

ORIGINS OF LIFE WORKSHOP ATLANTA OCTOBER 14-17

The Foundation for Applied Molecular Evolution will hold a distinctive conference on the "Origins of Life" in Atlanta Georgia, at the Georgia Tech Conference Center. Seeking to resolve paradoxes remaining in models for the origin of life under an "RNA first" model, it will feature talks by experts doing origins research in biology, chemistry and planetary science.

However, and distinctive, it will have each session a dialog that will include, as panelists, speakers as well as attendees, with open microphones on the floor for attendees to participate. A preliminary list of dialog topics is also listed below.

The conference begins with registration on Sunday, October 14, and ends mid afternoon Wednesday, October 17, in time to catch the later flights from Atlanta Hartsfield Airport. Accommodations may be arranged through our website. It also includes a copy of the book "Life, the Universe, and the Scientific Method", and admission on Tuesday night to the Fernbank Planetarium, which will be showing a premier of "The Origin of Life and the History of Earth".

Workshop materials will be delivered to registrants a month before the event. An outline of these is provided below.



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WORKSHOP MATERIALS (SUBJECT TO REVISION)

With a limited budget, the 3-year project that forms the background for this workshop made specific choices and assumptions:

1. It assumed that and terran life emerged here on Earth, not elsewhere in the cosmos.

2. It assumed that the first Darwinian biopolymer on Earth was RNA, making its focus the biological assembly of RNA.

3. It assumed that all of the needed organic chemistry occurred on Earth. Therefore, it is set aside astrochemistry and meteorites as a source of organic materials.

Questioning these choices may be an important part of this workshop.

Next, successful applicants to the program were required to present a paradox a paradox, a conclusion that life could not possibly have arisen via an RNA first model, based on, sound (or apparently sound) reasoning from acceptable premises. Each session will have one or two successful applicants presenting the paradoxes that they examined, and what contributions they have made towards resolving them.

A paradox is not another way of saying "a difficult problem", and only a few research problems are appropriately approached by constructing paradoxes. Such problems are those that are not directly approached by hypothesis based research, observation, or other tools of normal science.

The paradoxes that will open the workshop are these:

1. All compounds normally proposed as necessary for the prebiotic synthesis of RNA require a reducing atmosphere to form. However, early Earth did not seem to have a reducing atmosphere. Therefore, life could not have emerged on Earth via an RNA-first model.

2. Even if the prebiotic precursors for RNA did manage to be formed on early Earth, they (like all organic matter given energy) would have devolved to asphalt; theory as deep as the second law precludes Darwinism having emerged from asphalt. Therefore, life could not have emerged on Earth via an RNA-first model.

3. Even if the prebiotic precursors for RNA did survive this devolution, they could not have assembled in water to give oligomeric RNA, and even if they did, could not have survived in water. Therefore, life could not have emerged on Earth via an RNA-first model.

4. Even if oligomeric RNA formed on early Earth, it must have remained short, too short to have done anything useful. Therefore, life could not have emerged on Earth via an RNA-first model.

5. Even if long RNA molecules were formed on early Earth, they are more likely to have catalyzed destructive reactions than constructive reactions. Therefore, life could not have emerged on early Earth. Therefore, life could not possibly have emerged on Earth via an RNA-first model.

Anyone planning to attend who believes that they have an experiment-based solution to any of these paradoxes should contact the organizers, who will arrange for them to present. At the workshop, one dominant theme might well be to question whether these are the appropriate paradoxes to focus on. Above all, the goal of this workshop is to have the attendees leave feeling that important advances were made during the course of the workshop through its discussions.

ORIGINS OF LIFE WORKSHOP ATLANTA OCTOBER 14-17 PRESENTER AND PANEL-AUDIENCE DIALOG TOPIC LIST

Biochemistry

Ada Yonath, Weizmann Institute Andrew Ellington, University of Texas Elisa Biondi, The Foundation for Applied Molecular Evolution Charles Carter, University of North Carolina, Chapel Hill Sourav Roy, University of North Carolina, Chapel Hill George Fox, University of Houston Niles Lehman, Portland State University Andrej Luptak, University of California, Irvine Steven Benner, The Foundation for Applied Molecular Evolution

Chemistry

Clemens Richert, University of Stuttgart David Fialho, Georgia Institute of Technology Hyo-Joong Kim, Firebird Biomolecular Sciences Jennifer Heemstra, Emory University Matthew Powner, University College London Ram Krishnamurthy, The Scripps Research Institute Thomas Carell, Ludwig Maximilians Universität Tuomas Lönnberg, University of Turku Rihe Liu, University of North Carolina, Chapel Hill David Perrin, University of British Columbia

Planetary Science and geochemistry

Dustin Trail, University of Rochester Elizabeth Bell, University of California, Los Angeles Robert Hazen, Carnegie Institute for Science Matthew Pasek, University of South Florida Ramon Brasser, ELSI Tokyo Institute of Technology Stephen Mojzsis, University Colorado

DIALOG TOPICS

Panel-Audience Dialog: Why is it so difficult to get robust function from oligo libraries? Panel-Audience Dialog: What must we do to make our view of the Hadean more complete? Panel-Audience Dialog: Can we ever solve the RNA building block problem? Panel-Audience Dialog: What are the next steps in prebiotic research?

Dates: Sunday evening, October 14 - Wednesday, October 17, 2018 Where: Georgia Tech Hotel and Conference Center, 800 Spring St. NW, Atlanta, GA 30308 Registration: \$99.00 (including meals and light refreshments). *Lunch provided Monday, Tuesday and Wednesday, dinner provided Monday only. Light refreshments will be provided during morning and afternoon breaks. Accomodations: Arrange with conference center.

For further information, contact us at originsconference@ffame.org.

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UPDATED TENTATIVE SCHEDULE

SUNDAY, OCTOBER 14 Registration will be open 6-8 pm

MONDAY, OCTOBER 15

09:00 Introductory Welcome: Steven Benner. Foundation for Applied Molecular Evolution.

Monday Morning. Why we want RNA

<u>09:05 Principal Investigator Presentation</u>: **Elisa Biondi.** Foundation for Applied Molecular Evolution. *Selection of receptors, ligands, and catalysts from an expanded genetic alphabet.*

<u>09:40 Special Invitee</u>: **Jennifer Heemstra.** Emory University. Evolution of artificial genetic polymers capable of small-molecule recognition.

<u>10:10 Special Invitee</u>: **David Perrin.** University of British Columbia. Selection of RNase A-mimicking DNAzymes with amines, imidazoles, and guanidines.

10:40 Break 15 min

<u>10:55 Special Invitee</u>: Ada Yonath. Weizmann Institute. *Recent advances in functional RNA.*

<u>11:40 Panel-Audience Dialog</u>: Why is it difficult to get robust function from oligo libraries?

12:20 Lunch

Monday Afternoon. Geology

<u>14:00 Principal Investigator Presentation</u>: **Steven Benner**. Foundation for Applied Molecular Evolution. *Why RNA-first life could not have emerged on Earth. Paradox construction in origins research.*

<u>14:40 Special Invitee</u>: **Robert Hazen.** Carnegie Institution for Science. *(Tentative) Mineralogy of the Hadean.*

<u>15:10 Principal Investigator Presentation</u>: **Stephen Mojzsis.** University of Colorado. Unexpected expectations in the quest to understand life's emergence on the Hadean Earth.

15:30 Break 15 min

15:45 Special Invitee: Ramon Brasser. ELSI & Tokyo Institute of Technology.

When was the Earth ready to host life?

16:15 Special Invitee: Elizabeth Bell. UCLA

Evidence from the zircon record for early Earth environments.

<u>16:45 Special Invitee</u>: **Dustin Trail.** University of Rochester. *How can Hadean (> 4 Ga) zircons help us constrain prebiotic environments.*

17:15 Panel-Audience Dialog: What must we do to make our view of the Hadean more complete?

18:00 Break for Dinner

TUESDAY, OCTOBER 16

Tuesday Morning. Complexity and cofactors.

<u>09:00 Principal Investigator Presentation:</u> **George Fox**. University of Houston. *Exploration of RNA sequence space in the absence of a replicase.*

<u>09:40 Special Invitee</u>: **Clemens Richert.** University of Stuttgart. *The Peptido RNA World*.

10:20 Break 15 min

<u>10:35 Principal Investigator Presentation</u>: Niles Lehman. Portland State University. *What complexity in biopolymers is needed for the transition to life?*

11:20 Panel-Audience Dialog: How to explore "cofactor space" effectively.

12:00 Lunch

Tuesday Afternoon. Prebiotic chemistry for RNA and alternatives

<u>14:00 Principal Investigator Presentation</u>: **Hyo-Joong Kim.** Firebird Biomolecular Sciences. *The organic chemistry of RNA building blocks.*

<u>14:30 Special Invitee</u>: **Thomas Carell.** Ludwig Maximilian University. *The origin of canonical and non-canonical nucleosides.*

<u>15:00 Special Invitee</u>: **Matthew Powner.** University College London. *Prebiotic selection and assembly of peptides and nucleotides.*

15:30 Break 15 min

<u>15:45 Special Invitee</u>: **David Fialho**. Georgia Institute of Technology. *Considering Alternative Sugars and Bases: A Case for Pre-RNA*.

<u>16:15 Special Invitee</u>: **Ram Krishnamurthy**. The Scripps Research Institute. *RNA may not be the first, but we need to understand whether it can be formed prebiotically.*

16:45 Panel-Audience Dialog: Can we solve the RNA building block problem?

17:45 Pick up boxed dinner in lobby and board bus to Fernbank. Departure at 6pm.

19:00 Fernbank Planetarium presentation

WEDNESDAY, OCTOBER 17

Wednesday Morning. Phosphates

<u>09:00 Principal Investigator Presentation:</u> **Andrew Ellington**. University of Texas. *Evolving replicators based on phosphorothioate backbones.*

<u>09:40 Special Invitee</u>: **Tuomas Lönnberg**. University of Turku. *Phosphorothioate oligonucleotides by condensation of nucleosides and phosphorous acid in the presence of elemental sulfur.*

<u>10:10 Special Invitee</u>: **Matthew Pasek**. University of South Florida. *Phosphorylation of nucleosides.*

10:40 Break 15 min

Tools

<u>10:55 Principal Investigator Presentation</u>: **Andrej Luptak.** UC Irvine. *Towards RNA-catalyzed ATP synthesis.*

<u>11:30 Principal Investigator Presentation</u>: **Sourav Roy**. UNC Chapel Hill. *Dissecting oligopeptide-oligonucleotide interactions: leads from laboratory evolution.*

12:00 Lunch

Wednesday Afternoon. Immediate and future developments

<u>14:00 Special Invitee</u>: Chosen from the attendees. *To be announced.*

<u>14:30 Special Invitee</u>: Chosen from the attendees. *To be announced.*

15:00 Panel-Audience Dialog: What are the next steps in prebiotic research?

16:00 pm Adjourn

Remarks

A. This is not your normal conference. We will be adjusting the program in real time as events during the workshop suggest it should be adjusted. We have left a slot open for a presentation from an attendee.

B. Participants in the Panel-Audience discussions will be self-selected, on stage and from the audience. Their purpose is to get the best minds in this field away from their PowerPoints and talking interactively with each other about the problems at hand. Models for such discussions include:

(a) The 2002 Astrobiology meeting at NASA Ames. The schedule was cleared to allow Bill Schopf and Martin Brasier to debate the biogenicity of carbon material in Australian cherts, with the floor open for remarks from an expert audience; the format proved remarkably effective (*Nature* **417**, 782 (2002)).

(b) A workshop in the 1970s discussing the latest data from analyses of Moon rocks. Participants went into the conference not knowing how the Moon was formed, but came out with a consensus model for how the Moon was formed *Cameron, A. G. W.; Ward, W. R. (March 1976). "The Origin of the Moon". Abstracts of the Lunar and Planetary Science Conference. 7: 120–122. <u>Bibcode:1976LPL....7.120C</u>.*

We would like very much to walk out of this workshop with, if not a solution to the prebiotic synthesis of oligomeric RNA, then at least a clear understanding of where the remaining problems are and how we should approach solving them. Or, of course, that they cannot be solved at all, because life emerged in a different way.

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