



Life in the Universe

Life In the Universe

- What is Life?
- SETI
- Mars
- Panspermia
- Exotic Life Forms
- Extraterrestrial Planets
- Chemical Building blocks
- Habitable Zones
- Drake Equation
- Fermi Paradox
- Europa and other moons

This Evening's Topics

- Habitable Zones (Mike)
- The Drake Equation (John)
- The Fermi Paradox (John)
- Europa & other moons (Paul)
- The Rebuttal (Ray)
- Questions & Discussions (All)

Habitable Zones

Mike Ross

What Advanced Life Needs

- Time
- Place
- Niche

Time

- For rocky planets and Jupiters to form
- To evolve complexity

Rocky Planets

- Too early - low metallicity
 - ▼ no planets at all
 - ▼ no Jupiter
- Too late - high metallicity
 - ▼ large Earths with heavy elements
 - ▼ multiple gas giants
- Metallicity increases 8% per billion yrs

Evolve Complexity (1)

- 4.6 bya Earth formed
- > 4.0 bya Oceans form
- >3.9bya prokaryotes form
- 2.0 bya oxygen in
redbeds/eukaryotes
- 1.7 bya aerobic life takes over
- 1 bya seaweed
- 2.4 bya to 630 mya Snowball Earths?

Evolve Complexity (2)

- 620 mya Ediacara multicellular life
- 530 mya Burgess Shale Arthropods
- >350mya Amphibians appear
- 320 mya Reptiles appear
- 300 mya Proto Mammals Appear
- 230 mya Mammals Appear
- 6 mya Genus Homo

Evolve Complexity (3)

- < 100,000 ya Modern Man
- < 5,000 ya Astronomers

Place

- Somewhere in the Galactic suburbs
- Not in an active/elliptical Galaxy
- Stable Sun
- Circular planetary orbit
- Liquid water
- Night and Day
- Not too close to a cool Star

Galactic Habitable Zones (1)

- Hub - too close to volatile centre
 - ▼ Black Hole
 - ▼ Star Forming Regions
 - ▼ Supernova
 - ▼ Gamma Rays
 - ▼ X-rays

Galactic Habitable Zones (2)

- Thick Disk & Halo
 - ▼ Metallicity too low - older stars
- Thin Disk
 - ▼ Metallicity about right
- Distance from Galactic centre
 - ▼ Sun corotational with the Galaxy

Active/Elliptical Galaxies

- Active Galaxies
 - ▼ Active black holes
 - ▼ Starburst/Seyfert Galaxies
 - ▼ Colliding Galaxies
- Ellipticals/Globular Clusters ?
 - ▼ Old and therefore metal poor

Planetary Habitable Zones

- The zone where water is liquid
- For the Sun between 0.85 and 2 AU
- Depends on luminosity/mass of star
- More massive stars are less stable
- More massive stars burn out quicker
- Less massive stars risk rotational lock
- Less massive stars risk solar radiation

Stars in our neighbourhood

- There are 35 stars within 13 ly (inc Sun)
- Only three are more luminous
 - ▼ Sirius A
 - ▼ Procyon A
 - ▼ Alpha Centauri A
- 26 are M or high K types
- Only 2 others are not binaries
 - ▼ Tau Ceti
 - ▼ Epsilon Eridani

Niche

- Oceans
- Large Moon
- Plate Tectonics
- Occasional Mass Extinction

Oceans

- Provide mix of land and water
- Disipates heat
- Contributes to atmospheric circulation
- Gives rain
- Provides for tidal areas

Large Moon

- Keeps tilt of axis constant
- Generates higher tides in oceans
- stops rotational lock

Plate Tectonics

- Lubricated by water
- recycles carbon, oxygen etc
- builds mountains, valleys etc
- disipates heat from planetary core
 - ▼ Venus has different disapation method
 - ▼ Mars has stopped

Mass Extinctions

- Create new ecological niches
- Remove old settled species
 - ▼ Trilobytes
 - ▼ Nautiluses
 - ▼ Dinosaurs

But Not As We Know “It”

Molecular Clouds

Neutron Stars