**SPECIAL Spring Quarter 2019 INTERDISCIPLINARY COURSE**

**HOW PARADIGM SHIFTS ACTUALLY OCCUR**

EPSS #298, *Enrollment Limited to 16*

Wednesdays 9am to noon, CSEOL Library, 5681 Geology Bldg.

How do major changes of knowledge occur? Do they result from a “Eureka Moment”? What motivates the linchpin? What major Paradigm Shifts can be predicted? For example, how will you and all of humanity react if alien life is discovered on other worlds?

In 1962, U.C. Berkeley and later Princeton and MIT philosopher and historian of Science Thomas S. Kuhn (1922-1996) published a classic volume entitled “THE STRUCTURE OF SCIENTIFIC REVOLUTIONS” (Univ. Chicago Press), a landmark event in the history, philosophy, and sociology of scientific knowledge. Centered on the *Copernican Revolution* (Copernicus’ realization that the Earth flies around the Sun, not the other way around) with mentions of *Darwin’s Evolution* (fundamental to understanding the natural world), Kuhn’s book received enormous acclaim – but it was also subject to criticism, primarily from those who imagined it to indicate that truth was malleable and that such sea changes result from serendipity, pure “luck.” Kuhn objected, suggesting that his book had been “misread and misinterpreted”, an opinion he maintained until his death.

In 2019 – at the urging of Tom Kuhn – J. William (Bill) Schopf of UCLA’s Department of Earth, Planetary, and Space Sciences published a first-person account of how one such paradigm shift actually occurred (“LIFE IN DEEP TIME: DARWIN’S “MISSING” FOSSIL RECORD, A Personal Account of Paradigm-Changing Science”; CRC Press-Taylor and Francis). The volume documents the solution to what some regarded as “greatest unsolved problem in the Natural Sciences” – an absence of evidence of life’s early history that Darwin regarded as “inexplicable” that for 100 years had been regarded as both unknown and unknowable – a paradigm shift that extended life’s record to 3,500 million years, a seven-fold increase, and provided the basis for two new fields of science, Precambrian Paleobiology and Astrobiology, the search for life on other worlds.

**THE COURSE**

Designed to be **highly interactive** – discussions, Q&A and student presentations interspersed with theme-setting lectures – the course will address Paradigm Shifts from multiple perspectives. **ENROLLMENT IS LIMITED TO 16. All interested students (and faculty, space permitting) – from the Humanities and Social Sciences as well as the Physical and Life Sciences – are welcome!**
Tom Kuhn’s notions about how science progresses are as relevant now as they were in 1962 when they were first presented – and they are still criticized and debated.

For example, the following is a recent public letter (Oct. 2018) from the President of Sigma Xi, the Scientific Research Honor Society.

**Defending the Scientific Process**

Will key theories of modern science, including Darwinian evolution in biology and Einsteinian relativity in physics, survive future discoveries? Some people think such survival is impossible, because they believe that new scientific theories always overthrow the previous theories. This misunderstanding has been fostered in part by a famous book first published in 1962—**Thomas Kuhn’s The Structure of Scientific Revolutions**, which argued that scientific research proceeds for long periods of time within a certain manner of thinking (a “paradigm”), until too many pieces of evidence have turned up that are unexplainable or even paradoxical. Then suddenly there is a great leap (a “paradigm shift”): The old theory is abandoned for a new theory that explains much more, and the old paradoxes disappear. The concepts of the new theory are so different from the concepts of the old one that they are “incommensurable,” because the implicit assumptions have changed. For example, after the Copernican Revolution, when scientists abandoned the idea that the Earth was the immovable center of the universe, the Earth became a planet and the status of the Sun and Moon changed. The old theory was overthrown and never again taught as science.

Kuhn, whose first book was on the Copernican Revolution, appears to have assumed that all scientific revolutions are like that one. His argument implies that no scientific theory can ever be considered true, because it will eventually be overthrown by a bigger and better theory. Because the new theory will eventually be overthrown in its turn, it is ultimately no truer than the old one (even though it is temporarily more useful), so it is questionable whether science actually progresses; perhaps it just keeps changing.
But revolutionary scientific theories do not have to overthrow their predecessors except in the earliest stage of a science, when a scientific theory is replacing earlier ideas that were not well supported by evidence. Once a field of science undergoes the revolution that creates for it a solid intellectual foundation—like the ones that Newtonian mechanics gave physics and Darwinian evolution gave biology—that foundational theory can stand forever. Science then progresses by encompassing the foundational theory in a new and larger theory that explains things beyond the ken of the older theory. An encompassing theory does not overthrow the older theory—instead, it defines the limits within which the older theory is reliably true. Science does not simply toss one theory out for another: it makes real progress toward ever-larger truths. But there is a built-in enforcer of humility in science: We cannot regard something as true until we know about something bigger.

Joel Primack,
Sigma Xi President

October 15, 2018
**SPECIAL Spring Quarter 2019 INTERDISCIPLINARY COURSE**

**HOW PARADIGM SHIFTS ACTUALLY OCCUR**

EPSS #298

Wednesdays 9am to noon, CSEOL Library, 5681 Geology Bldg.
J. William Schopf (Dept. Earth, Planetary and Space Sciences)

**INSTRUCTOR:**

**J. WILLIAM SCHOPF** (Room 5687, Geology Building; schopf@ess.ucla.edu)

**Office Hours:** Mornings, 9-12, four days a week: Mondays, Tuesdays, Thursdays and Fridays – **12 hours per week** – and any other times at your convenience (if Prof. Schopf can't see you immediately, he will make an appointment).

**REQUIRED READING:**


**GRADING:**

There will be no mid-term or final examination.

Weekly there will be in-class discussions (of topics and questions noted on pages 10-13 of this Syllabus).

Each student will prepare a ≤3-page mini-manuscript (following the format detailed on pages 7-9 of this Syllabus) based on the “possible future paradigm shift” they have selected from the five topics listed on page 5 of this Syllabus; each will make a 20-minute PowerPoint Presentation (ppt.) of this manuscript to the class; and each will review the manuscript of another member of the class.

| In Class Discussions (pp. 10-12, below) | 30% |
| Ppt. Presentation (SESSION #5, p. 6, below) | 30% |
| Mini-Manuscript (pp. 7-9, below) | 30% |
| Mini-Manuscript Review (pp. 8, 9, below) | 10% |
| **TOTAL GRADE:** | **100%** |
COURSE SYLLABUS

April 3  SESSION #1 (ORGANIZATIONAL MEETING)
LECTURE  Abbreviated overviews of Kuhn and Schopf books, structure of the class, and outline of CLASS ASSIGNMENT to select one of five “possible future paradigm shifts” and its indicated major unsolved problem (Kuhnian “anomaly”):
#1 Extraterrestrial Life –
Paradigm: Life exists only on Earth.
Anomaly: CHON throughout Cosmos, conditions for life exist on other planets.

#2 Global Warming –
Paradigm: Global warming, dating from the Industrial Revolution (1880), is inexorable.
Anomaly: Human societies require energy but current rising CO₂ levels too high to offset with clean energy resulting in sea-level rise, hurricanes, both floods and water-shortage, population displacement, ecological impact.

#3 Nuclear Holocaust –
Paradigm: Nuclear war is inevitable.
Anomaly: Nuclear warheads widespread, regarded “necessary” for national protection.

#4 Human Population –
Paradigm: The continued rise of human over-population is unsolvable.
Anomaly: Reproduction genetically pre-programmed resulting in famine, disease, poverty, migration, war, ecological impact.

#5 Abiotic “Primordial Soup” –
Paradigm: Necessary precursor of the Origin of Life.
Anomaly: No direct geologic evidence.

YOUR TASK: Prepare a 3-page “mini-manuscript” and a 20-minute PowerPoint Presentation on the topic you select (see pages 7-9 below). In your manuscript and presentation to the class:
(1) Summarize the current paradigm;
(2) Discuss the indicated major unsolved problem;
(3) Propose a solution to this problem;
(4) Predict the result of the Paradigm Shift.

Reading Assignment for next week, Session #2:
Kuhn I – Preface and Chapters I-VI (pp. xxxix-xivi and 1-65)

April 10  SESSION #2 (KUHN I)
Students specify the paradigm they have selected for presentation
LECTURE: Overview of Kuhn Cycle, Pre-Science, Acceptance of Evolution
CLASS DISCUSSION Kuhn I: Pre-science, Paradigm, Normal Science, Anomaly

Reading Assignment for next week, Session #3:
Kuhn II -- Chapters VII-XIII and Postscript (pp. 66-208)
April 17  SESSION #3 (KUHN II)
Order of student presentations specified for Sessions #6-#9
LECTURE: Kuhnian Anomalies, Crisis-Revolution, New Paradigm
CLASS DISCUSSION Kuhn II: Crisis, Revolution, New Paradigm

April 24  SESSION #4 – NO CLASS
Schopf away; students prepare their manuscripts and in-class presentations

May 1  SESSION #5 (SCHOLARLY CONFERENCES, PRESENTATIONS AND PUBLICATIONS)
LECTURE: Conferences, presentations, publications
Why attend scholarly meetings? How should you prepare for the meeting?
What constitutes a good poster …good PowerPoint slides … a good talk?
How does a talk at a scholarly meeting differ from a class lecture?
What constitutes publishable work? How should you prepare a scholarly paper?
Who should co-author a paper? What should be the order of authorship?
How should you review the manuscripts of others?
CLASS DISCUSSION: From YOUR experience – as a participant, observer, or what you have heard from others – tell the class YOUR views about scholarly conferences, presentations and publications
Reading Assignment for next week, Session #6:
Schopf I – Introduction and Chapters 3-5 (pp. xi-xix and 25-77)

May 8  SESSION #6 (SCHOPF I)
LECTURE: Discovery of Darwin’s “Missing” Fossil Record -- A Paradigm Shift in the History of Science
CLASS DISCUSSION Schopf I: Biases in Science; Societal Changes
STUDENT PRESENTATIONS – Schedule specified in Session #3.
Manuscripts due from Session #6 Presenters (two copies, one for Schopf, the other for the student reviewer)
CLASS DISCUSSION OF PRESENTATIONS AND TOPIC(S) ADDRESSED
Reading Assignment for next week, Session #7:
Schopf II – Chapters 7-9 (pp. 125-213)

May 15  SESSION #7 (SCHOPF II)
LECTURE: Deep-Time Paleobiologic Techniques: Past, Present and Future
CLASS DISCUSSION Schopf II: Interdisciplinary-International Science; Neophyte Vs. Experienced Scientists; Are “Facts” Facts?
STUDENT PRESENTATIONS – Schedule specified in Session #3
Manuscripts from Session #7 Presenters due (two copies)
Student reviews of Session #6 manuscripts due (two copies, one for Schopf, the other for the student presenter)
CLASS DISCUSSION OF PRESENTATIONS AND TOPIC(S) ADDRESSED
May 22  SESSION #8 (STUDENT PRESENTATIONS)
STUDENT PRESENTATIONS – Schedule specified in Session #3.
Manuscripts from Session #8 Presenters due (two copies)
Student reviews of Session #7 manuscripts due (two copies)
CLASS DISCUSSION OF PRESENTATIONS AND TOPIC(S) ADDRESSED

May 29  SESSION #9 (STUDENT PRESENTATIONS)
STUDENT PRESENTATIONS – Schedule specified in Session #3.
Manuscripts from Session #9 Presenters due (two copies)
Student reviews of Session #8 manuscripts due (two copies)
CLASS DISCUSSION OF PRESENTATIONS AND TOPIC(S) ADDRESSED
Reading Assignment for next week, Session #10:
Schopf III – Chapters 1, 2, 6, 10 (pp. 1-40, 79-123, 215-220)

June 5  SESSION #10 (SCHOPF III)
Student reviews of Session #9 manuscripts due (two copies)
CLASS DISCUSSION SCHOPF III
Moon rocks, India, USSR, China: What else would YOU like to know about these episodes?
CLASS DISCUSSION OF KUHN’S Structure of Scientific Revolutions
Is the Kuhn Cycle really the way we learn about reality?
CLASS DISUSSION OF SCHOPF’S LIFE
How does Schopf’s experience compare with YOURS?
Finally, time permitting  QUIZ THE PROF: Satisfy your curiosity – ask Schopf anything you wish

Mini-Manuscripts: Instructions for Authors

On 10 April, students are to specify which of the five “possible paradigm shifts” they have selected for presentation. On 17 April, the schedule of presentations for Sessions #6-#9 (to occur weekly, May 8, 15, 22, and 29) will be distributed to the class.

Following the requirements specified below, each student is a prepare mini-manuscript addressing the possible paradigm shift they have selected. Each manuscript is to be handed-in on the day scheduled for its presentation and presented as a 20-25-minute PowerPoint lecture to the class.

Each manuscript must conform to the strict requirements specified below.

- Two hard-copies of each manuscript should be brought to class -- one for Schopf, the other for the student who will review the manuscript during the following week.
• Each student will present a 20-25 minute ppt. lecture summarizing the mini-manuscript prepared, followed by questions from the class and a discussion of the presentation.
• Each student will review/evaluate a manuscript prepared by another class-member (with two hard-copies of each review -- one for Schopf, the other for the author of the paper) to be brought to class the following week.

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.

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Mini-Manuscripts: Instructions for Reviewers

At the class session following the in-class presentation of the manuscript you are assigned to review, provide two hard-copies of your review (one for Schopf, one for the author) of the first mini-manuscript.

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 BOLD, 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
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  - 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
IN-CLASS DISCUSSION QUESTIONS

April 10   SESSION #2 - (KUHN I – Preface and Chapters I-VI: pp. xxxix-xivi, 1-65)
Paradigm-establishing Parts of the Kuhnian Synthesis

**KUHN I:**
(1a) What are the roots of *pre-science* notions and assumptions?
(1b) Why were (and sometimes still are) such ideas widely accepted?

(2a) When did the “*pre-science to science*” transition occur?
(2b) Why did this transition occur?

(3a) What is required for the establishment of a *Scientific Paradigm*?
(3b) How and why does this occur?

(4a) What does Kuhn mean by *Normal Science*?
(4b) How does Kuhnian Normal Science progress?

(5) Why are so many Americans distrustful of science and the “Hidden Knowledge” of the so-called Academic Elite?

April 17   SESSION #3 (KUHN II – Chapters VII-XIII and Postscript: pp. 66-208)
Kuhnian Anomalies, Crisis-Revolution, New Paradigm

**KUHN II:**
(1a) What constitutes a Kuhnian *scientific Anomaly*?
(1b) How are such Paradigm-misfits discovered?

(2a) What does Kuhn mean by a *scientific Crisis*?
(2b) Why do such Crises occur?

(3a) What constitutes a Kuhnian *scientific Revolution*?
(3b) Who are the “deciders” who put a new paradigm in place?

(4a) What are the *genetic bases* of the Kuhn Cycle – “nurture,” “nature,” or both?
(4b) What does the Kuhn cycle reveal about scientists and the way they interact?

(5) *What else have you learned* from Kuhn’s book?

April 24   SESSION #4 – NO CLASS
May 1  SESSION #5 – SCHOLARLY CONFERENCES, PRESENTATIONS AND PUBLICATIONS

CLASS DISCUSSION

From YOUR experience – as a participant, observer, or what you have heard from others – tell the class YOUR views about scholarly conferences, presentations and publications.

What have YOU learned about
(1) Professional Conferences
(2) Job Interviews
(3) Poster Presentations
(4) Conference Presentations
(5) Effective Teaching
(6) Writing Professional Papers
(7) Reviewing Manuscripts

May 8  SESSION #6 (SCHOPF I – Introduction and Chapters 3-5: pp. xi-xix, 25-77)

History of Darwinian Evolution, Origins of the New Paradigm, and Societal Changes

AND STUDENT PRESENTATIONS

SCHOPF I:
(1a) Why did Dawson and Cuvier rely on religion?
(1b) Do cultural biases (Dawson, Cuvier), “Authoritative Assertion” (Seward) and/or politics (Timofeev) affect science today?
(1c) Do biases – cultural (home, school, church), “Authoritative Assertion” (the Prof’s opinion), and/or politics affect YOU?

(2a) Now, long after Darwin’s Origin, why is there still controversy about the teaching of evolution in U.S. public schools?
(2b) The U.S. and its universities have co-evolved to meet societal changes (viz., religious, racial, gender, economic issues). What is the root of these changes? Are they justified and beneficial or ill-advised and unnecessary?

CLASS ANALYSIS OF STUDENT PRESENTATIONS:
(1) Demeanor of the presenter
(2) Structure/format/visuals of the presentation
(3) Reasonable anomaly solution?
(4) Plausible result of Paradigm Shift?
May 15  SESSION #7 (SCHOPF II – Chapters 7-9 (pp. 125-213)
Deep-Time Paleobiologic Techniques: Past, Present and Future

SCHOPF II:
1) The PPRG was a highly unusual interdisciplinary, international, “Young Turks” experiment. What are the potential benefits – and detriments – of these traits?

(2a) For a scientist, what are the strengths and weaknesses of being “young” Vs. “old”? (2b) If teaching and learning is a “two-way street,” why do teachers allow students to “sell themselves short”?

(3) Are facts malleable? … e.g., “alternative facts”? , “truth is not the truth”? , ”fake news”? Are some “facts” better established than others?

CLASS ANALYSIS OF STUDENT PRESENTATIONS:
(1) Demeanor of the presenter
(2) Structure/format/visuals of the presentation
(3) Reasonable anomaly solution?
(4) Plausible result of Paradigm Shift?

May 22  SESSION #8 (STUDENT PRESENTATIONS)

CLASS ANALYSIS OF STUDENT PRESENTATIONS:
(1) Demeanor of the presenter
(2) Structure/format/visuals of the presentation
(3) Reasonable anomaly solution?
(4) Plausible result of Paradigm Shift?

May 29  SESSION #9 (STUDENT PRESENTATIONS)

CLASS ANALYSIS OF STUDENT PRESENTATIONS:
(1) Demeanor of the presenter
(2) Structure/format/visuals of the presentation
(3) Reasonable anomaly solution?
(4) Plausible result of Paradigm Shift?
June 5  SESSION #10 (SCHOPF III – Chapters 1, 2, 6, 10 (pp. 1-40, 79-123, 215-220)
Bill’s Youth, Education, Adventures in Other Lands, and Guiding Principles

**SCHOPF III:**

(1) Questions/Comments about Schopf’s Adventures
   - 1971-1973: India
   - 1972-1975: USSR
   - 1978-1982: China
What else would YOU like to know about these episodes? For example, sample return and space exploration? The roots of Astrobiology? Indian culture, science and geological fieldwork? The USA-USSR Cold War and the FBI/CIA Vs. KGB? Current-day Russia? Modern China and Chinese capitalistic Socialism?

**KUHN CYCLE**

(2a) Is the Kuhn Cycle really the way science advances?
(2b) What other “possible future paradigm shifts” would YOU propose and how might these dilemmas be solved?

**SCHOPF’S LIFE**

(3a) How does Schopf’s life experience compare with YOURS? Are YOU also a descendant of immigrants? Does that fit with YOUR ancestry, YOUR values?
(3b) Even in grade-school Bill was a problem-solver. How have YOU “beat the system.”?
(3c) Bill has learned much from traveling the world. What could YOU learn from visiting other lands?
(3d) Bill has had a “Wonderful Life” at UCLA. Is that true for YOU? How could YOUR UCLA experience be improved?

(4) **QUIZ THE PROF** *(time permitting).*
Satisfy your curiosity – ask Schopf anything you wish.