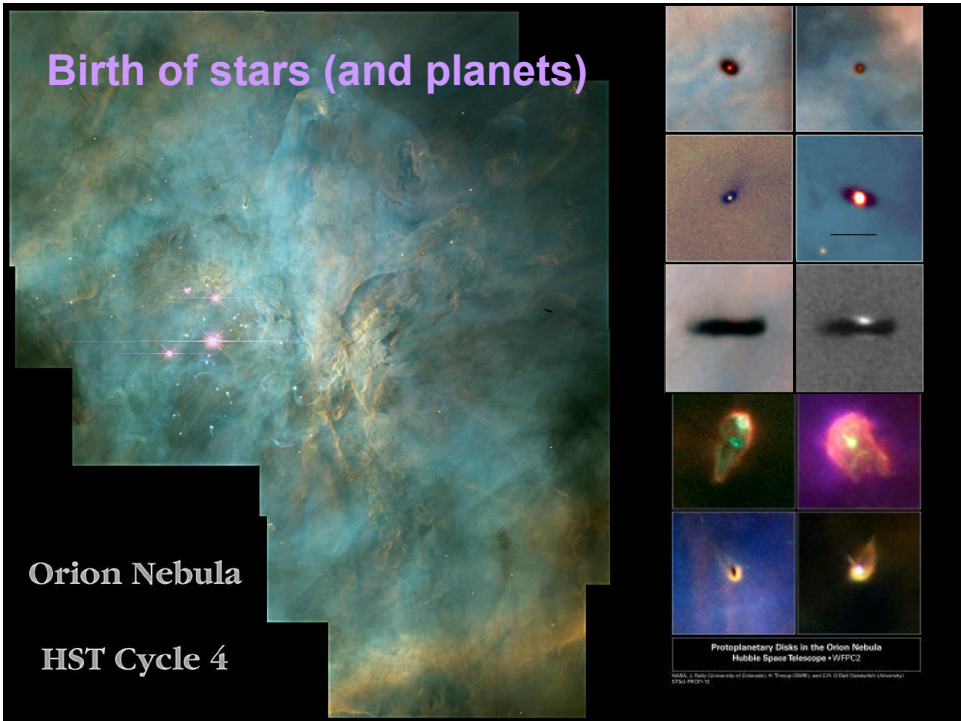




# Intelligent life in the Universe

**Mayank Vahia**  
Tata Institute of Fundamental Research, Mumbai

References: Vahia (2005, 2006) and references therein



## Birth of stars (and planets)

Orion Nebula  
HST Cycle 4

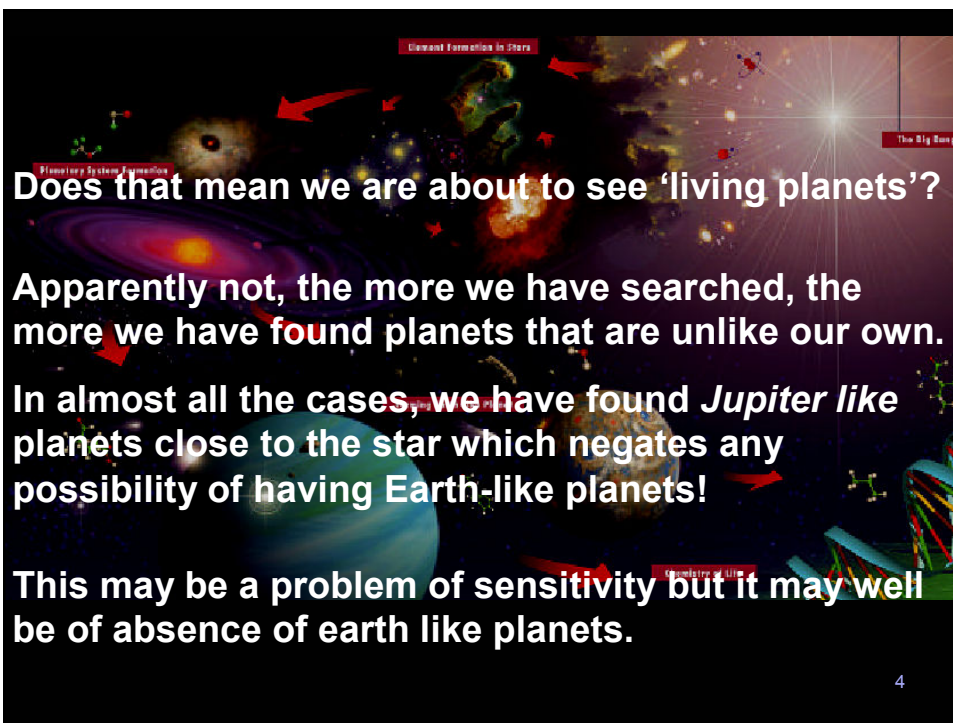
Protoplanetary Disks in the Orion Nebula  
Hubble Space Telescope - WFFC2

© NASA & Space Telescope Science Institute, 2004. All rights reserved. STScI 10/27/04

## Results so far

- 146 Stars are known to have planets (about 200 have been searched)
- 170 planets have been found
- 18 are multiple planet systems

(data as of January, 2006)



Does that mean we are about to see 'living planets'?

Apparently not, the more we have searched, the more we have **found** planets that are unlike our own.

In almost all the cases, we have found *Jupiter like* planets close to the star which negates any possibility of having Earth-like planets!

This may be a problem of sensitivity but it may well be of absence of earth like planets.

4

# DYNAMICS OF LIFE

5

## What is life?

We find it easier to define life by *what it is not!*

We assume life does the following:

- 1) It consumes food
- 2) It reacts to its environment in a complex manner
- 3) It grows and self replicates
- 4) It produces a large number of chemical reactions

At the core of life is aperiodic complexity and not *order*.

A more accurate definition would be: **A living objects are a region of order which use energy to maintain their organization against the disruptive force of entropy!**

LIFE CONSISTS OF MOLECULES THAT KNOW

- WHAT THEY LOOK LIKE
- HOW TO MAKE A COPY OF THEMSELVES

6

## Carbon of life

- It seems that where ever the life is found, it will be carbon based. This is because:
  - Carbon is best suited for living molecules which are:
    - Capable of accepting all types of atoms (both acidic and basic) in reactions
    - Capable of forming really long chains of chemicals
    - Can make very flexible chains with reversible reactions
    - Can form both, close chained and open chained molecules which are very versatile
    - It is easily available in the Universe
  - It has a companion of water, a unique liquid that has:
    - Wide temperature where it remains liquid
    - It is an *excellent* solvent
    - It is chemically a simple molecule
    - It has the 'triple point' advantage
    - It has high specific heat and high vapour pressure
  - Si, the other element of periodic table that can form long molecules has *none* of these advantages.
- However, such a life form *need not be* oxygen breathing or biped.

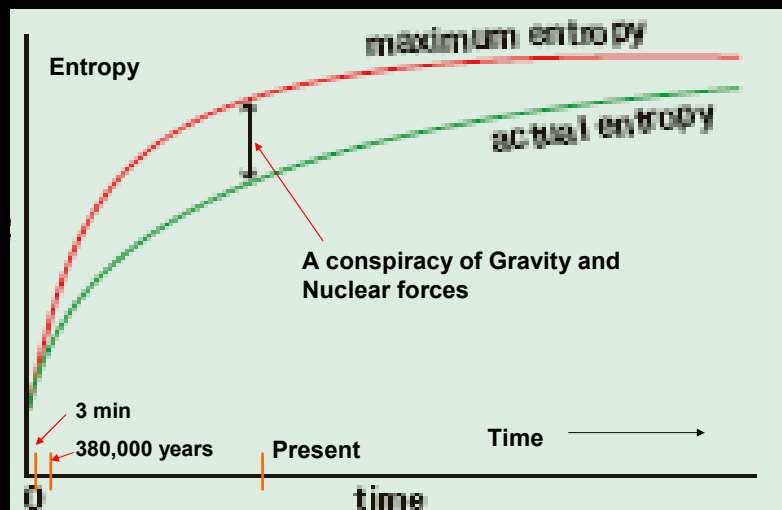
7



Life takes matter from *disorder* to *order* while the natural flow is from *order* to *disorder*.

This creates some fundamental problems.

9



# Process of creation of life

Random Arrangement

T O N F O M S I H I N S R I A T

Crystal structure (ordered system)



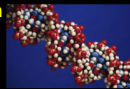
F I N T H I T S S I M A R I N D O

Random Complex System



F N T H T I S S I M A R I O O N

Information containing system



THIS IS INFORMATION

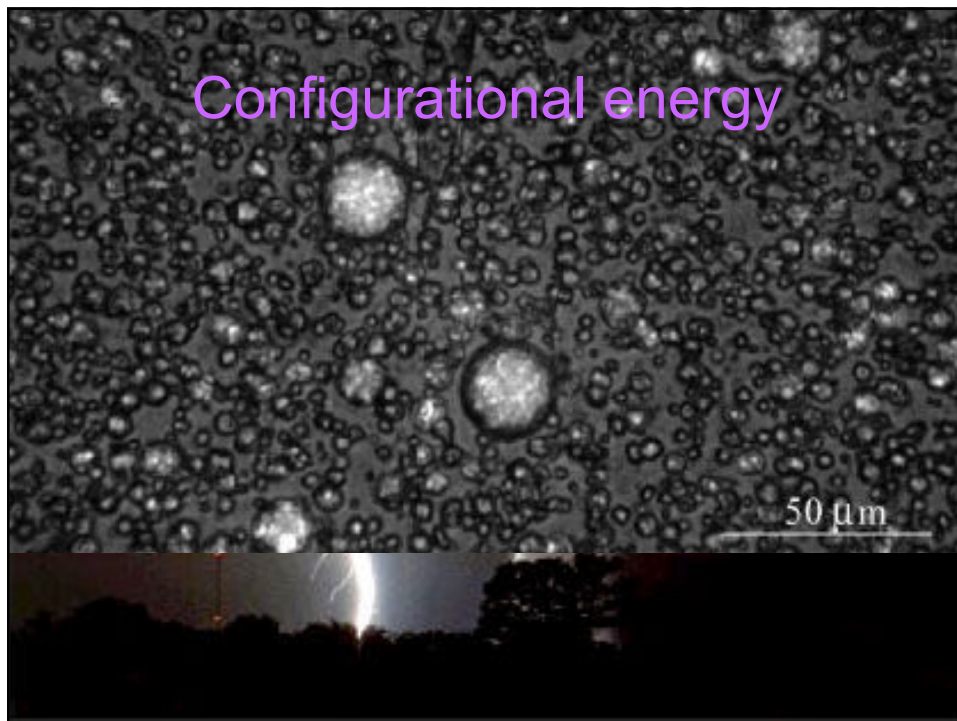
Most common

Can occur naturally  
(e.g. by removing thermal energy)

Can be created by feeding energy e.g. *inside* living systems

We know no way of creating this!

Needs addition of Configurational energy



## Conditions for evolution of life

- Residual material around a small, 2<sup>nd</sup> or 3<sup>rd</sup> generation star
- Correct mix of elements
- *Coherent environment*
- Long term stability
- Correct temperature and temperature gradients and *something more that we don't know.*

How common it is, is a matter of opinion and debate. Some even argue that planets are not needed for this but the conventional wisdom is that planets are necessary to precipitate life.

13

## How can this happen?

- **Chance** – probability is less than  $10^{-45}$ !
- **Selective survival of molecules that are fit to create life**
- **Inherent Self-Ordering Tendencies in Matter**
- **Mineral catalysis** – one cannot get an aperiodic-sequenced polymer using a very periodic template
- **Non-linear non-equilibrium systems and autocatalytic work** fail to distinguish between order and complexity.

It is possible at present to synthesize a few proteins in the laboratory. But necessary chemical manipulations to accomplish the configurational entropy and overcome thermal problem is *externally* provided.

14

## Ideas about origin of life on earth

- Miller's experiments and primordial soup
- Hoyle and Wikramasinghe's proposal of extraterrestrial origin
- Divine intervention
- Correct tuning of fundamental parameters and lifeless universes
- Does the universe exist because we do...

15

## PROBLEMS IN FINDING A PLACE TO CREATE LIFE



16

# Problems in creating life - 1

## Chemistry

### CARBON – WATER: FORM THE BASIS OF LIFE.

- We have never seen molecules with more than a few atoms – except for a few carbon nanostructures.
- Even the simplest molecules of life have a few hundred thousand atoms.
- These molecules may have the size but do not have the structure which can self replicate.
- There is no sense in creating molecules that say “FN THTISSI MARIOON”
- We need molecules that can say “THIS IS INFORMATION”
- To make matters more complicated, we need molecules that understand what “THIS” means etc.
- Hence an entire scaffolding of supporting molecules are required simultaneously at one place!

17

# Problems in creating life - 2

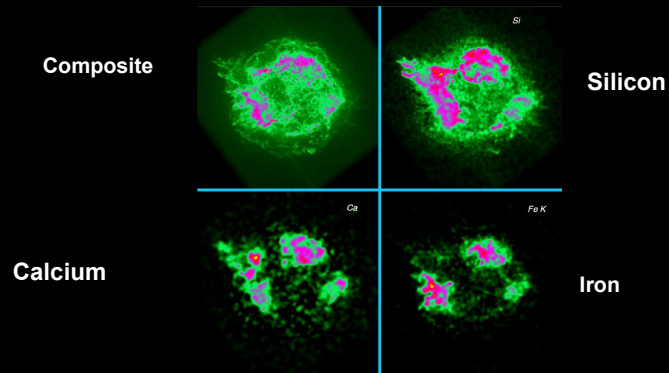
## Biology

- Large scale, information containing carbon chains are required at correct place in correct sequence!
- Self replicating (living) molecules require specific ordering of atoms
- Importance of nitrogen
- Importance of Ozone - oxygen is not available freely in un-inhabited planets
- Evolution from:
  - molecular to cellular life
  - cellular to complex life forms

18



We are all ashes of some dead star!



Since life requires elements that are only made *inside* stars, life can arise only on planets around second (or later) generation stars

21

## SEARCHING FOR A PLACE TO CREATE LIFE



## What will we look for?

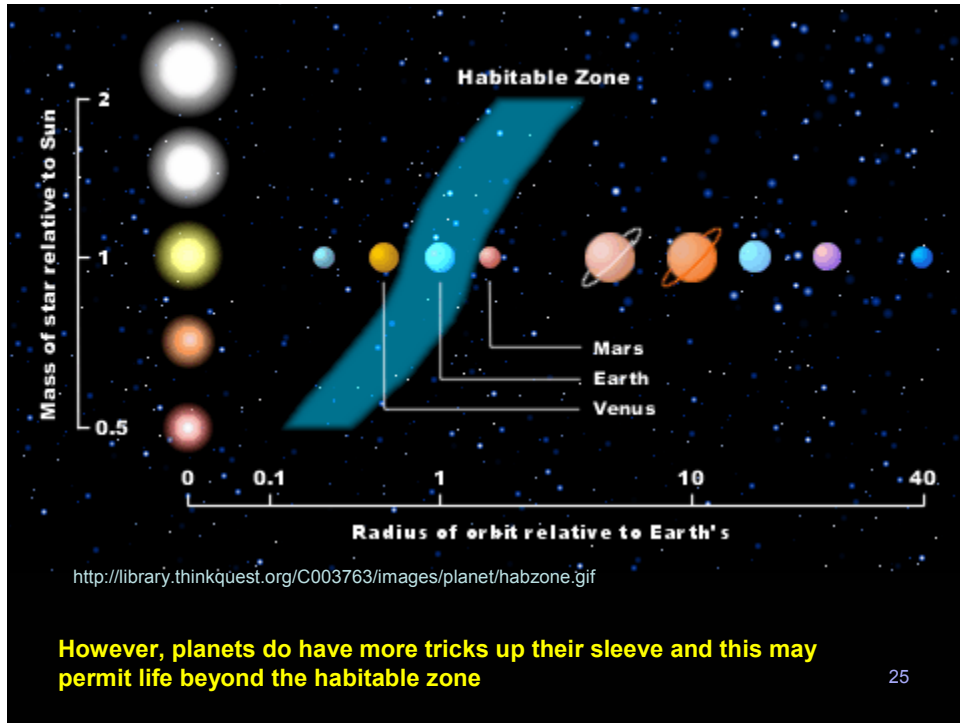
- Ability of planet to provide a stable insulated environment with a balance between internal heat and star light.
- Size of the parent star – large stars do not live very long.
- Distance from the parent star.
- Its eccentricity.
- Its composition, particularly O<sub>2</sub> gas in a Nitrogen atmosphere.
- Water.
- Long term stability.

23

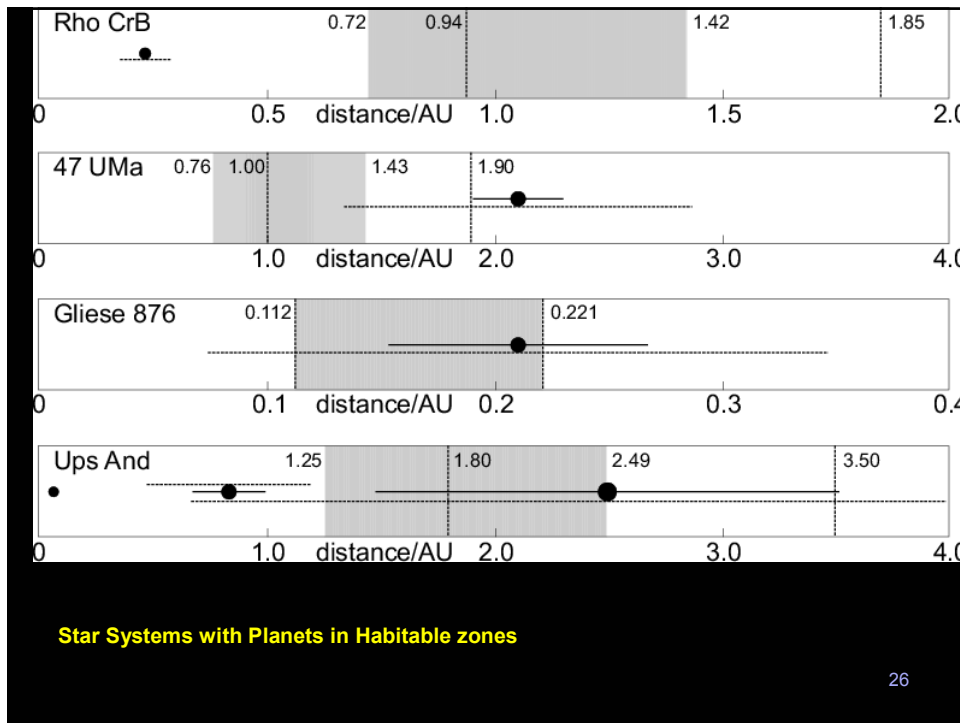
## Habitable zone around a star

- Habitable zone around a star has to be:
  - Planet with a correct mixture of internal heat and stellar radiation. Too much of either can have scalding affect on molecules.
  - Should support liquid water.
  - It cannot get so hot as to photo dissociate water (if the sun was 10% hotter or 3% closer, this would happen on Earth). This gives a proximity limit of 0.95 AU for a livable planet around our Sun
  - The outer edge is defined by CO<sub>2</sub> condensation temperature which will shutdown the carbon cycle. This gives a maximum distance of 1.37 AU for a livable planet around Sun.

24



25



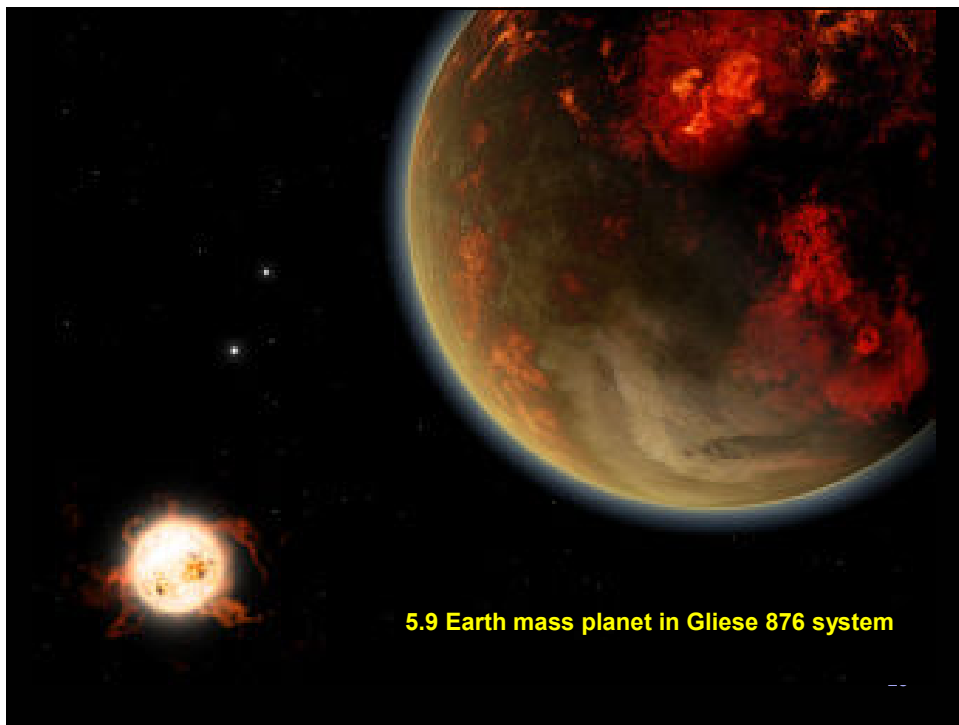
26



Planetary System with Gleiss 876

Art by Lynette Cook

27



5.9 Earth mass planet in Gliese 876 system





## Life on moons of planets?

**Euceladus (Saturn)**



**Titan (Saturn)**



**Io (Jupiter)**



# FROM LIFE TO INTELLIGENCE

33

## Long term habitability of Earth

- Importance of
  - correct temperature range.
  - Planet size and structure.
  - Moon.
  - Jupiter and other outer planets.
  - isolation of the star.
  - circular orbit and its tilt of the axis of rotation.
  - magnetic field.
  - Complex geological upheavals to regenerate Earth.

34

## Evolution of Intelligent life

- Taking life from simple self replicating molecules is not a simple task. It requires:
  - Transformation from molecule to a cell.
  - For a cell to transform to multi-cellular being.
  - Sexual form of reproduction to improve survival chances.
  - Need for evolution of intelligence as a survival strategy.
  - Technological advances beyond survival needs.

35

## Search for Intelligent life on Habitable Planets

- Drake's Equation: *The probability of finding intelligent life is:*

$$P = P_t P_s P_p P_h P_g P_i P_e P_c P_l P_r P_d$$

Where

**P = Total probability given by:**

$P_t$  = total number of stars in the galaxy (~ $10^{11}$ )

$P_s$  = percentage of stars that can have planets (~20% late type only)

$P_p$  = percentage of star that actually have planets (~80%)

$P_h$  = percentage of stars with habitable zones (~10%)

$P_g$  = percentage of planets with stable circular orbits

$P_i$  = percentage of planets where life has evolved

$P_e$  = percentage of planets where life has moved beyond simple molecules

$P_c$  = percentage of planets where life has moved to multi-cellular structure

$P_l$  = percentage of planets that have intelligent life

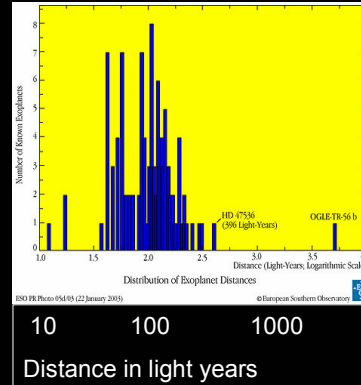
$P_r$  = percentage of life that avoided self destruction

$P_d$  = duration before which they emit detectable signals to earth

36

# What if there is intelligent life

- Contacting them will not be easy because of vast distances. So signals take long time to travel AND become fainter as the square of the distance.
- Travelling will certainly not be easy as long as we cannot find a way around Relativity.
- Assuming that they can get around relativity, they will have to be technologically sophisticated and yet have overcome the pathetic desire to dominate.



**Interplanetary transport typically takes 10,000 times more time to reach a place than light. i.e. 1 yr to 10,000 yrs!**

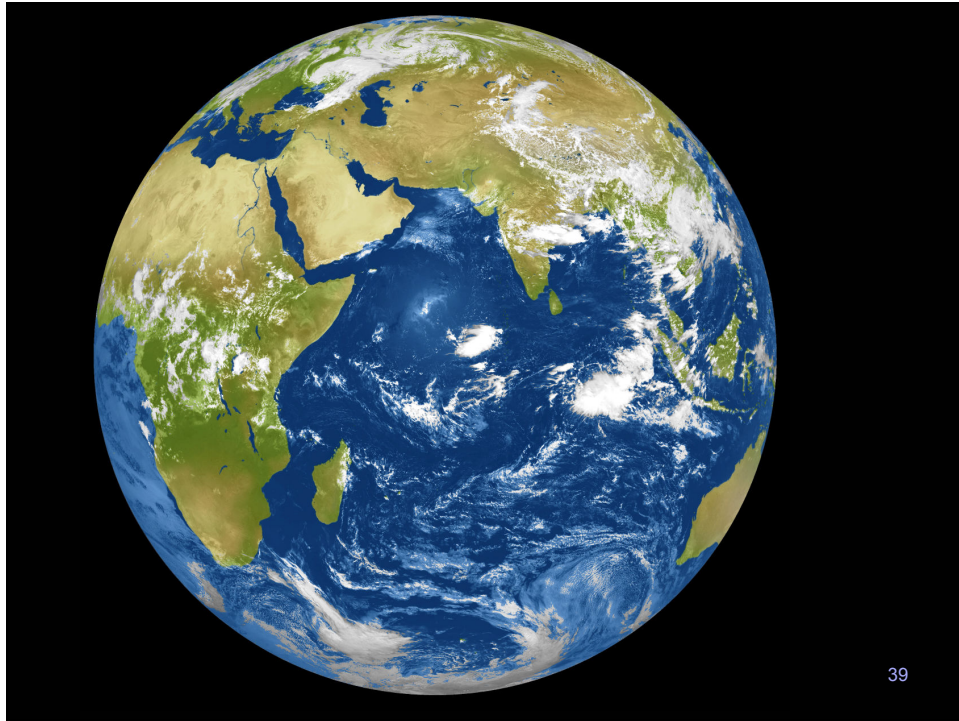
37

# Some ideas on intelligent life elsewhere

- How many manage to overcome the 'Nuclear barrier'?
- How many avoid pollution and resultant self-destruction?
- How many are not on stable planets in terms of planet quakes and meteor showers?
- If advanced, how many are keen on exploration?
- If they are keen on exploration, are they violent?
- Maybe some will notice our 'radio activity' and will come towards us in future. If they come,
  - Will they come in person?
  - Will they send their robots?
  - Will they send their atom bombs, just to 'evict' us from this beautiful and habitable planet?

Some have argued that the very fact that we have not had 'visits' interstellar travelling super-intelligent life forms don't exist, then of course there are those who believe in UFOs.

38



39

## Acknowledgement

- I have extensively used web based resources to highlight various issues.
- All the pictures in the lecture are from various known and unknown authors.
- I thank them all for their willingness to share their ideas and work on internet.

40

End

41