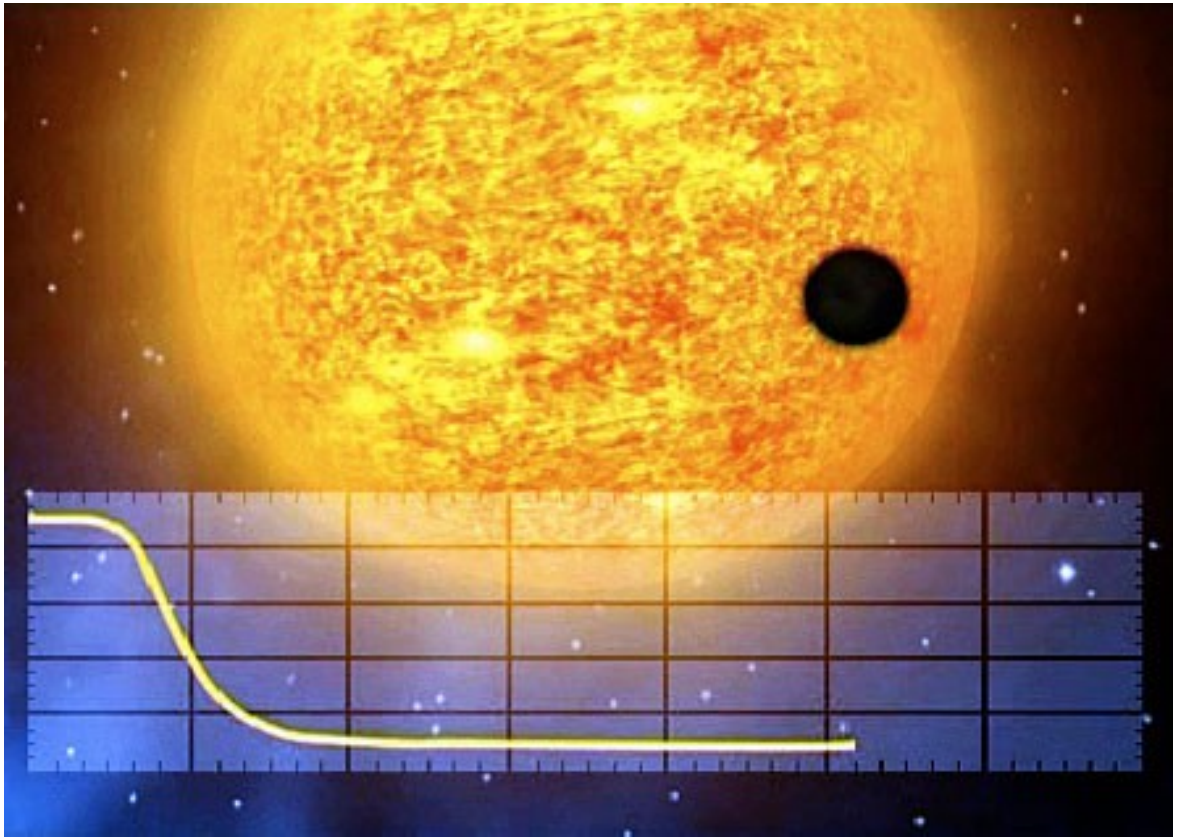
Announcements

- The third homework is due **Monday**, Feb. 9.
- The first exam is Wednesday, Feb. 11.
- Monday, Feb. 9, will be a review, please e-mail questions.
- If you need help to go an Astronomy tutorial; the schedule is on the class web site.

Planet discovery accounced Feb. 3



- Found eclipses with European Space Agency's COROT satellite
- About twice the diameter of Earth
- No more than 11 times Earth's mass
- Thanks to Matt Scandora

An object is moving toward us at a great speed. Therefore, the light it emits is Doppler shifted to

A) Redder, longer wavelengths

B) Redder, shorter wavelengths

C) Bluer, longer wavelengths

D) Bluer, shorter wavelengths

Life Beyond Earth

- What is life?
- Where might we find life?
- History of life on Earth

What is Life?

- What are the essential characteristics of life?

What is Life?

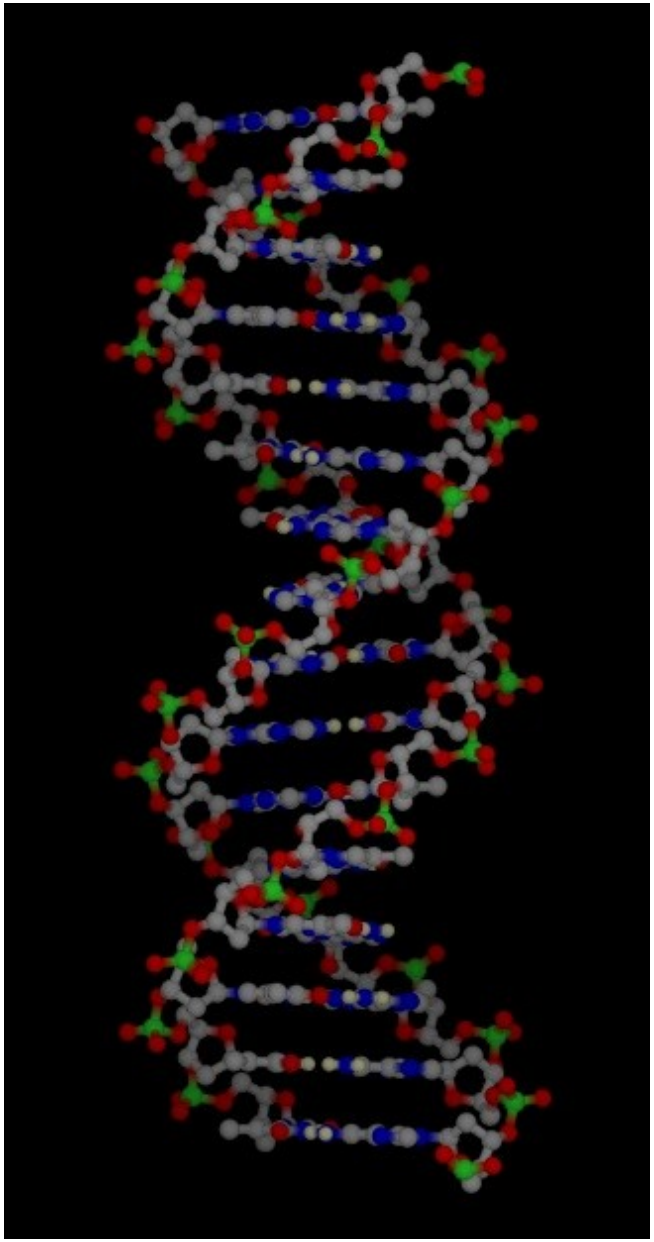
Essential elements are:

- Life reproduces itself
- Life is able to adapt and pass changes to new generations

This seems to require a genetic code which can stores information about how to grow new organism and is passed from generation to generation

Life on Earth

- Is based on `organic' molecules – those containing carbon atoms
- Carbon can combine with hydrogen and other atoms to form complex molecules
- Complex molecules appear necessary to store the information needed for a genetic code
- Life on Earth uses DNA, a carbon-based molecule, to store the genetic code



Life on Earth

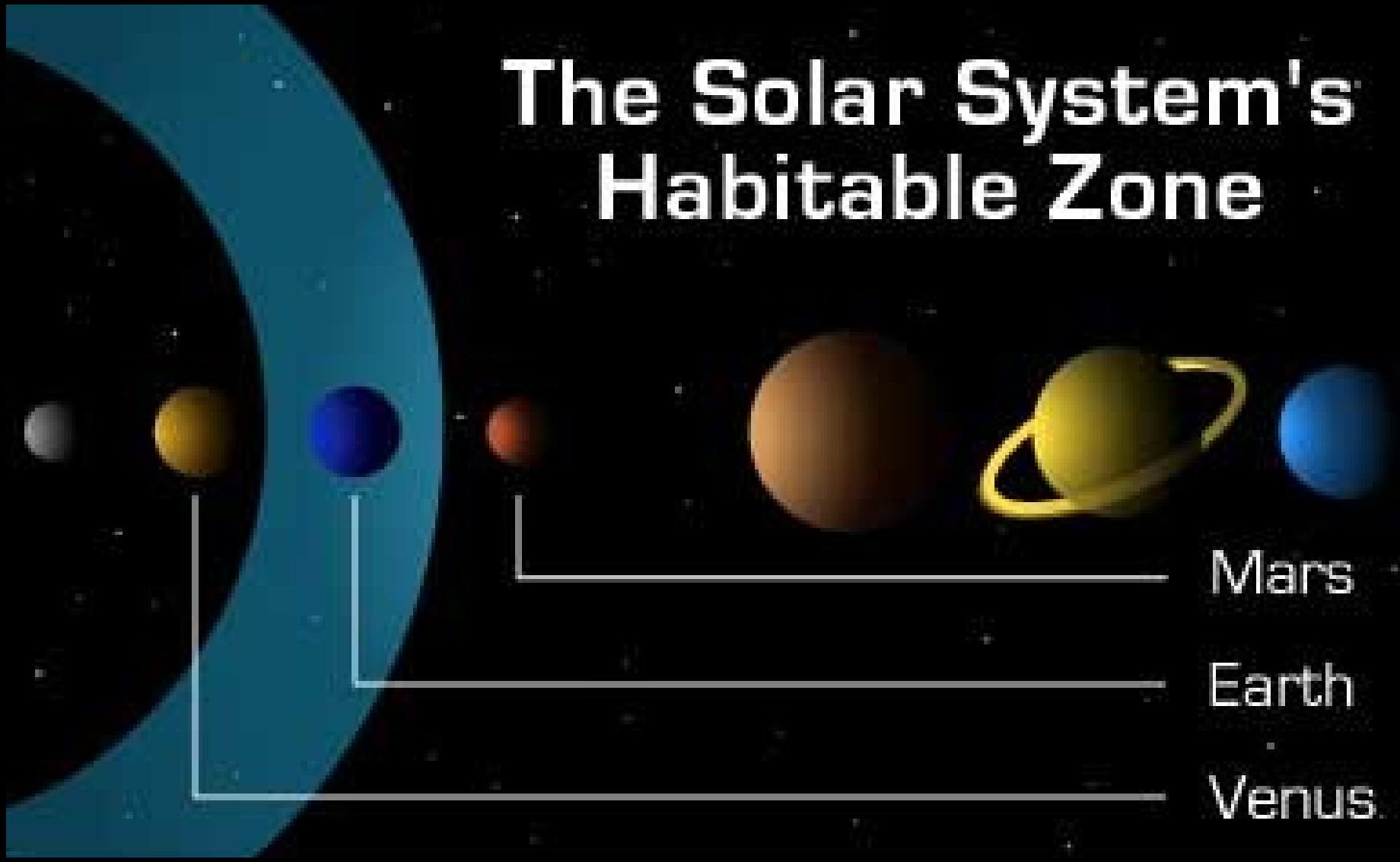
- Life on Earth appears to require water
- No life is know to exist in the complete absence of water
- Water allows other molecules to dissolve, move around, and interact with each other

Organic molecules

- Organic molecules are found on meteorites dating back to the origin of the solar system.
- Molecules are common in interstellar space.

Habitable zone

- The requirement for water suggests those planets which have liquid water may be the most promising havens for life.
- In order to have liquid water, a planet must be “not too cold and not too hot”, i.e. at a temperature between freezing and boiling.
- How warm a planet is depends on its distance from the sun.

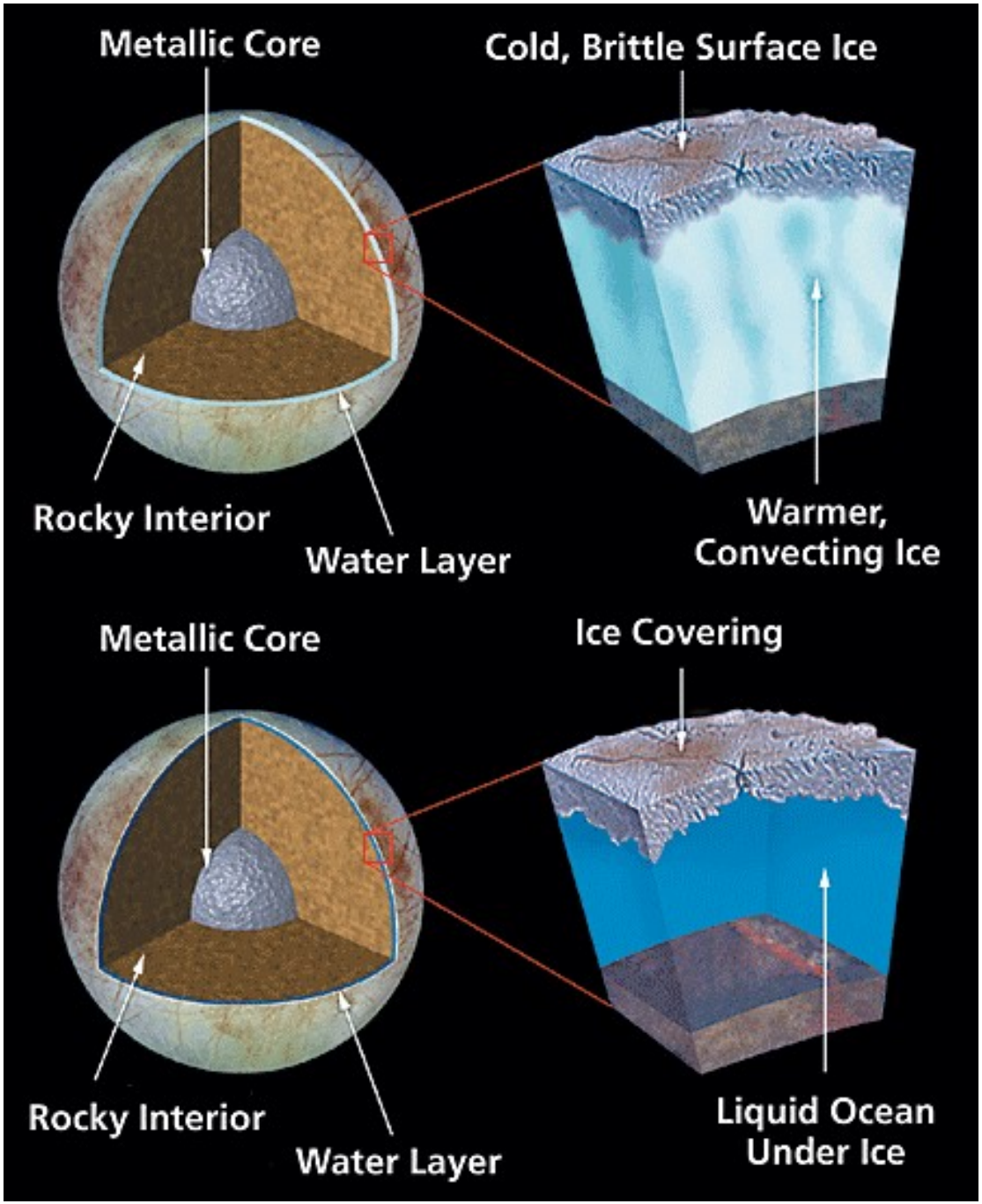

The Solar System's
Habitable Zone
Mars
Earth
Venus

Are there any exceptions to the habitable zone?

- Yes, if there are sources of energy other than the sun to keep a planet (or moon) warm.
- Possible energy sources
  - Radioactivity
  - Tides

Europa

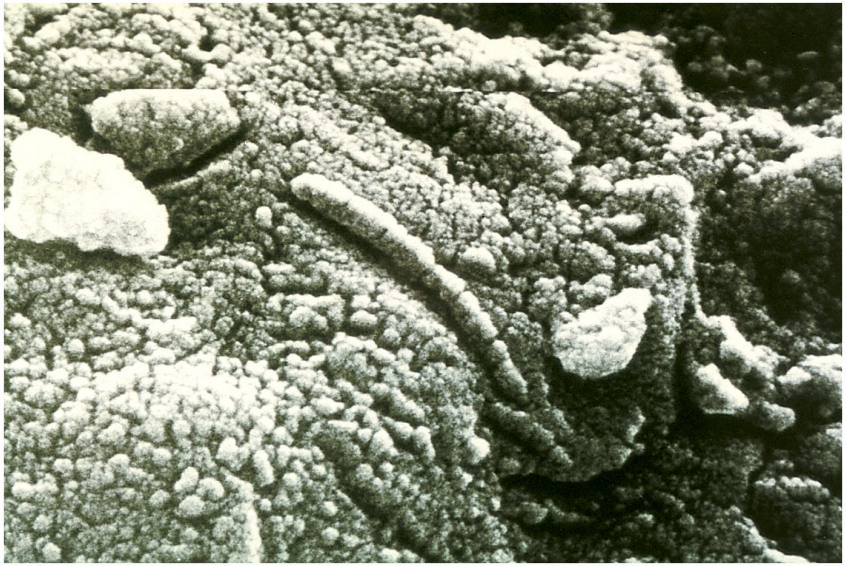
- Liquid water oceans are though to exist on Jupiter's moon Europa



Mars

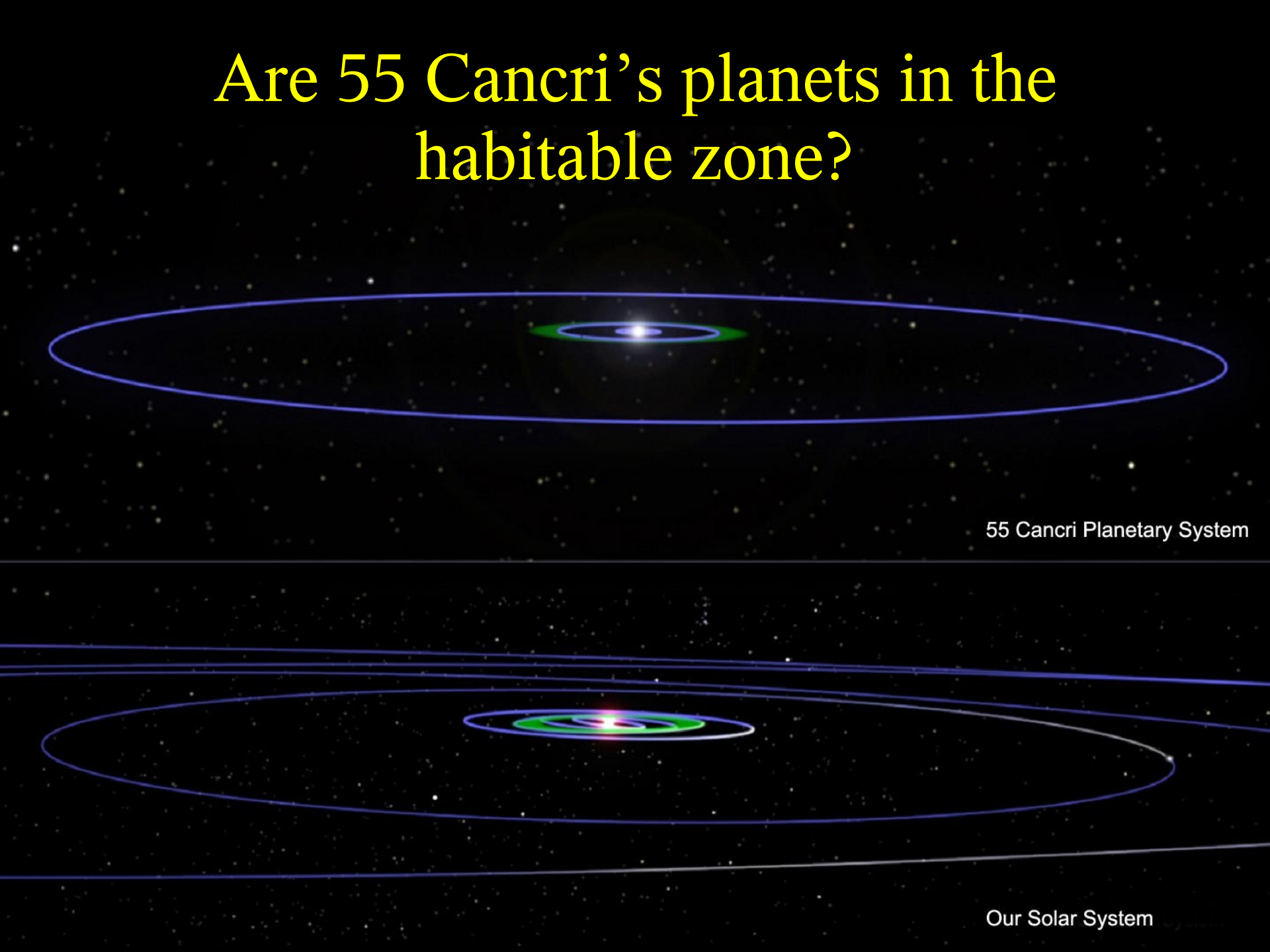
- Mars may have had liquid water early on.

Meteorites from Mars

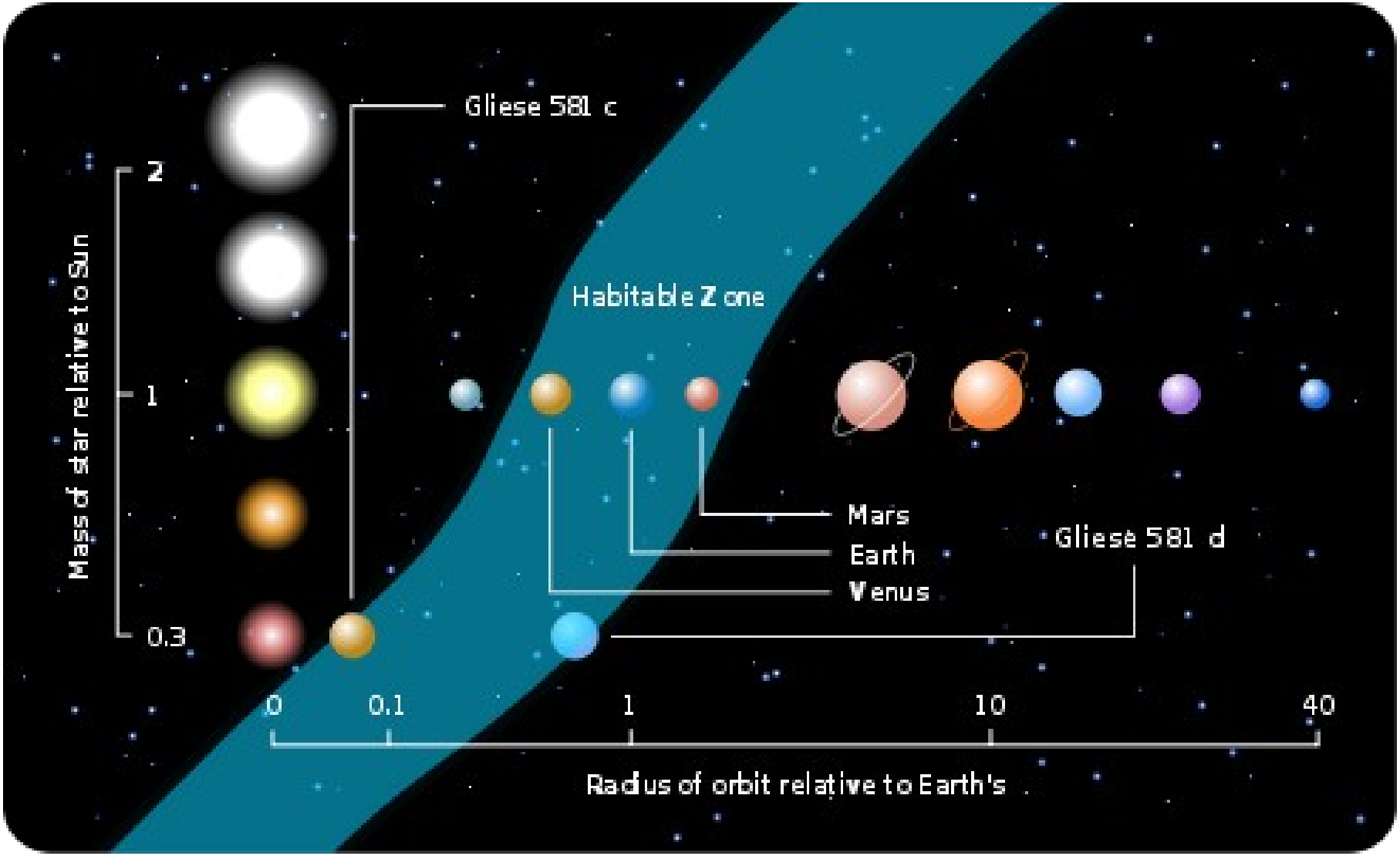


- An ancient Martian rock that came to Earth as a meteorite may show evidence that microorganisms once existed on Mars
- Additional rock samples are needed to provide corroboration

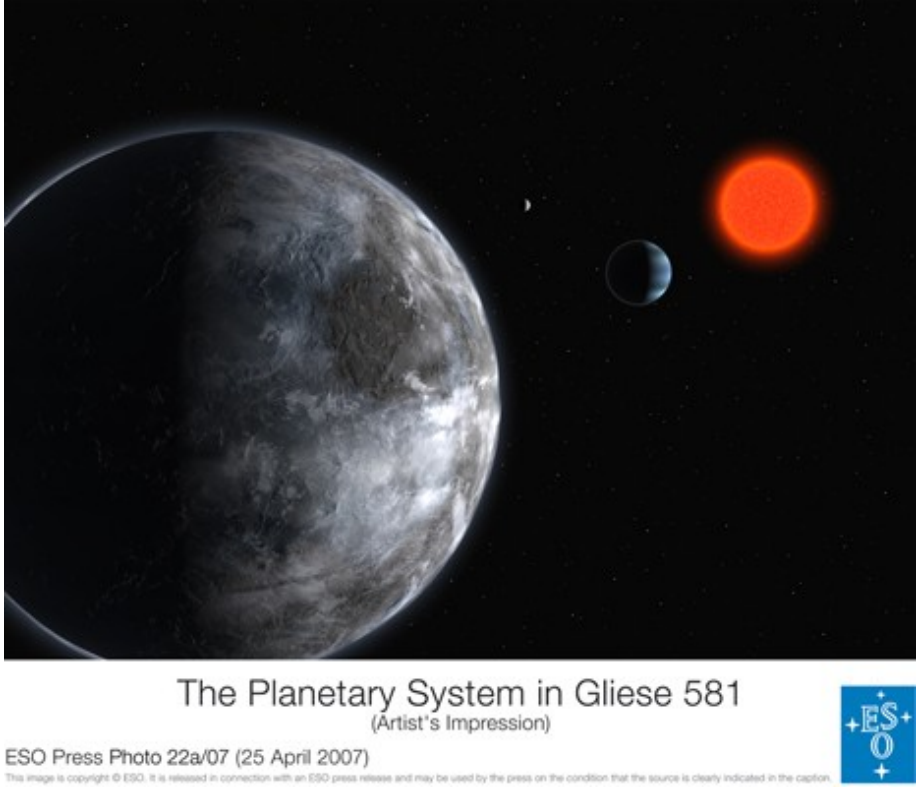
Are 55 Cancri's planets in the habitable zone?



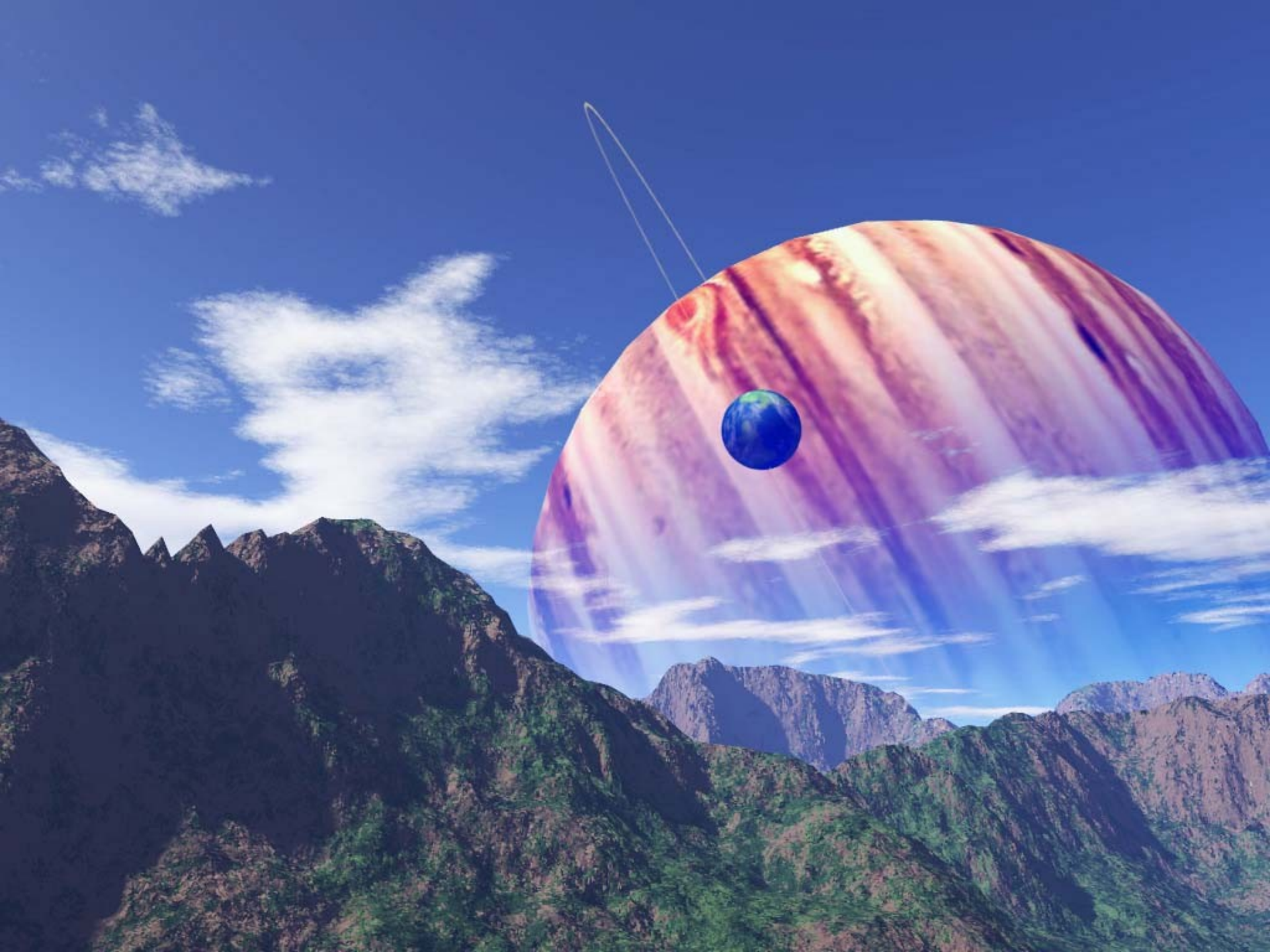
Habitable zone



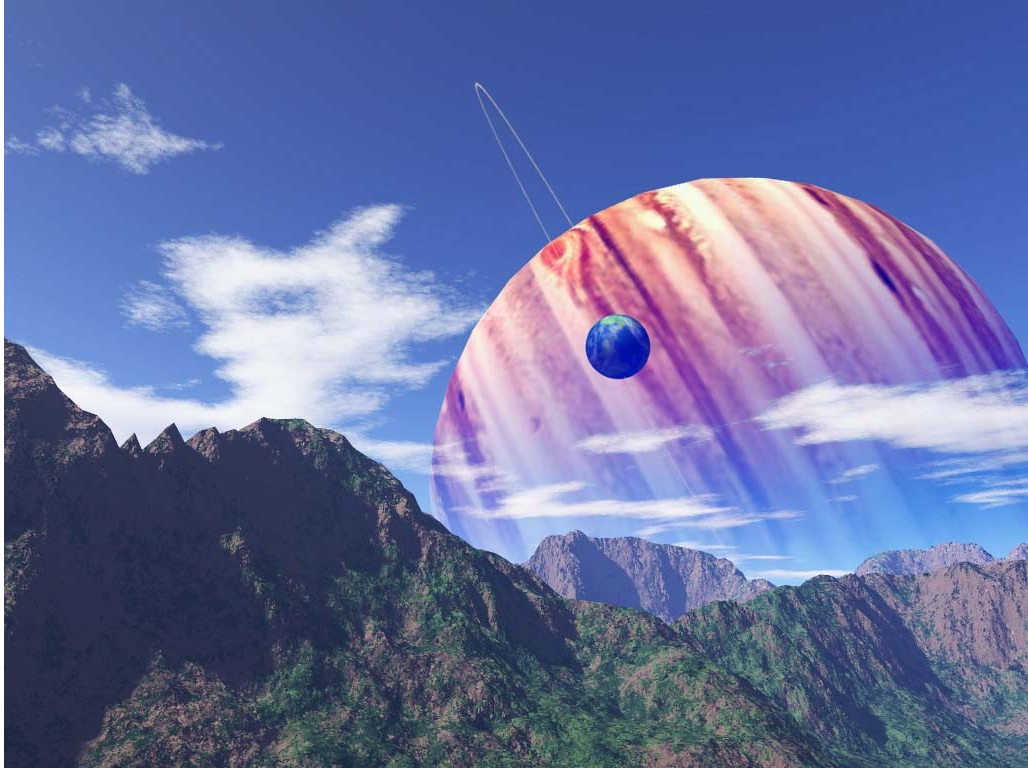
Best place to move?



- Gliese 581C
- 5 times Earth mass
- Orbits in 13 days
- Thought to be rocky
- Star is a red dwarf
- At right temperature to have liquid water



Best place to move?



- Fourth known planet of 55 Cancri is in habitable zone
- Could have rocky moons
- Moons would be at the right temperature for liquid water
- Would have a cool view

The lowest mass extrasolar planets have been found by looking at red and brown dwarf stars. This is because

A) Low mass stars have low mass planets

B) The dim stars make it easier to see their accompanying planets

C) Giant planets would destroy the small stars

D) Low mass stars experience a bigger wobble due to the gravitational pull of the planet

Evolution of Life on Earth

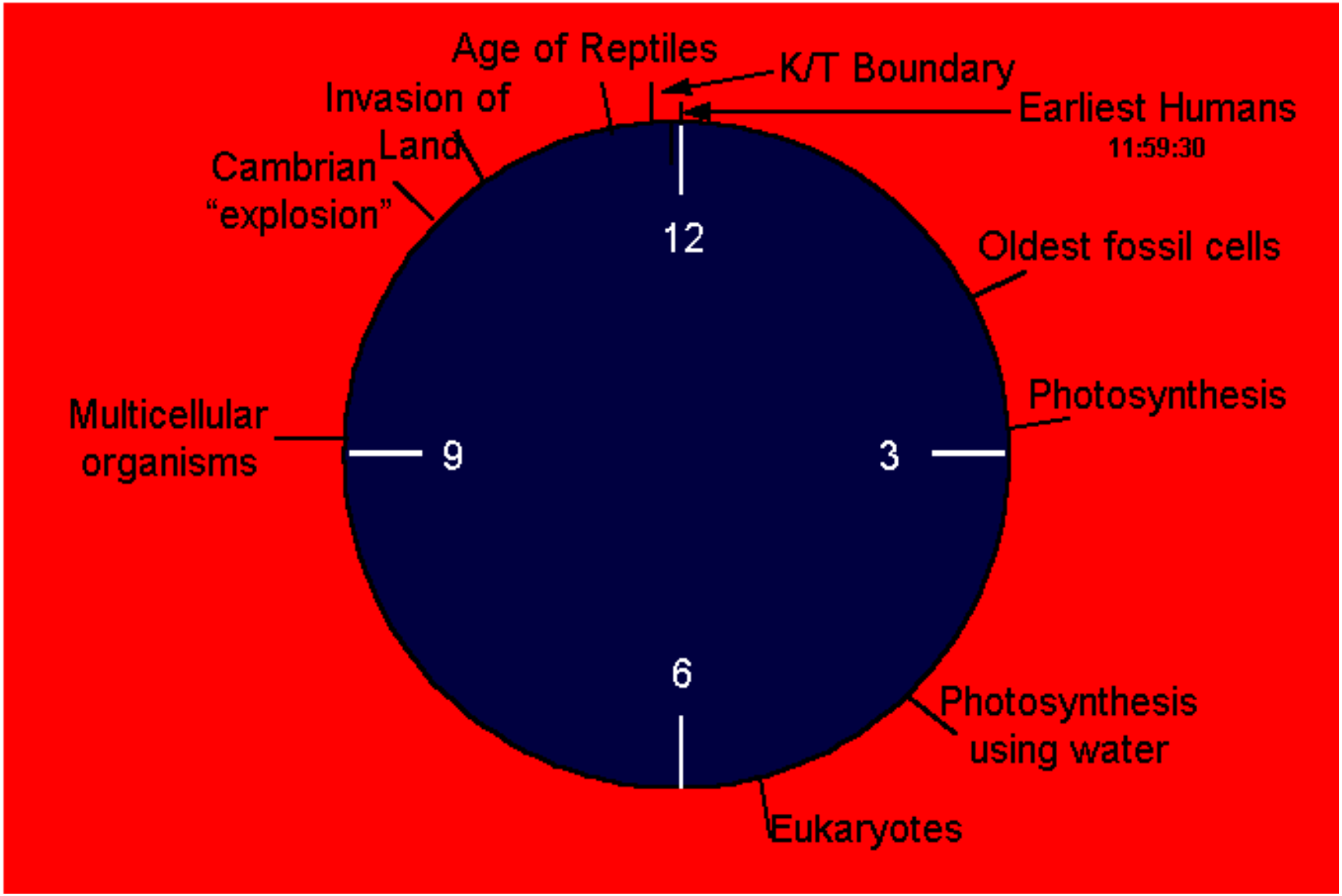
- Even if we find life on another planet, is it likely to be a higher form of life such as mammals or something simpler?

- What form of life occupied the Earth for most of its history?

Evolution of Life on Earth

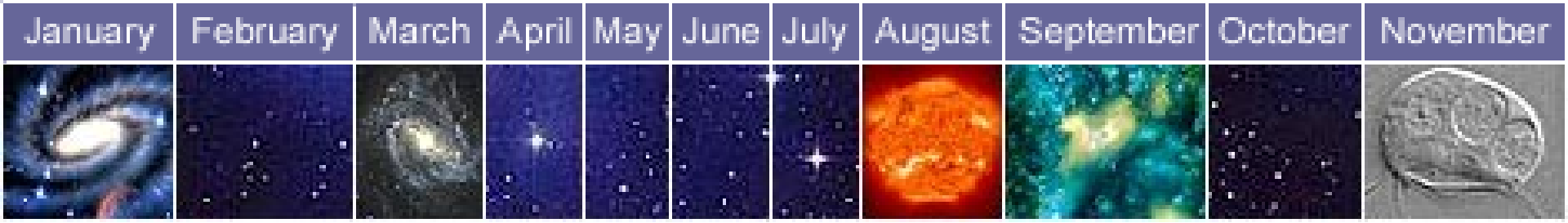
- 4.6 billion years ago – Earth formed
- 3.96 “ “ “ – oldest rocks
- 3.5 “ “ “ – oldest fossils – single celled life
- 0.7 “ “ “ – multicellular life
- 0.0001 “ “ “ – humans (homo sapiens)

History of life on Earth in 12 hours



Carl Sagan's "Cosmic Calendar"

The history of the Universe in one year



Big bang

Milky Way forms

Sun and planets form

Oldest known life - single cell

First multicellular life

December

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15 Cambrian Explosion (burst of new life forms)	16	17 Emergence of first vertebrates	18 Early land plants	19	20 First four-limbed animals	21 Variety of insects begin to flourish
22	23	24 First dinosaurs appear	25 First mammalian ancestors appear	26	27 First known birds	28
29 Dinosaurs wiped out by asteroid or comet	30	31 10:15am Apes appear 9:24pm First human ancestors to walk upright 10:48pm Homo erectus appears 11:54pm Anatomically modern humans appear 11:59:45pm Invention of writing 11:59:50pm Pyramids built in Egypt 1 second before midnight: Voyage of Christopher Columbus				

Search for Extraterrestrial Intelligence (SETI)

- We could avoid this whole business of searching for planets and primitive forms of life, if extraterrestrials would just send us a message.
- There are active searches for such signals, mainly in the radio, some using visible light.

- One thing that is needed is more computing power. You can volunteer your computer to process SETI signals while the screen saver is on at the web site http://setiathome.ssl.berkeley.edu/

Review Questions

- What is needed for life?
- What is the habitable zone?
- Besides Earth, what are the most likely locations for life in our solar system?
- For what fraction of the history of the Earth have humans existed?