Today’s Events

- Last two lectures look at **Possibilities of Life Elsewhere – and Extra-Solar Planets**
- **Final Exam Review tonight** by Ben Brown, here, 7-9pm. Final review sheet available.
- Extra-credit observing projects due today
- Homework 10 returned + answers
- Overview read Chap 24: Life beyond Earth
- Course evaluation today at end of class

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**Life in the Milky Way galaxy**

**Which do you think is most likely?**

A. life of any kind is present only on Earth
B. primitive life exists elsewhere (Mars, other planetary systems), intelligent life is unique to Earth
C. intelligent life developed elsewhere, but has since died out
D. other civilizations exist, but are rare
E. other civilizations are very common

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**Building blocks for life forms**

What is LIFE?

Organism needs INCORPORATE environment TO SUSTAIN ITSELF
- METABOLISM (energy source)
- GROWTH
- SELF-REPRODUCTION

Key to success may be complexity!

LIFE ON EARTH IS SUPERORCHESTRATED, WITH DELICATELY BALANCED CHEMICAL REACTIONS

Under what conditions can this develop?

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**How does life start?**

Three propositions

1. **Evolve spontaneously**
   - **GROUP DISCUSSION**
     -Neighboring students

2. **PROTEIN EMBRYO formation FROM MIXTURES of AMINO ACIDS and water
   -ogeneous polypeptides in water, membrane formation
   - DEVELOPMENT of synergistic, self-replicating PROTEINS

3. **SELF-ORGANIZATION OF ORGANIC Molecules into `cells`
   - DEVELOPMENT of cell membranes
   - FORMATION of nucleus

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Building blocks for life forms

1. **Building on previous with complex chemistry**
   - HEPARIN, C, oxirane, O, phosphorus, Si, sulfur, in water, PHOSPHORUS

2. **Some sort of nucleus with high bioactive properties**
   - **H**2O, H2O, N, phosphorus

3. **Hormone temperatures (~ 38°C)**
   - **HEPARIN**
   - **RHAPSODIA**

4. **Maintain UV radiation, electrical discharge... to get things started**
**Life on Earth**

1. **Carbon-based**
   - Origin of life: Primordial soup
2. **Proteins**
   - Flowing, primitive, complex"
3. **4 ingredients**
   - DNA/RNA, proteins, water, energy
4. Simple life form: Nanobacteria

**Proteins**
- Complex
- DNA – RNA encoding

**Simple life form: nanobacteria**

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**Life in many forms ... some surprising**

 Thermal pools in Yellowstone host life, despite very harsh conditions (high temperatures, acid water)

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**Zones of habitability: requirements for carbon-based life (ecospheres)**

**Varying zones of habitability around stars**

- A-type stars
- Favorable, but lifetime on MS?

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**Ecospheres to nurture and sustain life (on planets)**

- Habitable planets would have \( S > 0 \) \( \dot{S} > 0 \) and \( M > 0 \)
  - Low beta, high gravity, local energy
  - \( S = 0 \) and \( \dot{S} < 0 \)
  - Heat source is very high
  - No energy, no habitable zone

**Ecospheres around stars**

- A5
- F5
- G2
- K5
- M5

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**Requirements for life**

1. Liquid water
2. Moderate energy: \( H \geq 1 \mathrm{J} \) to \( T \leq 1000 \mathrm{K} \)
3. \( N > P \) or \( N < P \)

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**Ecospheres**

1. Chemical diversity
2. Energy sources
3. Moderate energy
4. Habitability

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**2009 nm**
Requirement for liquid water defines a habitable zone: range of distances from a star where the surface temperature is between freezing and boiling.

Not known observationally how often a rocky planet occupies the habitable zone.

Thought on theoretical grounds that habitable planets should be common.

Course Evaluation

More on hunting for extra-solar planets and estimating chances for life in ultimate lecture: plus winners for "finest crib sheets"