SYLLABUS

EPSS #M 118 & BIOL EE#145 ON-LINE, Fall Quarter 2020 – Advanced Paleontology

PALEOBIOLOGY – ASTROBIOLOGY ON-LINE (Via Zoom)

Early Life on Earth and the Search for Life on Other Worlds

Wednesday mornings, 9-11:50

INSTRUCTOR:

J. WILLIAM SCHOPF (E-mail: schopf@ess.ucla.edu; Tel: 310-825-1170)

“Office Hours”: Available via E-mail or Telephone, 9-11:30am, four days a week:
Mondays, Tuesdays, Thursdays and Fridays – 10 hours per week

REQUIRED TEXT:


GRADING:

There will be no mid-term or final examination.
Weekly there will be in-class discussion sessions of topics and questions noted on pp. 6-9
Each student will be expected to:

(1) Participate in all in-class discussions (and assessments of in-class presentations; pp. 6-9
(2) Prepare two ≤3-page mini-manuscripts (following the format detailed on pp. 3, 4) based on the topics they have selected from those listed on pp. 4-6
(3) Present two 10-minute PowerPoint Presentation (ppt.) summarizing the ideas in their manuscripts
(4) Review two manuscripts of another member of the class (see page 3 of this Syllabus). (5) Assignment of Course Grades:

Participation In-Class Discussions (pp. 6-9 below) _____________ 30%
Mini-Manuscripts (pp. 3, 4, below) ____________________________ 25%
Ppt. Presentations (Session #6, and Session #8, below) __________ 25%
Mini-Manuscript Reviews (p. 3, below) _________________________ 20%

TOTAL GRADE: 100%

NOTE: This course is OPEN TO ALL UNDERGRADATES, ALL GRADUATE STUDENTS in EPSS and BIOL EE, and ALL INTERESTED FACULTY (regardless of Departmental affiliation) who may wish to audit
### WEEKLY SCHEDULE

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#### #1 – 07 Oct – ORGANIZATIONAL MEETING

READING ASSIGNMENT for Oct 14: Intro (pp xi-xix), Oparin-Dalí (pp. 97-110)

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#### #2 – 14 Oct – STUDENTS SPECIFY PRESENTATION TOPICS

Lecture: ORIGIN OF LIFE and OPARIN’S VISIT TO DALÍ’S HOME

In-Class Discussion: see page 6 of this Syllabus

READING ASSIGNMENT for Oct 21: Darwin’s Dilemma, History, Breakthroughs (pp. 25-72)

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#### #3 – 21 Oct – STUDENT PRESENTATION SCHEDULE ANNOUNCED (for Nov 18 and Dec 02)

Lecture: GEOLOGICAL TIME SCALE and HISTORY OF PRECAMBRIAN PALEOBIOLOGY AND ITS RELEVANCE TO THE SEARCH FOR LIFE ON OTHER WORLDS

In-Class Discussion: see page 6 of this Syllabus

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#### #4 – 28 Oct - Lecture: EVIDENCES OF EARLY LIFE (stromatolites, microfossils, stable light isotopes, molecular biomarkers, rRNA Phylogenies)

Lecture: TOOLS OF THE TRADE (optical microscopy, Raman spectroscopy, confocal laser scanning microscopy, mass spectrometry, secondary ion mass spectrometry, biomolecular techniques)

In-Class Discussion: see page 7 of this Syllabus

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#### #5 – 04 Nov - Lecture: PUBLICATION AND PRESENTATION: What is publishable work? How should you prepare a scientific paper? How should you review the manuscripts of others? How should you prepare for a scientific meeting? What constitutes a good poster/PowderPoint slide/good talk? How does a talk at a scientific meeting differ from a class lecture?

In-Class Discussion: see page 7 of this Syllabus

READING ASSIGNMENT for Nov 18: Oldest Evidence of Life (pp. 150-178)

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#### #6 – 18 Nov – STUDENT PRESENTATIONS: 1st MINI-MANUSCRIPT (Topic #1A or #1B, schedule TBA)

1. Submission of 1st Mini-Manuscript (doc, docx, or pdf) sent to Schopf and all members of the class
2. In-class presentation of 10-minute PowerPoint Lecture

   Lecture: SURVIVING SEDIMENTARY ROCKS AND THE ARCHEAN FOSSIL RECORD
   (stromatolites, microfossils, isotopes)

   In-Class Discussion: see page 8 of this Syllabus

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#### #7 – 25 Nov – Reviews of 1st "Mini-manuscripts" (doc, docx, or pdf) – sent to Schopf and the manuscript’s author

Lecture: MOLECULAR PHYLOGENY AND PRECAMBRIAN MICROBES (methanogenic bacteria, sulfur bacteria, photosynthetic bacteria, cyanobacteria)

Lecture: CYANOBACTERIAL EVOLUTIONARY STASIS (hypobradytely and the "Volkswagen Syndrome")

In-Class Discussion: see pages 8, 9 of this Syllabus

READING ASSIGNMENT for Dec 2: Apollo Moon Rocks, India, USSR, China (pp. 79-118)

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#### #8 – 02 Dec - - STUDENT PRESENTATIONS ON 2nd MINI-MANUSCRIPT (Topic #2, schedule TBA)

1. Submission of 2nd Mini-Manuscript (doc, docx, or pdf) sent to Schopf and all members of the class
2. In-class presentation of 10-minute PowerPoint Lecture

   Lecture: APOLLO 11 & 12; THE ORIGIN OF ASTROBIOLOGY AND THE IMPACT OF NASA’s NAI

   In-Class Discussion: see page 9 of this Syllabus

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#### #9 – 09 Dec – Reviews of 2nd "Mini-manuscripts" (doc, docx, or pdf) – sent to Schopf and the manuscript’s author

THE SEARCH FOR LIFE ON MARS AND OTHER WORLDS

In-Class Discussion: see page 9 of this Syllabus

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#### #10 – 16 Dec – THANKSGIVING HOLIDAY (NO CLASS)

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#### #11 – 23 Dec – CLASS RECOMMENDATION (Discuss various papers and ideas for final presentations)

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#### #12 – 30 Dec – PRESENTATION PREPARATION (individual and group)

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#### #13 – 06 Jan – PRESENTATIONS (individual and group)

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#### #14 – 13 Jan – PRESENTATION PREPARATION (final)

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#### #15 – 20 Jan – PRESENTATION PREPARATION (final)

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#### #16 – 27 Jan – PRESENTATION PREPARATION (final)

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#### #17 – 03 Feb – PRESENTATION PREPARATION (final)

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#### #18 – 10 Feb – PRESENTATION PREPARATION (final)

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#### #19 – 17 Feb – PRESENTATION PREPARATION (final)

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#### #20 – 24 Feb – PRESENTATION PREPARATION (final)

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#### #21 – 02 Mar – PRESENTATION PREPARATION (final)

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#### #22 – 09 Mar – PRESENTATION PREPARATION (final)

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#### #23 – 16 Mar – PRESENTATION PREPARATION (final)

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Mini-Manuscripts: Instructions for Authors

Following the requirements specified below, each student is to prepare two "mini-manuscripts, each addressing one of the topics listed below. For the first manuscript, in doc, docx, or pdf format, to be sent to Schopf and all members of the class and presented as a 10-minute PowerPoint lecture on Nov 18, select topic #1A or #1B (listed below). For the second manuscript (to be presented as a 10-minute PowerPoint lecture on Dec 2) address topic #2 (listed below).

Each manuscript must conform to the strict requirements specified below.

- Each manuscript, in doc, docx or pdf format, is to be sent (preferably in advance) to Schopf and all members of the class.
- Each student will present a 10-minute PowerPoint lecture summarizing the mini-manuscript prepared, followed by questions from the class and a discussion of the presentation.
- Each student will then review/evaluate a manuscript prepared by another class-member (with copies of your review, in doc, docx or pdf format, sent to Schopf and the manuscript’s author.)

Strict mini-manuscript requirements:

1. Total length no more than 3 pages, double-spaced at 12 font, including an introductory (abstract-like) paragraph (in bold type) and any references and figures.
2. Follow the format specified for a "Letter" to Nature. See Instructions for Authors: http://www.nature.com/nature/authors/ [for help, see the following page of this Syllabus]
3. Do not include a "Methods Summary" and do not include the end-items required by Nature (Acknowledgements, etc.)
4. Do, however, follow the Nature format for manuscript title, author's name and affiliation, text references, figure legends, and reference citations.

Mini-Manuscripts: Instructions for Reviewers

On or before Nov 25, send copies of your review of the first mini-manuscript (doc, docx, or pdf) to Schopf and the manuscript’s author.

On or before Dec 9, send copies of your review of the second mini-manuscript (doc, docx, or pdf) to Schopf and the manuscript’s author.

Preparation of an appropriate review/evaluation of a submitted manuscript takes time, effort, honesty, and tact. It is important to recognize that the reviewer's primary obligation is to help the author improve the presentation. The reviewer's responsibility is not that of embarrassing the author or of "showing-off" the knowledge and prowess of the reviewer! Be helpful, not hurtful and, to the extent consistent with your appraisal of the work, be positive, not negative.

Strict Review/Evaluation requirements:

1. Total length no more than 1 page, double-spaced at 12 font.
2. In your opening paragraph, briefly (<3 sentences) summarize the key points of the paper (establishing for the author and journal editor that you have actually read the work!)
3. Review the paper, suggesting, if appropriate, ways that you think the presentation could be improved in a revised version of the paper.
4. You may wish to suggest additional relevant items that you think the author has neglected -- but do not overload the author with criticism and/or add-on tasks (after all, the author has already devoted a great deal of time and effort to prepare the paper).
5. If the paper is "excellent" -- say so and be done with it! Do not neglect to praise the author -- if praise is warranted.
6. At the end of your review, give the work a "grade": -- A+/-; B+/-; or C+-/ (an item that will not be included when you review a "real" manuscript).
To access *Nature*. Instructions for Authors

GO TO: http://www.nature.com/nature/authors/
PAGE TITLE: "For Authors --Guidelines to preparing and submitting a manuscript"

CLICK ON: Manuscript formatting guide

RELEVANT SECTIONS ARE IN RED, BELOW:

Table of contents
- 1. Formats for Nature contributions
  - 1.1 Articles
  - 1.2 Letters
  - 1.3 Brief Communications Arising and Corrections
  - 1.4 Other types of submission
- 2. The editorial process
- 3. Presubmission enquiries
- 4. Readability
- 5. Format of Articles and Letters
  - 5.1 Titles
  - 5.2 Text
  - 5.3 Methods
  - 5.4 References
  - 5.5 End notes
  - 5.6 Life sciences reporting guidelines
  - 5.7 Tables
  - 5.8 Figure legends
  - 5.9 Figures
  - 5.10 Production quality figures
  - 5.11 Extended Data
  - 5.12 Supplementary information
  - 5.13 Chemical structures and characterization of chemical materials
- 6. Submission

**First "Mini-Manuscript" Topics**

SELECT ONE OF THE TWO SUB-TOPICS BELOW

To be sent to Schopf and all in the class and presented as a PowerPoint Lecture **Nov 18**

Note: This is not an easy exercise -- which is why you now have six weeks to ferret out relevant facts and to prepare your *First mini-manuscript* and PowerPoint presentation. The goal of this exercise is to help you understand that life and Earth have evolved in tandem -- as is certain to be true of life on other worlds --and to encourage you to “Think out of the Box.”

**THE PRIME QUESTIONS (Select #1A or #1B) FOR MINI-MANUSCRIPT #1**

What could aliens deduce from a "Noah's Arc" of Earth-life?

From analyses of their systematic biotic census of Earth-life and studies at their home planet of the menagerie collected, what could they infer about the planetary properties and astronomical setting of the Earth, the nature of Earth's present surface environment, and the history of Earth-life and of its environment?
THE SITUATION:
Intelligent aliens arrive in orbit around the Earth. During their trip, their spacecraft was impacted by an asteroid and their science instruments are all but inoperable. Virtually everything has been destroyed—totally inoperable, including all instruments designed to measure the physical properties of the Earth and its place in the Solar System (e.g., its mineralogy, topography, surface environment, relation to Sun and Moon, and everything else) as well as all instruments designed to investigate in situ the attributes of Earth-life (e.g., its biochemistry, metabolism, morphology, phylogeny, and everything else).

The only research equipment remaining is that designed to collect, at systematically recorded locations, living specimens that comprise a total biotic sample of life on Earth—a "Noah's Arc" that represents all Earth-life—and to keep these organism alive and return them to the aliens' home planet for future study.

For your 1st "Mini-Manuscript" and 10-minute presentation, select either #1A or #1B

#1A Planetary properties and astronomical setting of the Earth and its present-day surface environment
Based solely on the organisms collected, what could these aliens deduce about such planetary properties as Earth's mass? Size? Shape? Rotation? Distance from the Sun? From the Moon? And what, based entirely on biology, could they deduce about Earth's present-day surface conditions? The relative areas of land and ocean? Topography of the land surface? Magnetic flux? Ocean chemistry? Atmospheric composition and pressure? Ambient temperature? Environmental periodicity (e.g., day-, month- and year-lengths)? What else might they learn?

#1B Interrelated biotic-environmental evolution over geological time
Based only on living organisms (no fossils), what could these aliens deduce about the history of Earth's biota and the environment? Changes over geological time of day-length? Of Earth-Moon relations? Of atmospheric composition (e.g., O₂, CO₂, CH₄)? Of biologically useable nitrogen (viz., NH₃, NO₃, and N₂)? Of ambient UV-flux? Of ambient temperature? Of the presence of liquid water? Of Darwinian Evolution? What else might they learn?

Second "Mini-Manuscript" Topic
To be sent to Schopf and all in the class and presented as a PowerPoint Lecture Dec 2

THE PRIME QUESTION FOR MINI-MANUSCRIPT #2
What would be the sociological implications of the discovery of life on other worlds?
How do you predict that humans would react to this new knowledge? Would it matter, how would it matter, and why?

For your 2nd "Mini-Manuscript" and 10-minute presentation, address question #2

THE SITUATION:
Throughout the world, people of all countries and all societies have a strong cultural/religious heritage—based typically on ancient texts that assume, imply, or assert that life on Earth is unique, the single example in the Universe. What would be the sociological, philosophical, psychological, cultural, and political ramifications of the discovery of life on other planets? Are there historical precedents to such a sea-change in knowledge and, if so, what impact did they have? Sort through the ramifications: Would the impact vary with the type of life discovered—bacteria … plants … animals … intelligent beings …life-forms unlike anything we know? Would the discovery of fossil life have the same impact as the discovery of living organisms? How would humans react emotionally—passively or actively …positively or negatively … welcomingly or with loathing and fear? Would the proximity and type of evidence matter … unequivocal
fossils and/or living organisms on a nearby planet (e.g., Mars) … demonstrably intelligent signals from a nearby Solar System (e.g., Alpha Centauri, ~4 light-years distant) … repeated intelligent signals from a far-off galaxy sent in the distant past? And, especially interestingly, *How would the discovering scientists be regarded* … with fame and adulation or with loathing, hatred, as “know-nothing, trouble-causing pariahs”? And, *what would be the roots of such reactions*? Religion? Culture? Politics? Education? Other?

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**IN-CLASS DISCUSSION QUESTIONS**

**SESSION #2**

**OCT 14 – ORIGIN OF LIFE, OPARIN’S VISIT TO DALÍ’S HOME**

(1) Did Earth-life originate on Earth or did it arrive on this planet from elsewhere -- *i.e., is Panspermia plausible*?

(2) If panspermia is plausible, *what can be deduced about the planet on which Earth-life originated*?

(3) If Earth-life originated on Earth, *why is there no known evidence of a pre-biotic primordial soup*?

(4) *Is the origin of Earth-life a "solvable problem"* – or can it be surmised only from seemingly plausible laboratory simulations?

(5) If life is created in laboratory experiments, *will this show how life actually originated*?

**SESSION #3**

**OCT 21 GEOLOGICAL TIME SCALE, HISTORY OF PRECAMBRIAN PALEOBIOLOGY AND ITS RELEVANCE TO THE SEARCH FOR LIFE ON OTHER WORLDS**

(1) *What is the purpose of dividing geological time into Eons, Eras, Periods, etc? Are such terms really necessary*?

(2) *If we were now to start with a clean slate, what system would we now devise to subdivide geological time?* Subdivisions ordered by stratigraphy and fossils, and *named by first regions studied*? Subdivisions *ordered by biotas*? *Subdivisions of equal (e.g., 100 Ma) rather than varying duration*?

(3) Both Darwin (in 1838) and Alfred Russel Wallace (~1845) “discovered” Natural Selection after reading Thomas Robert Malthus’ Essay on the Principle of Population. *Why and how did Malthus’ book have such an impact on Darwin and Wallace*?

(4) After Darwin received Wallace’s manuscript, their essentially identical concepts were presented back-to-back at the July 1 meeting of the Linnean Society of London. *Why is it that Darwin received the credit and Wallace is regarded as merely the “validator”? Was this appropriate*?

(5) Both before Darwin, Cuvier (extinctions, 1815) and after Darwin, Dawson (Eozoön, 1865), interpreted their findings on the bases of Biblical teachings. *Why did Cuvier and Dawson rely on religion*?

(6) Do culture-based predilections (Cuvier, Dawson) “Authoritative Assertion” (Seward) and/or international politics (Timofeev) affect science today? *Do similar predilections – cultural (home, friends, religion, society), “Authoritative Assertion” (the expert's opinion), and/or politics affect YOU*?

(7) Now – 250 years since the US Constitutional “separation of church and state,” 170 years after Darwin’s *Origin*, and nearly 100 years after the “Scopes Monkey Trial” (William Jennings Bryan Vs. Clarence Darrow, Dayton Tennessee, 1925) – *why is there still controversy about the teaching of evolution in U.S. public schools*?
SESSION #4
OCT 28 – EVIDENCES OF EARLY LIFE AND TOOLS OF THE TRADE

(1a) On Mars, what "smoking gun" should be sought -- what plausible discovery would spur an all-out concerted effort to search for present or past life? Discovery of Coaly kerogen? Carbonisotopic signatures? Amino acids?

(1b) If any of these were detected, how could biologically generated organics be distinguished from products of abiotic syntheses, whether on Mars or delivered to Mars in carbonaceous chondrites?

(2) In the search for evidence of ancient life on Mars (and on Earth), what differences are there between techniques/strategies designed to "search" and those intended to "characterize"?

Is there a difference between the two, and, if so, how do they apply to own studies?

(3) In some fields of science “sound theory” seems to stand alone in the absence of observable facts … e.g., in theoretical physics, mathematical constructs such as inflation theory; and in origin-of-life models, the Oparin-Haldane “primordial soup.” Is theory primary – leading to its subsequent factual investigation? Or are facts primary – promoting investigation of their veracity and construction of a fact-based synthesis?

(4) Without samples returned to Earth, can any evidence from Mars be expected to "prove" that it has harbored past life? Images of “stromatolites”? Of “microfossils”? Measurements of isotopes? Detection of molecular biomarkers? What evidence would you believe and why would you regard it as definitive?

(5) How much of NASA’s media releases do you accept as fact? Everything? Some but not all? Should we be skeptical about what we are told by NASA? If so, why? If not, why not?

SESSION #5
NOV 4 – PUBLICATION AND PRESENTATION

Tell the class about YOUR experiences. This is your chance to tell your peers how they can avoid whatever pitfalls YOU encountered and how they can benefit from YOUR experiences!

(1) If you have attended a scientific meeting, what was it like? Useful? A “vacation”? An utter waste? If you have NOT attended scientific meetings, what do your friends tell you about them?

(2) Presenting a poster or a talk at a scientific meeting is obviously different from TAing a course, but is it an arduous chore? Or a “walk in the park”? Or both – demanding and important – but good fun?

(3) Have you ever co-authored a scientific publication … how did that go? What were YOUR responsibilities?

(4) Who should co-author a scientific publication? Only those who have contributed or also others – friends and colleagues – to bolster their careers?

(5) Have you ever been the lead author of a scientific publication? Is that easy? Difficult? What were YOUR responsibilities? What did you learn?

(6) If you could make the “rules,” how would YOU delegate lead authorship of a scientific contribution?

Assign it to a student to give the student the experience and promote their career?
Assign it to the “guiding light,” the one who presented the problem, set it in context, saw how it might be solved?
Hold a lottery, with all participants having an equal chance?
SESSION #6  
NOV 18 -- SURVIVING SEDIMENTARY ROCKS AND THE ARCHEAN FOSSIL RECORD  

Student Presentations  
Alien Deduction of Planetary Properties, Astronomical Setting, and Present-day Environment  
Alien Deduction of History of Earth’s Biota and the Environment  

Class Discussion of Presentations  
Speak to screen? Demeanor – Confident? Convincing?  
#3 STRUCTURE & SCIENCE Logical Progression – beginning, middle, end? Conclusion Supported? Significant omissions, errors? Talk properly timed?  

Class Discussion Questions  
(1) On Earth, microorganisms are far more successful than later-originating multicellular life – microbes are physiologically more diverse, inhabit far more environments, and have a living biomass that far exceeds the combined mass of all eukaryotic plants, animals, fungi and protists. Will this be true on other planets?  

(2) On Earth, the earliest ~85% of the known history of life is dominated by microbes. Plants and animals arose late in evolutionary history – the “evolutionary distance” between the origin of life and multicellularity being at least six times longer than that between trilobites and humans. Will this be true on other planets?  

(3) Will life on other worlds necessarily exhibit Darwinian evolution? What alternatives might there be? Is genetically programmed self-survival – the “me-first gene” – required of life, or could organismal altruism – the “group-first gene” – be of selective advantage?  

(4) Contact! The Sun (~5 Ga-old) is “middle aged” – as is the Solar System. Some fraction of the myriad other stars and planets billions of years older can be expected to harbor “intelligent life.” Given the great age of their civilizations – and our youth (a mere thousands of years) – such aliens would be capable of feats indistinguishable from magic. Two end-point scenarios have been proposed for Contact! – Having human-like motivations, they demolish human life on Earth (cf. European colonization worldwide). Or, being more experienced and wiser than Earthlings, they elect not to disrupt human existence. Which, if either, of these scenarios (“bad guys” vs. “good guys”) do YOU regard more likely? Or, do you imagine some other outcome – For example …  
  The Aliens subjugate humans to do their will?  
  They genetically modify humans to be like them?  
  They so differ from Earthlings that they have no interest in Earth or Earth-life?  

SESSION #7  
NOV 25 – PHYLOGENY, PRECAMBRIAN MICROBES, CYANOBACTERIAL HYPOBRADYTELY  

(1a) Can fossils reveal the “time of origin” or only the “time of first appearance”?  
(1b) All known fossils belong to the present-day Kingdoms of Life (plants, fungi, animals, protists, prokaryotes). Can we be sure that these are the only major groups that have ever evolved?  

(2a) Why has life evolved at such varying rates: Tachytelic (“fast,” ~1-Ma-duration species); Horotelic (“standard rate,” ~10 Ma); Bradytelic (“slow rate,” ~100 Ma); Hypobradytelic (“super-slow rate,” ~1000 Ma).  

(2b) Why did horotelic Phanerozoic life evolve much more rapidly than the hypobradytelic microbes of the Precambrian?
(3a) Is "biologic time" equivalent to "geologic time"? That is, do biologic and geologic processes change at essentially the same rate or do their rates differ by orders of magnitude?

(3b) Biological evolution results from “Natural Selection of the best adapted.” What is the primary cause of such Selection – organismal interactions or adaptation to a changing physical environment?

(3c) If the root cause is biology, how could slow geological changes "trigger" rapid biological changes?

(4) Molecular phylogenetics has major limitations (based only on living organisms and subject to non-biological assumptions, e.g., “parsimony”) as does the fossil record (necessarily incomplete). Which of these two strategies do you find more compelling? Why? How can their current deficiencies be addressed?

SESSION #8

DEC 02 – APOLLO 11 & 12 AND THE NASA ASTROBIOLOGY INSTITUTE

Student Presentations

Implications of the Discovery of Life on Other Worlds

Class Discussion of Presentations

#3 STRUCTURE & SCIENCE Logical Progression – beginning, middle, end? Conclusion Supported? Significant omissions, errors? Talk properly timed?

Class Discussion Questions

(1a) What do YOU know about the US-USSR Space Race? e “good,” Commies “bad”?
In schools, “Duck and Cover”? How the USA Interstate Highway system began?

(1b) WHY did Apollo 11 and 12 so greatly inspire all peoples throughout the world?

(1c) Should this country NOW send astronauts to Mars … or first, again, land on the Moon?

(2a) The PPRG was a highly unusual Interdisciplinary, International experiment. What are the potential benefits – and DETRIMENTS – of this approach?


(2c) If YOU found yourself in a position to mold YOUR field of science, what would YOU do?

(3) What else would YOU like to know about these episodes? The Apollo Program? “Spy” monitoring by the KGB vs. the CIA? The cultures and science of Russia? Of India? Of China? ASK ANYTHING YOU WISH!

SESSION #9

DEC 09 – THE SEARCH FOR LIFE ON MARS AND OTHER WORLDS

(1) The geysers of Enceladus contain a rich assemblage of organics. The most likely energy source for organic synthesis is submarine volcanic fumarolic heat. Could thermal energy power living systems? If not, why not? If so, why has heat not been used metabolically by Earth-life?

(2) Will Alien Extraterrestrial Life be INTELLIGENT? What is Intelligence? What are the Roots of Human Intelligence?

(3) Must death occur on other worlds? On Earth, why is death universal? On other planets, could organisms live forever?