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

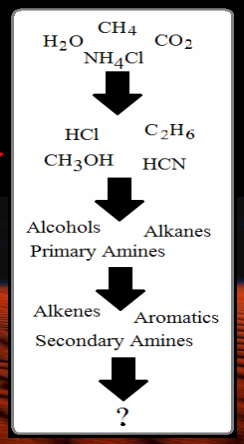
Chemistry/Physics – Homolysis

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

1. Initiation

2. Propagation

3. 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

Source	Energy (cal/cm^2/yr)
Sunlight (all wavelengths)	260,000
Electric Discharges	4
Cosmic Rays	4
Radioactivity (to 1.0 km depth)	0.8
Volcanoes	0.13

Source: Miller and Urey

- Entropic considerations

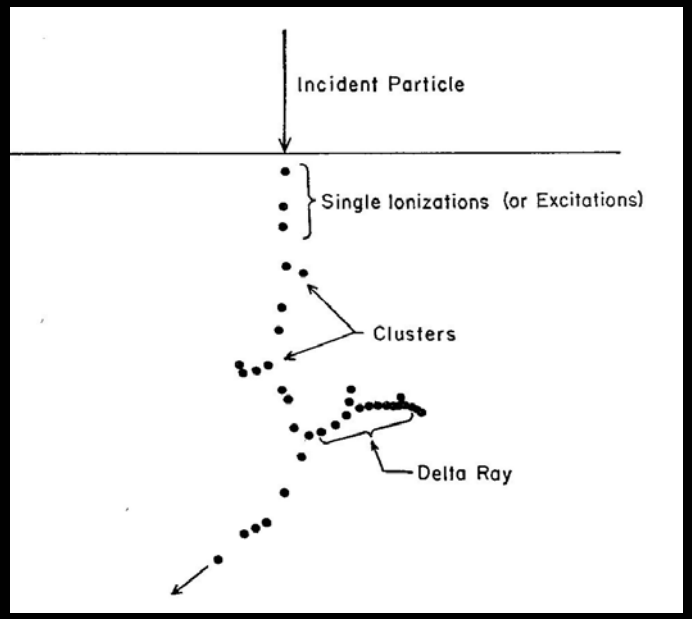
Form of Energy	Entropy Per Unit Energy
Gravitational Energy	0
Nuclear Energy	10^{-6}
Internal Heat of Stars	10^{-3}
Sunlight	1
Chemical Reactions	1-10
Terrestrial Waste Heat	10-100
Cosmic Microwave Radiation	100-1000

Source: Van Nostrand's Sci. Encyclopedia

Chemistry/Physics - LET

- Linear Energy Transfer –

  $L = dE/dx$
- 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

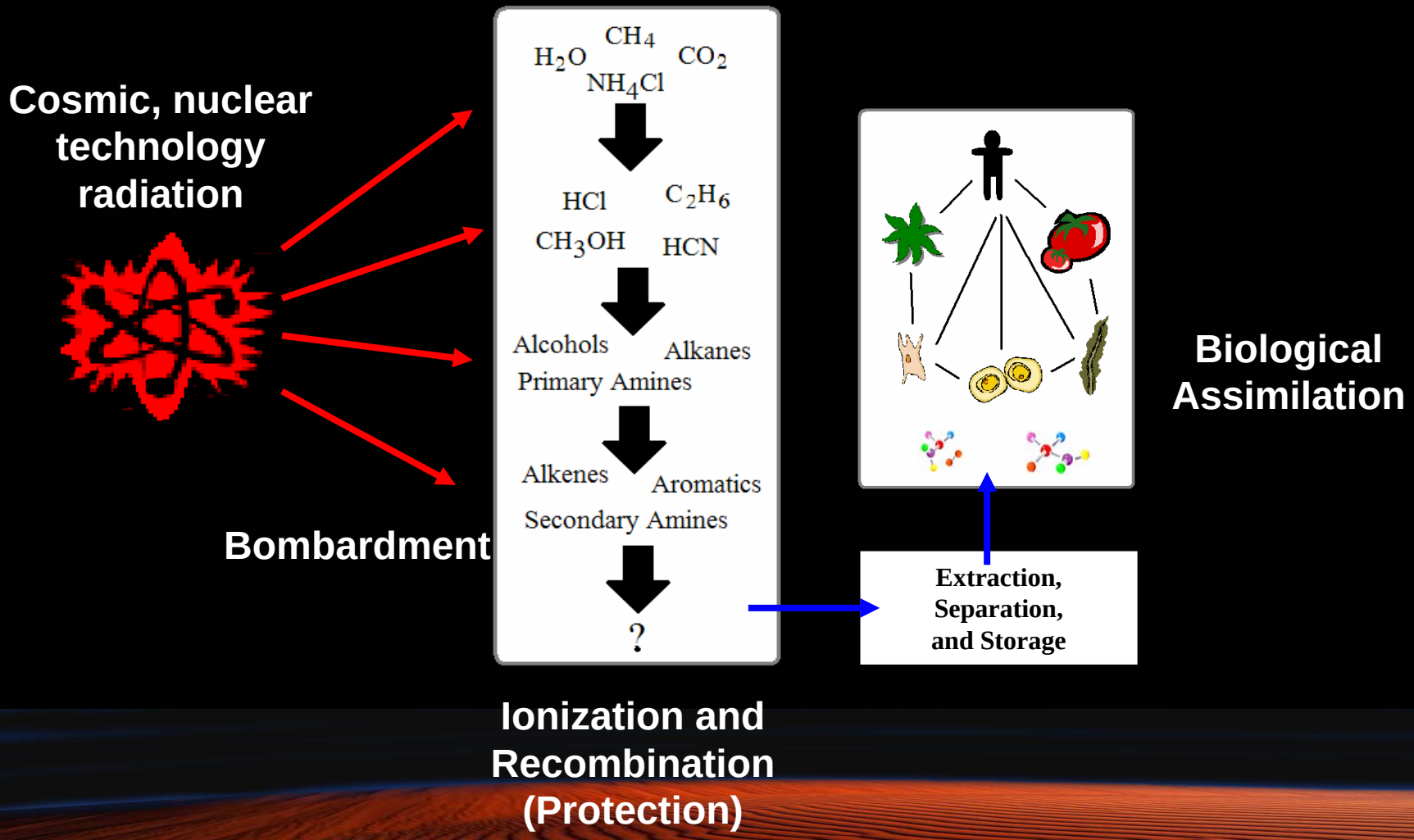
- Abiogenic production of (extraterrestrially) exotic monomers and polymers
  - Trophic support for primary (and secondary, tertiary?) members of enclosed biosphere
  - Limited production of mechanically-valuable inorganic monomers and polymers

Closed-system recycling

\+ <u>abiogenic molecule production</u>

= independent biosphere

Spaceflight biospherics



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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