Working group: What physical principles predict life?

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We are immersed in life here on Earth, but life isn't found on the Moon. Nor has it arisen, so far as we know, anywhere else in the solar system. Why do some physical environments precipitate life, and why don't others?

SFI researchers sought clues during a working group at SFI last week.

On some level, it's obvious why nothing lives on the Moon: It's a cold, waterless place without much of an atmosphere. A deeper answer is that Earth's biosphere manages to take in energy from sunlight and use it to build and maintain life.

But that answer leads to a still deeper question, according to the

meeting's organizers, SFI Professor David Wolpert, Omidyar Fellow alum James O'Dwyer, and SFI Professor and VP for Science Jennifer Dunne: If the Earth really does use sunlight to convert a disorderly lump of mass and energy into organized living things, why can't the Moon, Earth's nearest neighbor, do something similar using different mechanisms?

One part of the answer, Wolpert says, might lie in information theory. In addition to being central to modern biologists' understanding of evolution, information theory overlaps heavily with thermodynamics, the area of physics concerned with how the different kinds of internal energy of a system (such as heat and stored chemical energy) might be affected by the outside world.

The meeting explored the question of whether there are broad principles—grounded in the laws of physics—that determine whether any given environment in the universe is likely to contain a "living system" (examples: 1,000 miles deep in Jupiter's atmosphere; near the event horizon of the Sagittarius A black hole; in the Sun's photosphere)? Knowing only the physical conditions there, would we expect to find "living systems" that are evolving into ever more complex forms.

Each talk in the meeting focused on at least one of three related questions:

- Are there physical principles that predict life?
- What can we learn of these principles from observations of life on Earth?
- Do these principles constrain patterns of organization in ecological systems?

At the end of the meeting, the participants distilled some of the tentative answers to these questions, ranging from the speculation that coarse-grained "Earth-like" and "non-Earth-like" dynamics might differ in predictable ways, that the thermodynamic cost of computation is important for life, and that living systems will always display periods of equilibrium punctuated by bursts of diversification.

The group also touched on the question of determinism in biological systems, both from a theoretical perspective and also in reference to highly-controlled experimental results for synthetic ecological communities, developed by one of our participants.

"In many talks and discussions, the nature of information flow between different scales of organization emerged as an important theme and open question," says O'Dwyer. "We look forward to future collaboration on each of these ideas."

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