The Origin of Life and Spaceflight Biospherics

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Presentation Overview

• Introduction
• Origin of Life
  – Old and New Theories
  – Implications
• Chemistry and Physics of Reaction
• Spaceflight Biospherics
  – Integration of Concepts
  – Implications
• Summary
Introduction

• Premises
  – Manned exploration: prohibitive technology is biospheric-, not launch-related
    • No excessive dependencies, no excessive launches
  – Origin of life is relevant; useful
    • Abiogenic production of organic mono- and polymers
  – Abiogenic processes liberate spaceflight logistics from Earth refueling dependencies
    • Life originating here yields life thriving there
Origin of Life

• Many theories; no definitive proof
  – Miller-Urey (lightning synthesis)
  – Sagan (infalling meteor shock synthesis)
  – Panspermia (extraterrestrial material/biota)
  – Cairns-Smith (crystalline mineral catalysis)
  – Waschterhauser (chemolithotrophic catalysis)
New Theory- Radiolytic Synthesis, Organic Takeover

- Life has a terrestrial origin
  - Radioactive decay provides energy impetus
  - Mineralogical associations provide elements and molecules as nutritive resources, helpful catalysts
  - Environmental (geological + atmospheric) setting provides effective reaction matrix
  - Localized production site provides recombinant reaction processes and diversification of reaction yield
Chemistry/Physics – Homolysis

• Basics of Homolysis:
  – Low-entropy energy bombardment (Initiation)
  – Extremely reactive free radicals w/unpaired valence electrons (Propagation)
  – Radical recombination and product yield (Termination)
Chemistry/Physics – Energy (1)

- Many energy sources possible
  - Chemical, radiative, electrical, thermal, etc.
- \( E = U - TS \)
  - \( E \) = Helmholtz free energy [J]
  - \( U \) = Total input energy [J]
  - \( T \) = Temperature of reaction [K]
  - \( S \) = Entropy of reaction [J/K]
- Decrease \( T \), decrease \( S \), or increase \( U \) to increase \( E \), the ‘useful’ energy left to do productive work (under optimal conditions)
Chemistry/Physics – Energy (2)

- Energetic considerations

- Entropic considerations

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<th>Source</th>
<th>Energy (cal/cm²/yr)</th>
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<tr>
<td>Sunlight (all wavelengths)</td>
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<td>Electric Discharges</td>
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<td>Cosmic Rays</td>
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<td>Radioactivity (to 1.0 km depth)</td>
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<td>Volcanoes</td>
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Source: Miller and Urey

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<td>Nuclear Energy</td>
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<td>Internal Heat of Stars</td>
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<td>Terrestrial Waste Heat</td>
<td>10-100</td>
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<tr>
<td>Cosmic Microwave Radiation</td>
<td>100-1000</td>
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Source: Van Nostrand’s Sci. Encyclopedia
Chemistry/Physics - LET

- **Linear Energy Transfer** – $L = \frac{dE}{dx}$
- Not all radiolytic sources equal
  - Alpha: high-LET
  - Beta, gamma: low-LET
  - Physics are stochastic, but net effects are quasi-predictable
    - Bragg Curves, radiobiological treatment

Source: LET Physics, ICRU Pub.
Spaceflight Biospherics

• Current reference designs:
  – Initial resources, subsequent replenishment
• Recycling is significant, but so far insufficient for biospheric independence
• Current ISRU techniques produce useful inorganic molecules
• New concept: Origin of life processes yield organically assimilable ISRU products
Implications

- Abiogenic production of (extraterrestrially) exotic monomers and polymers
  - Trophic support for primary (and secondary, tertiary?) members of enclosed biosphere
  - Limited production of mechanically-valuable inorganic monomers and polymers

Closed-system recycling
+ abiogenic molecule production
= independent biosphere
Spaceflight biospherics

Cosmic, nuclear technology radiation

Bombardment

Ionization and Recombination (Protection)

Extraction, Separation, and Storage

Biological Assimilation

H₂O → CH₄ → HCl → Alcohols → Alkenes

NH₄Cl → CO₂ → C₂H₆ → Alkanes → Aromatics → Secondary Amines

? → Extraction, Separation, and Storage
Conclusions of Research

• Corpuscular radiolytic reactions were not proven unfeasible; *but* feasibility requires testing
• Immediate experimentation (new and old theories)
  – No origin of life constraints
  – Wide array of reactants and catalysts
  – Industrialize process
• Proposed device can be multifunctional when integrated with current designs
• Proposed device could revolutionize methods of extraterrestrial survival, and hence methods of exploration, *enabling colonization*. 
Summary

• Biospheric independence leads to reduced overall mission costs, increased flexibility
• Origin of life studies can enable greater understanding of artificial biospheric generation and stability
• Research indicates homolytic processes could revolutionize space survival by protecting crew, and stabilizing biosphere through regenerative organic energy input
End of Presentation

Special thanks- NIAC/USRA

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