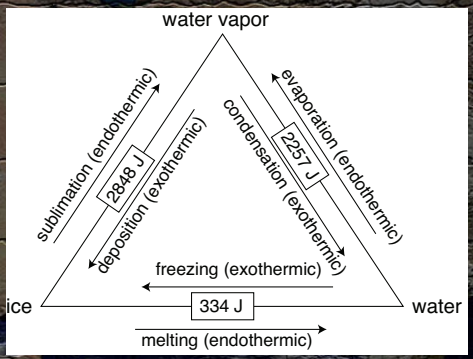

Fig. 2.12

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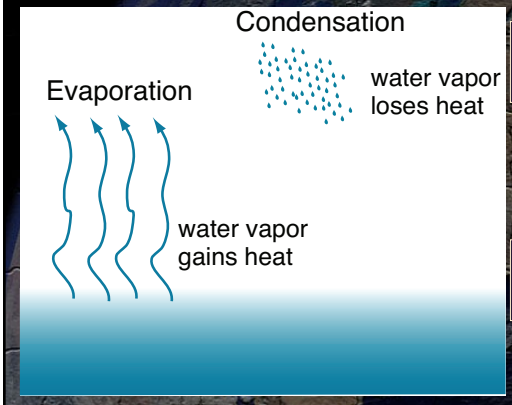
Latent Heat, Evaporation and Condensation



evaporation:
water vapor absorbs heat

condensation:
water vapor releases heat

Fig. 2.13

it takes 600 cal to evaporate 1g water

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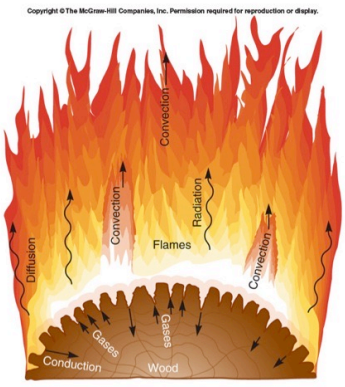
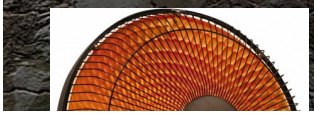
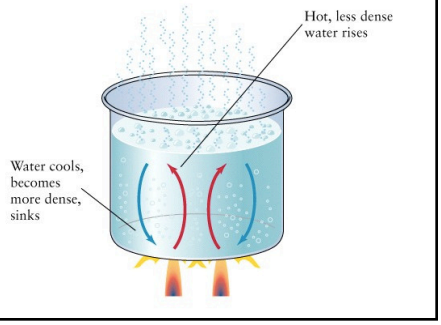
4 Ways to Transport Heat

- conduction (energy passed between vibrating atoms)
- radiation (EM waves, no particle movement)
- diffusion (migration of single particles)
- convection (mass transport; MOST EFFECTIVE)

Fig 2.11







Source: P. Abbott "Natural Disasters"

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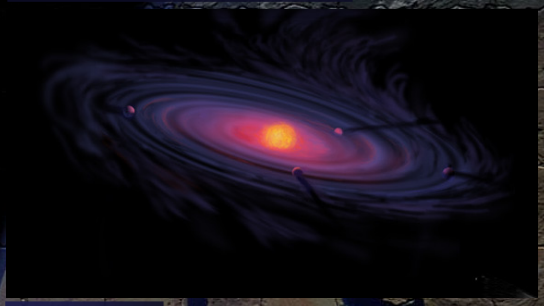
Ages of the Universe, Sun and Earth

Protoplanetary disk



Moon Formation

Source: wikipedia

Fig 3.9

1) universe: ~ 13.8 billion years
2) solar system: ~ 4.5 billion years
3) sun and planets formed at same time
4) moon: ~ 4.4 billion years (Mars-size impactor on Earth)

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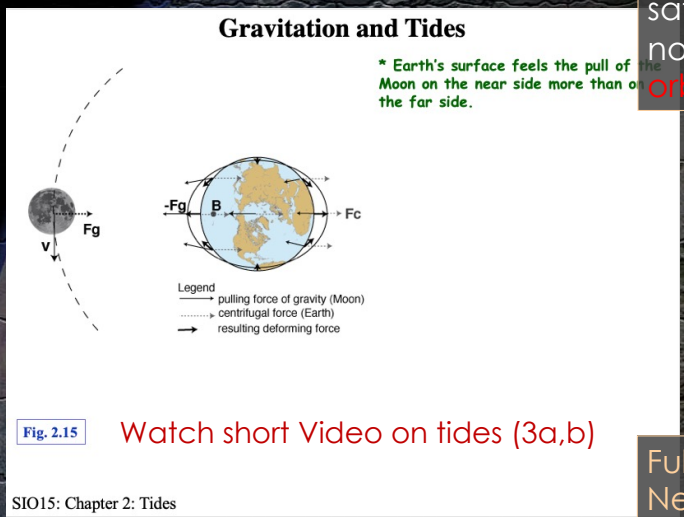
Earth Tides (Sun-Earth-Moon System)

Moon
satellite
not a planet
orbits Earth



Watch short Video on tides (3a,b)

Full Moon
New Moon
Lunar Eclipses

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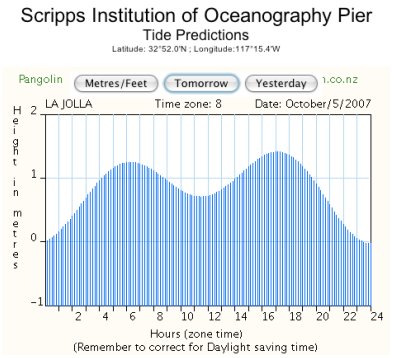
Change of Tides at a Specific Location

Most places on Earth experience two high tides and two low tides per day (*semi-diurnal tides*).

For example, the tides on October 5, 2007 at the SIO pier looked like the diagram to the right:

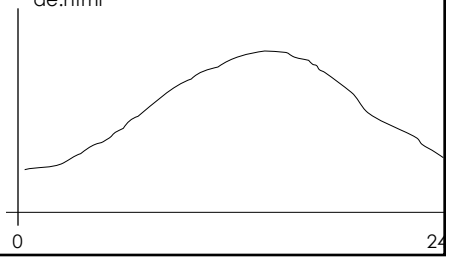
Fig. 2.17



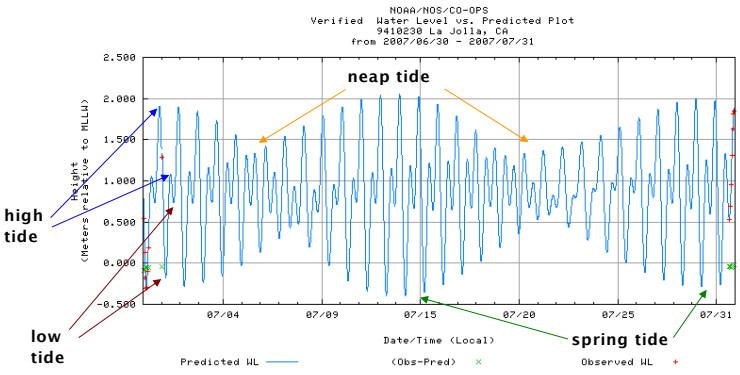
http://ocean.peterbrueggeman.com/piertide.html

A few places experience only one high and one low tide per day (*diurnal tides*).

The tides throughout the day look like this:



The Moon, Sun and Tides at a Specific Location



http://tidesandcurrents.noaa.gov

during a synodic month, La Jolla experiences two spring tides and two neap tides.

The period between Full Moons is about 29.5 days (synodic month).

Tidal range: High-low tide

Members of our Solar System - Planets

Sun
Mercury
Venus
Earth
Mars

Jupiter
Saturn
Uranus
Neptune

Pluto/Charon …. Eris … (dwarfs)

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Members of our Solar System - Planets

terrestrial planets, inner p.: Mercury, Venus, Earth, Mars (high density); rocky planets
gas giants, outer planets: Jupiter, Saturn, Uranus, Neptune (low density)

mass: sun has 99% of mass

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Angular Momentum

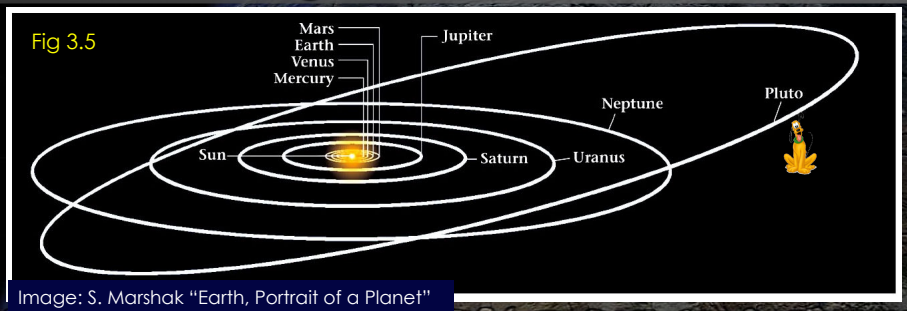
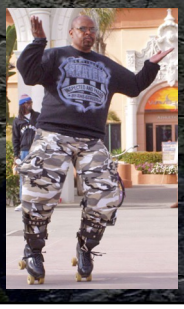


Image: S. Marshak "Earth, Portrait of a Planet"

momentum: $p = m*v$
angular momentum: $L = I*\Omega$

planets have 99% of angular momentum

comparable angular momentum
-> inner planets orbit faster than outer planets
(like skater tugging in arms)



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Pluto

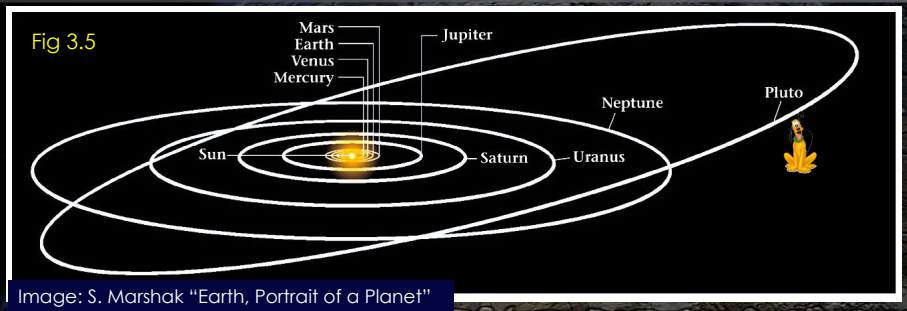

Image: S. Marshak "Earth, Portrait of a Planet"

Orbit
- highly elliptical
- Tilted with respect to ecliptic

- discovered in 1930
- Only 2/3 of Moon
- Weird orbit
- large satellite (Charon)
- Smaller than Xena (2005)

Renamed: Eris

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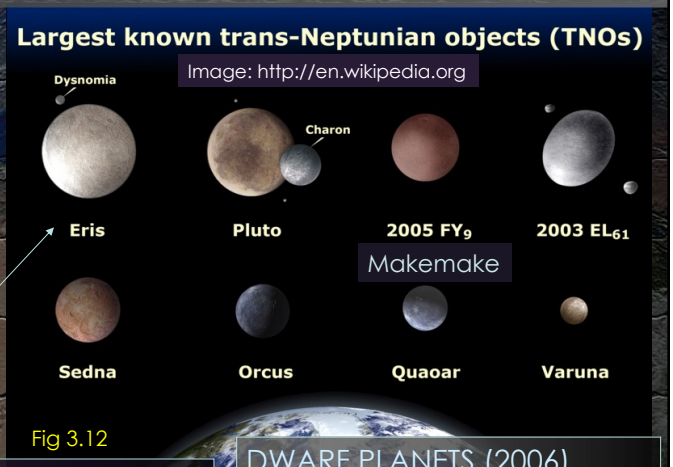
Dwarf Planets



Xena (2005) (farther out than Pluto)

Fig 3.12

- Pluto (and Charon)
- large trans-Neptunian objects
- large asteroids (e.g. Ceres)

DWARF PLANETS (2006)
- ✓ own orbit around sun
- ✓ not at satellite
- ✓ round
- ✓ has NOT cleared its orbit

The Asteroid Belt

Fig 3.13

Bode's Law

see course book!

- asteroid belt between Mars, Jupiter (tug of Jupiter prevented planet formation)
- source of some impactors

Fig 3.14

Asteroids

- rocky
- low density

IDA; 56km long + Dactyl

source: wikipedia/NASA

Ceres; 940 km across
dwarf planet

source: wikipedia/NASA

most too small to be rounded
3 large > 500km diameter (Ceres, Pallas, Vesta)
some have Earth crossing orbits: Apollos
(Amors: Mars-crossing)

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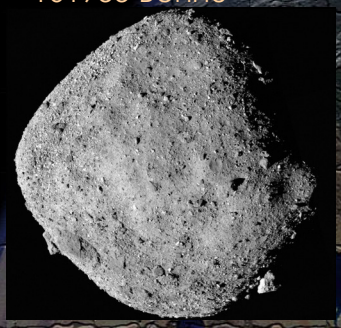
Fig 3.14

Apollos - Near-Earth Asteroids

101955 Bennu



source: wikipedia/NASA

discovered 11 Sep 1999
may impact 24 Sep 2182 ± 6 years
mean radius 245 m

OSIRIS-Rex mission 2016
returned samples to Earth (1 cup?) 9/24/23
opened 1/13/24 (122 g/4.3 oz)

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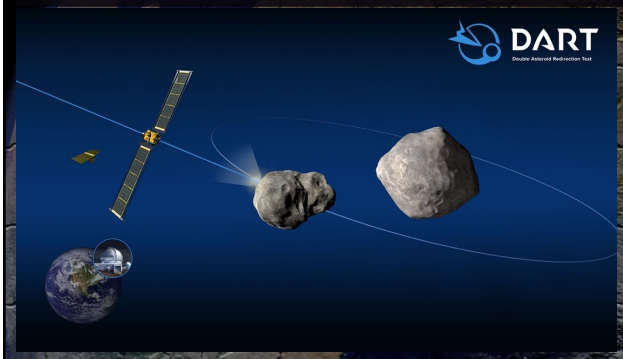
DART - Double Asteroid Redirection Test

- Launch: Nov 2021 (SpaceX Falcon 9), Vandenberg, CA
- Refrigerator size (372 kg) (NASA)
- Dimorphos, moon of Didymos
- Impact: Mon 9/26/22 (equivalent of 5 tons TNT); 150 m crater
- analyzed data for next 6 months
- Purpose: deflect Dimorphos/shorten orbit by 73 s
- actual: shortening by 32 min!



ESA follow-up launch of Hera 2024 to arrive 2026

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DART - Double Asteroid Redirection Test

Challenges:
Extent of deflection depends on
Speed
Impact angle
Mass/surface density of Dimorphos (very low density/loose pile)

Dimorphos: 160 m (4.8B kg, 1km from Didymos)
Didymos: 780 m, 523B kg

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Comets

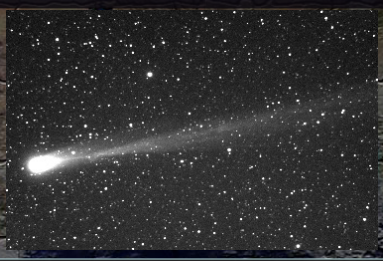
"dirty snowballs"

- icy (frozen volatiles)
- rocky core (few km across)
  (Halley comet: 40km)
- sunlight and solar wind

-> comet ejects ionized gases and dust
-> tail

McNaught, 2007
Lovejoy, 2011

Hale-Bopp, 1997



Hyakutake, 1996

- Kuiper belt beyond Neptune: short-period comets
- Oort cloud: long-period comets

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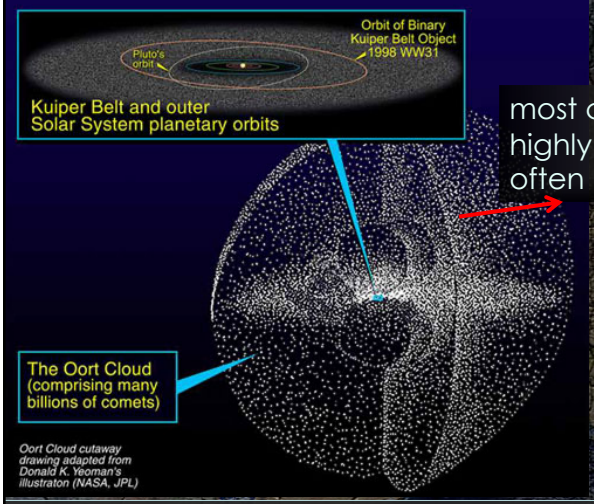
Comets

Fig 3.17



most comets are long-period
highly elongated orbit
often not discovered until late

- Kuiper belt beyond Neptune: short-period comets (recurrence < 200 yrs)
- Oort cloud: long-period comets

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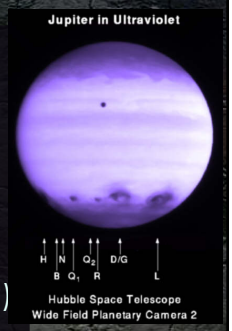
1994: Comet Shoemaker-Levy 9

Fig 3.20

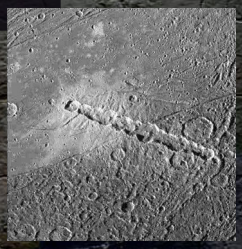
source: NASA/wikipedia

UV Hubble Image taken 21 July1994



- first observation of an extraterrestrial impact
- discovered 24 March 1993 at Palomar Obs.
- probably captured by Jupiter 20-30 years earlier
- fragmentation during July 1992 encounter
- impact 16 – 22 July 1994
- scientists argued whether impact would be seen at all
- captures by Jupiter not uncommon (19 July 2009) ("cosmic vacuum cleaner")

Hubble Image taken 17 May 1994



crater chain on Ganymede

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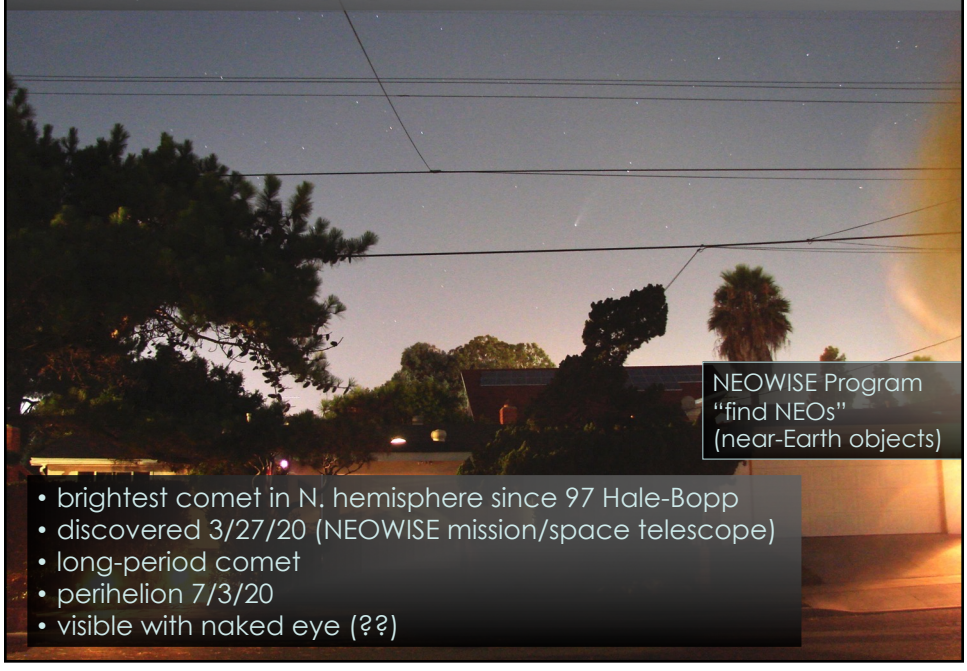
2020 Comet NEOWISE



NEOWISE Program
"find NEOs"
(near-Earth objects)

- brightest comet in N. hemisphere since 97 Hale-Bopp
- discovered 3/27/20 (NEOWISE mission/space telescope)
- long-period comet
- perihelion 7/3/20
- visible with naked eye (??)

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Comets – Where does Earth's water come from?

currently a matter of great debate

- comets
- primordial

some have organic compounds

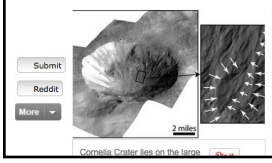
9/29/15

Earth
Europa
Enceladus
Mars??

water #1 condition for life to form

Surprise! Water Once Flowed on Huge Asteroid Vesta

by Mike Wall, Space.com Senior Writer | January 27, 2015 11:00am ET



Liquid water apparently flowed on the surface of the huge asteroid Vesta briefly in the relatively recent past, a surprising new study suggests.

"Nobody expected to find evidence of water on Vesta. The surface is very cold and there is no

Cornelia Crater lies on the large

LIQUID WATER FOUND ON MARS

BY KENNETH CHANG

Scientists have for the first time confirmed liquid water flowing on the surface of present-day Mars, a finding that will add to speculation that life, if it ever arose there, could persist now.

"This is tremendously exciting," James Green, the director of NASA's planetary science division, said during a news conference Monday. "We haven't been able to answer the question, 'Does life exist beyond Earth?' But following the water is a critical element of that. We now have, I think, great opportunities in the right locations on Mars to thoroughly investigate that."

That marks a shift in tone for NASA, where officials have played down the notion that the dusty and desolate landscape of Mars could be inhabited today.

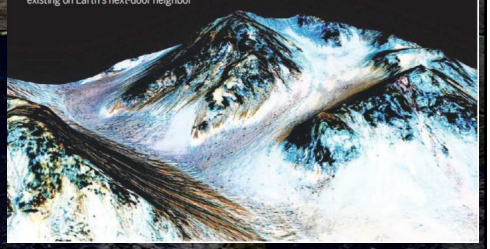
But now, John Grunsfeld, NASA's associate administrator for science, talked of sending a spacecraft in the 2020s to one of these regions, perhaps with experiments to

SEE MARS • A7

"Mars is not the dry, arid planet that we thought of in the past."

James Green
director of NASA's planetary science division

Finding could have big implications for possibility of microscopic life-forms existing on Earth's next-door neighbor



Source: San Diego U-T

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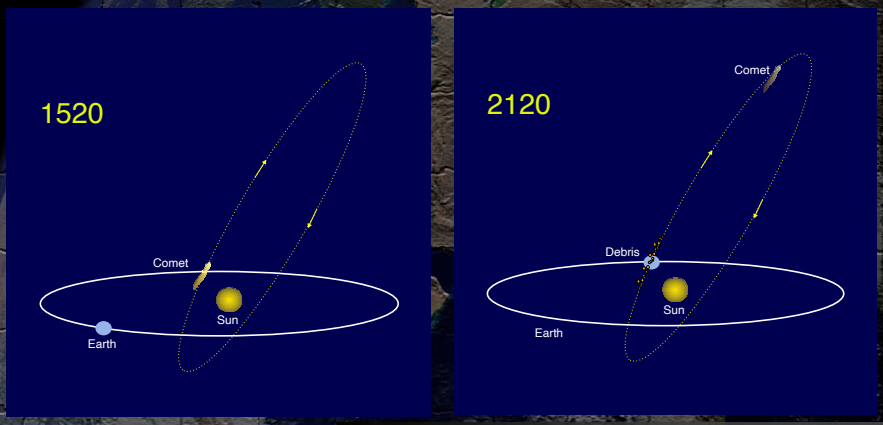
Comets & Meteor Showers

Fig 3.19

Meteor Shower: comet dust burning up in atmosphere
remnant tail/debris field of ancient Earth-crossing comet



shows at same time every year
whenever Earth moves through debris field

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Meteorites

Fig 3.19

- Meteoroid: object entering Earth's atmosphere
  comet, asteroid or similar
- Meteor: phenomenon seen in sky
- Meteorite: piece(s) left on Earth's surface after impact

Willamette meteorite

Meteors, shooting stars

fragments of asteroids and comets that impacted on Earth
- ❖ stony meteorite (less likely to survive)
- ❖ iron meteorite (from core of differentiated asteroids)

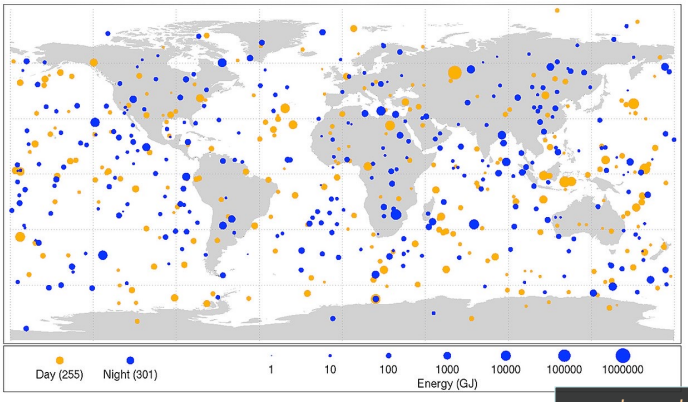
Bolides/Fireballs

Fig 3.19

extremely bright meteors

- no day/night difference
- geographically random

Bolide events 1994-2013
(Small asteroids that disintegrated in the Earth's atmosphere)



source: wikipedia

most meteoroids burn up in Earth's atmosphere

The 1908 Tunguska Event

mass exploded <10 km high in atmosphere?

source: wikipedia

felled trees
no radioactivity
blast = 12-15 megatons (Bikini Atoll Bomb)
light phenomenon 200 km away
people knocked off their feet from shock wave
pressure fluctuations in Britain
volcanic area

remains from Comet Encke???

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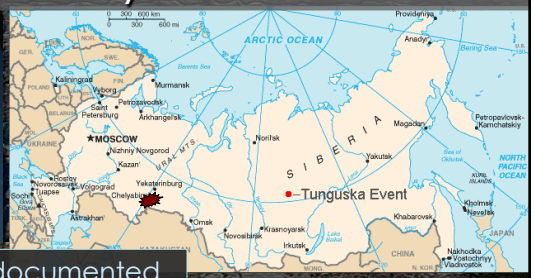
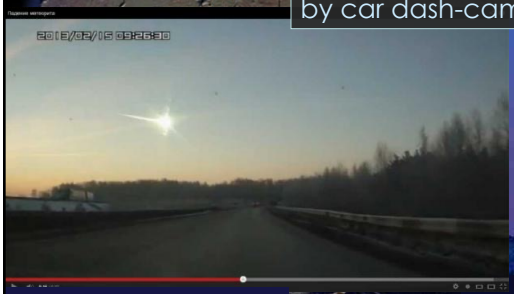
The 15 Feb 2013 Chelyabinsk Meteor



source: wikimedia

very well documented by car dash-cams !!



source: nationmultimedia

source: wordpress

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The 15 Feb 2013 Chelyabinsk Meteor

mass exploded ~25km high in atmosphere?

remains from 30-m asteroid 2012 DA_{14} 16h later??

Chelyabinsk Zinc Factory

source: wikipedia

blast = <1 megaton (Tunguska 10x larger!)
(20-30 Hiroshima bomb)
light phenomenon 200 km away
large number of small meteorites
roof of zinc factory collapsed (from shock wave?)
injuries due to blown-out windows (7,200 buildings)
ground movement recorded 4000 km away

Chelyabinsk Drama Theater