Average or not?

Just how unique is our Earth?

Bart Busschots - Whitaker Awards 2005

Introduction

- I am NOT a Biologist! (no higher than JC Science!)
- I am an Astronomer
- Interest in Biology stemed from the work of Frank Drake and others at the SETI Institute
- The ultimate question to me is “Are we alone?”
- Always believed (based mainly on pure optimism) that there must be loads of life like us in our galaxy.
- The Book “Rare Earth: Why Complex Life is Uncommon in the Universe” (P. Duglas Ward & D. Brownlee) forced me to relunctantly think again!

Unique in what way?

- In this talk I will be looking at Earth's most impressive feature, its support of higher life.
- Bacterial life is amazingly resilient and has been found in the most extreme environments.
- Higher life seems to be a lot less resistant to extremes.
- For the purpose of this talk I will consider higher life to be complex, intelligent life forms like Humans, Chimps and Dolphins.

The Swinging Pendulum

- Opinions on just how unique Earth is seem to keep swinging from side to side (as well as generating controversy!)
- First we believed Earth was unique (based on religion more than anything else)
- Then Scientific opinion began to swing the other way. (Drake Equation, explosion in discovery of Extra Solar Planets)
- Now Scientific opinion seems to be starting to swing back, Earth appears to be quite special after all!

What is needed for Higher Life?

- A temperate environment rich in the elements needed for organic molecules (mainly Carbon)
- Protection from Stellar and Cosmic radiation.
- An environment conducive to diversification
  - Many varied environments
  - Some catastrophes to kick start evolution
- Stability, evolution from simple organic compounds to higher life appears to be a long and slow process so these conditions must exist over a very long period (~4 Billion years on Earth)

Earth's Key Features - Location

- Located in the Galaxies 'Habitable Zone' (lots of heavy elements and a quite neighborhood)
- Located in the Sun's 'Habitable Zone'
- In orbit around a very special star
  - Rich in heavy elements
  - Big yet long lived (rare)
- Just the right amount of debris our early solar system to acquire needed water and carbon without destroying the planet (Jupiter responsible)

Earth's Key Features - Continued

- Has molten core and plate tectonics
  - Provides Magnetic Field which acts as a vital shield
  - Allows Earth to cycle Carbon
  - Allows Earth to re-distribute Oxygen and Water
  - Acts as Earth's thermostat
- Abnormally large moon
  - Stabilizes the Earth's axis of rotation, VITAL to keep climate stable
- Catastrophe's that are not too catastrophic
  - 'Snow Ball Earth'
  - Mass Extinctions caused by geophysical events

How Rare are these Features?

- Galactic Habitable Zones:
  - Majority of stars in each galaxy are outside the habitable zone (tightly packed in core)
  - Many galaxies are so poor in heavy elements that they have no habitable zone at all
- Solar Habitable Zones
  - Narrow
  - If stars are too small no zone at all as planets in zone will be too small to hold atmospheres or will be tidally locked

How Rare are these Features?

- Suitable Star:
  - 90% of stars are smaller than the sun
  - Most stars larger than the sun are short-lived
  - Most stars are multiple stars so no stable orbits for planets
- Molten core:
  - need radioactive elements to keep molten – rare in the universe
- Large Moon:
  - Very rare as creation process very unlikely

How Rare are these Features?

- Catastrohes:
  - Fine line between 'Snow Ball Earth' events and total planet wide extinction ending all life
  - Fine line between impacts causing mas extinctions and impacts causing total extinction

Conclusion

- Earth is a lot more unique than many people once thought
- Not the center of the universe but a very special place all the same
- Bacterial life may well be ubiquitous but higher life is unlikely to be as common as Drake predicted (10,000 civilizations in our galaxy).