Perspectives on Science and Mathematics

PHIL 2314-001
Fall 2013
Instructor: Dr. Kenneth Williford

Meeting Time: Tu & Th 11:00-12:20

Meeting Place: Preston Hall (PH) 110

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Tu & Th 2:30-4:00PM & by appointment

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Course Description

In this course we cover topics and episodes in the history of science and mathematics from a philosophical point of view. In this incarnation of the course, we will focus on logic and argumentation in mathematical and scientific contexts and the nature of scientific reasoning and theory assessment. We will begin by considering some ancient problems in the theory of knowledge (epistemology), move on to discuss how one branch of epistemology became a mathematical discipline in its own right—Deductive Logic. We'll pause to consider the wonders and limitations of logic and its connection to the paradoxes of set theory and semantics. We'll see how these paradoxes drove much important work on the foundations of mathematics in the 19th and 20th centuries. Our discussion of logic will prepare us for and naturally lead us to a discussion of inductive or probabilistic inferences, which form another pillar of our inferential knowledge. We'll focus on the different types of inductive arguments one is likely to encounter in scientific and everyday contexts and consider the history of attempts to understand how inductive reasoning works. We'll cover Bayes' Theorem and show how it is the centerpiece of very intuitive and useful theory of confirmation with surprising applications. Our discussion of probabilistic reasoning will put us in a good position for the third part of the course, a discussion of the age of the earth (and how we know it) and the theory of evolution (what it does and does not say, and how we know it to be true). We'll consider the history of evolutionary thinking as well as the history of design arguments. We'll get clear on Natural Selection, Undirected Variation, and Common Ancestry—the foundational ideas of Darwin's theory. A major goal behind this way of structuring the course is to get students to see that mathematical ideas (in this case, in Logic and Probability) form part of the backbone of all scientific knowledge; and that the pursuit of science and philosophy has generated and can still generate crucial mathematical ideas—hence math students should take an interest in the sciences and science students (other that students of physics) should take an interest in mathematics. And all should take an interest in philosophy! The boundaries between these disciplines are thus somewhat artificial.

Course Objectives/Learning Outcomes

Students will come to understand that science has a fascinating history, is underpinned by deep philosophical presuppositions about the nature of knowledge and the nature of reality, and depends upon special social and

cultural factors for its continued growth and revision. The pedagogical usefulness of historical and philosophical material in the teaching of science and mathematics will also be emphasized. The successful student will acquire the ability to skillfully incorporate material from the history, philosophy, and sociology of science into the teaching of science and will also acquire a nuanced understanding of the social and cultural forces that have shaped the history of science and mathematics and continue to affect the appropriation of the sciences today.

Readings

All reading material for this course will be provided by the instructor. The material will be posted on Blackboard.

Evaluation

(1) Attendance, participation, and quizzes (25%)
(2) One take-home midterm exam (25%)
(3) One lesson plan (25%)
(4) One 10-page research paper (25%)

Attendance and Participation

Attendance will be taken everyday (there will be a sign-in sheet), a student may have up to three unexcused absences without this affecting his or her grade adversely. Participation will be noted.

Quizzes

There will be frequent but small quizzes over the reading material. There will be a quiz almost every week. **Quizzes will be posted on Blackboard and should be turned in on Blackboard as well.** At the end of the semester the cumulative quiz average will be combined with attendance and participation grades to yield 25% of the final grade.

Take-Home Midterm Exam

Around midterm, there will be a take-home examination consisting of two essay questions and some short-answer questions. Answers will need to be typed, double-spaced, and in a 12-point font with reasonable margins. In order to answer the questions adequately, the student will not only need to be familiar with the reading and lecture material. It will count for 25% of the final grade. More information concerning expectations and evaluation criteria will be provided later. **The exam is to be turned in through Blackboard.**

Lesson Plan

Each student will be responsible for developing and presenting a 5E lesson plan. The lesson plan will have to do with a topic from the history or philosophy of science or mathematics. The target audience will be high school students. The lesson plans will be presented to class during the final days of the semester. Fellow students will give feedback. More details and specifications will be given out at a later date. The lesson plan and its presentation will count for 25% of the final grade.

Research Paper

Each student will write a 10-page research paper on a topic in the history or philosophy of science or mathematics. The paper will need to be typed, double-spaced, and in a 12-point font with reasonable margins. The topic will need to be cleared with the instructor early on. The student will need to include an annotated bibliography. The bibliography will need to be in MLA or APA format. Shortly after midterm, students will need to turn in a draft bibliography and a draft of approximately one half of the paper (roughly five pages) for comment from the instructor. Shortly after that students will exchange draft papers with two other students in order to give each other feedback. Records must be kept of all feedback. This will figure into participation grades, and the extent to which a student learned from good feedback will be a factor in the determination of their final paper grade. The paper will count for 25% of the final grade and must be turned in via Blackboard no later than 1:30PM on Tuesday, December 10. More details and specifications will be given out at a later date.

There is no final examination in this class.

Course Dates: August 22-December 4

Class Meeting Time: Tuesdays and Thursdays 11:00AM-12:20PM

IMPORTANT POLICIES OF MINE

Late Work: All late work will be docked a full letter grade for every day that it is late.

Laptops and Phones: In my class I do not allow students to use laptops, smartphones, or other electronic devices without special permission. Any note taking must be done the old fashioned way. However, since recordings of all lectures and all Power Point slides will be posted Blackboard, students are discouraged from taking handwritten notes while in class. There is neuroscientific evidence that attempting to write while listening actually impedes understanding. Students are encouraged to listen and ask questions and write sparingly.

Homework for Other Courses: Students are not allowed to read for or do homework for other courses while in my class.

UNIVERSITY POLICIES

Drop Policy: Students may drop or swap (adding and dropping a class concurrently) classes through self-service in MyMav from the beginning of the registration period through the late registration period. After the late registration period, students must see their academic advisor to drop a class or withdraw. Undeclared students must see an advisor in the University Advising Center. Drops can continue through a point two-thirds of the way through the term or session. It is the student's responsibility to officially withdraw if they do not plan to attend after registering. **Students will not be automatically dropped for non-attendance**. Repayment of certain types of financial aid administered through the University may be required as the result of dropping classes or withdrawing. For more information, contact the Office of Financial Aid and Scholarships (http://wweb.uta.edu/aao/fao/).

Americans with Disabilities Act: The University of Texas at Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including the *Americans with Disabilities Act (ADA)*. All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of that disability. Any student requiring an accommodation for this course must provide the instructor with official documentation in the form of a letter certified by the staff in the Office for Students with Disabilities, University Hall 102. Only those students who have officially documented a need for an accommodation will have their request honored. Information

regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.uta.edu/disability or by calling the Office for Students with Disabilities at (817) 272-3364.

Academic Integrity: Students enrolled in this course are expected to adhere to the UT Arlington Honor Code:

> *I pledge, on my honor, to uphold UT Arlington's tradition of academic integrity, a tradition that values hard work and honest effort in the pursuit of academic excellence.*
>
> *I promise that I will submit only work that I personally create or contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code.*

UT Arlington faculty members may employ the Honor Code as they see fit in their courses, including (but not limited to) having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System *Regents' Rule* 50101, §2.2, suspected violations of university's standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student's suspension or expulsion from the University.

Student Support Services: UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. Resources include tutoring, major-based learning centers, developmental education, advising and mentoring, personal counseling, and federally funded programs. For individualized referrals, students may visit the reception desk at University College (Ransom Hall), call the Maverick Resource Hotline at 817-272-6107, send a message to resources@uta.edu, or view the information at www.uta.edu/resources.

Electronic Communication: UT Arlington has adopted MavMail as its official means to communicate with students about important deadlines and events, as well as to transact university-related business regarding financial aid, tuition, grades, graduation, etc. All students are assigned a MavMail account and are responsible for checking the inbox regularly. There is no additional charge to students for using this account, which remains active even after graduation. Information about activating and using MavMail is available at http://www.uta.edu/oit/cs/email/mavmail.php.

Student Feedback Survey: At the end of each term, students enrolled in classes categorized as "lecture," "seminar," or "laboratory" shall be directed to complete an online Student Feedback Survey (SFS). Instructions on how to access the SFS for this course will be sent directly to each student through MavMail approximately 10 days before the end of the term. Each student's feedback enters the SFS database anonymously and is aggregated with that of other students enrolled in the course. UT Arlington's effort to solicit, gather, tabulate, and publish student feedback is required by state law; students are strongly urged to participate. For more information, visit http://www.uta.edu/sfs.

Final Review Week: A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week *unless specified in the class syllabus*. During

Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. During this week, classes are held as scheduled. In addition, instructors are not required to limit content to topics that have been previously covered; they may introduce new concepts as appropriate.

Emergency Exit Procedures: Should we experience an emergency event that requires us to vacate the building, students should exit the room and move toward the nearest exit, which is located at the rear of the room. When exiting the building during an emergency, one should never take an elevator but should use the stairwells. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist handicapped individuals.

Tentative Schedule & Important Dates

This schedule may be subject to some adjustments as the semester progresses. There will be readings to accompany many of the lectures. These will be announced in class and posted on Blackboard. We will not be able to cover every topic and example listed under each lecture in equal depth.

Thursday, August 22

Introductory Lecture/Discussion 1: Philosophy, History and Science and Mathematics Education

Questions Raised and Discussed: Why do UTeach students have to take this course? Why should science teachers care about the History and Philosophy of Science and Mathematics? Can this course help you teach Science and Mathematics? What is the relationship between Science and Mathematics and human knowledge? What are the cultural factors that support the generation and transmission of knowledge? What is the relation between the practice of teaching, the theory of knowledge (Epistemology), and the History of Science and Mathematics?

Tuesday, August 27

Introductory Lecture 2: What is Knowledge? An Introduction to Epistemology and the Philosophy of Science and Mathematics

Questions Raised and Discussed: How should we define knowledge? What is the difference between knowing *how* to do something and knowing *that* something is the case? What is the relationship between knowledge and truth? What is the concept of truth? What is the difference between knowledge based on perception and knowledge based on inference? Do we have any knowledge? Can understanding the nature of knowledge help us to teach (transmit knowledge) better? What do we consider the main sources of knowledge and the disciplines that deal in genuine knowledge? Have all cultures throughout history always agreed on what the main sources of knowledge are?

Thursday, August 29

Discussion & Review Day

Main Topics: Epistemic vs. Practical Rationality & The Regress of Epistemic Justification

After a brief review and presentation on the distinction between epistemic and practical justification, students will divide into groups. Each group will discuss the following question: Could all epistemic justification be inferential? Each group will present its answer and the reasons for its answer. Then there will be a general debate and discussion of these proposed answers and reasons. Then there will be a closing discussion of the history of this problem and its relation to theories of scientific knowledge and the axiomatic method in Mathematics.

Tuesday, September 3

(Online) Lecture 3: Argument, Logic and Probability

Questions Raised and Discussed: What is an argument? What are the components of an argument (viz., premises and conclusions)? What are propositions or statements? What is it for a statement to true or false? What is the relationship between statements and beliefs? What are the differences between Logic, Probabilistic Reasoning, and Rhetoric? How do arguments relate to knowledge (and inferential justification)? What is the difference between deductive reasoning and inductive reasoning? What is it for a deductive argument to be valid or invalid, sound or unsound? What is it for an inductive argument to be strong or weak? What is *non sequitur*? How were the topics of Logic and Probability important in the History of Science and Mathematics? Are they still important for *everyone* now?

No Class Meeting this day. Online Lecture and Homework Exercises.

Homework Exercises to be turned in via Blackboard by Monday September 9 (at 11:59PM).

Thursday, September 5

(Online) Lecture 4: Basic Deductive Logic Part One—Propositional Logic

Questions and Topics Raised and Discussed: Truth-Values: True & False, 1 & 0. Bivalence and Consistency. The logical connectives: And, Or, If/Then, Not, If-and-Only-If). Tautologies, Contingent Statements, and Contradictions. Common propositional argument forms: Modus Ponens, Modus Tollens, Hypothetical Syllogism, Constructive and Destructive Dilemmas, Disjunctive Syllogism. Two proof strategies: Conditional Proof and Reductio ad Absurdum. Two common formal fallacies: Affirming the Consequent, Denying the Antecedent. Truth-tables. Using truth tables to test arguments for validity, to test single statements for tautologousness, contingency, and contradictoriness, and to test sets of statements for consistency. Is this material useful for teachers (besides Computer Science and Mathematics teachers)? Some notes on the history of Propositional Logic and from Ancient Greece to the Computer Age.

No Class Meeting. Online Lecture and Homework Exercises.

Homework Exercises to be turned in via Blackboard by Monday September 9 (at 11:59PM).

Monday, September 9 ***Census Date***

Tuesday, September 10

Discussion & Review Day

Main Topics: Identifying Arguments vs. Non-Arguments, Identifying Propositional Argument Forms, Using Truth-Tables to test for Validity and Consistency, etc.

After a review of all the material from Lectures 3 & 4, students will divide into groups and be given examples of arguments taken from a variety of scientific and philosophical texts. The groups will come up with an analysis of the texts, isolating premises from conclusions, argument forms, rhetorical elements, and analyzing the arguments for validity and sets of statements for consistency, as appropriate. Two randomly selected groups will present their analyses in class for general debate and discussion.

Thursday, September 12

Lecture 5: Basic Deductive Logic Part Two—Predicate Logic

Questions and Topics Raised and Discussed: The Logic of All and Some—the Quantifiers. Universal statements versus Existential and Particular statements. Aristotle's Square of Opposition and George Boole's "Modern" Square. Categorical Syllogisms. How to use Venn Diagrams to test Categorical Syllogisms for validity. Immediate Inferences. Universal Instantiation and Generalization; Existential Instantiation and Generalization. Common formal fallacies in Predicate Logic. Predicates and Classes (Sets). Relations between Classes. How Predicate Logic and Propositional Logic relate. Notes on the history of Predicate Logic and its relation to Science and Mathematics from Aristotle to Boole, Frege and the Computer Age. Why should we care about learning Predicate Logic? Will this help one teach anything (other than Mathematics and Computer Science)? This history of logical notations.

Tuesday, September 17

Discussion and Review Day

Main Topics: Interpreting and Assessing Predicate Logic Arguments using Venn Diagrams

After reviewing the material from Lecture 5, students will divide into groups and be given examples of arguments taken from a variety of scientific and philosophical texts or some Predicate Logic exercises. The groups will come up with an analysis of the texts or exercises, isolating premises from conclusions, argument forms, rhetorical elements, and analyzing the arguments for validity by using Venn Diagrams, as appropriate. Two randomly selected groups will present their analyses in class for general debate and discussion.

Thursday, September 19

Lecture 6: Fallacies, Debate, and Dialectic in the History of Science, Mathematics, and Philosophy (and Everywhere Else!)

Questions and Topics Raised and Discussed: Common Informal Fallacies, the Distinction between Logic and Rhetoric, Proof in Mathematics, Evaluation of Evidence in Science and Law, the practice of Debate and Dialectic in Ancient Greece and in Medieval Scholasticism (European and Indo-Tibetan), Debate, Competition, and Controversy (public and private) in the History of Science and Mathematics (e.g., the trial of Galileo, public Mathematics competitions in Renaissance Italy (e.g., Tartaglia vs. Ferro), the 1860 Oxford Evolution debate). What are the cultural factors conducive to free inquiry and the unrestricted assessment of argument and evidence? Should we care about preserving a culture that enshrines these factors? What are some example of times and places in history when these factors were not operative? What were the consequences? Is any of this important for science teaching?

Tuesday, September 24

Discussion and Review Day

Main Topic: Debate and Dialectic in Scientific and Mathematical Contexts

After reviewing the material from Lecture 6, students will divide into groups of three. Each group of three will consist in two debaters and one referee. Each group will be given a topic to debate. For example, one debater may be given the task of arguing for a heliocentric model of the solar system while the other is given the task of questioning that model. The goal of each debater is to argue as carefully as possible, raise important questions about the meanings of terms, examine sources of evidence suggested by the opponent, etc. The job of the referee is to make sure that no one commits formal or informal fallacies or resorts to pure rhetoric and that the debaters do not talk past each other or evade answering questions, etc. In the last portion of the class, at least one pair of debaters (more if time permits) will be randomly selected to engage in debate about a given topic of importance in the history of Science and Mathematics while the instructor plays the part of referee.

Thursday, September 26

Lecture 7: The Paradoxes of Logic and Set Theory and Their Significance for Mathematics

Questions and Topics Raised and Discussed: The Axiomatic Method in Mathematics from Euclid to the *Principia Mathematica* of Russell and Whitehead. Work in the "Foundations of Mathematics". What is mathematical knowledge? Frege's and Russell's Logicism, Hilbert's Formalism, Brouwer's Intuitionism. What is mathematical proof? What are axioms? Axiomatization and data compression. Formalization. Axiomatic Set Theory. The Paradoxes of Naïve Set Theory: Russell's Paradox, Mirimanoff's Paradox, Cantor's Paradox. Semantic Paradoxes of Self-Reference: The Liar Paradox, Curry's Paradox, Berry's Paradox. The application of paradox-like reasoning within mathematics: Gödel's Incompleteness Theorems. From philosophical inquiries into the epistemology of mathematics to the computer (from Frege to Turing): How philosopher-mathematicians created the computer age. That's what philosophy has done for us lately!

Tuesday, October 1

Discussion & Review Day

Main Topic: The Liar Paradox—What can it teach us about mathematical intuition?

After reviewing material from Lecture 7, students will divide into groups and attempt to develop proposals for resolving the Liar Paradox ("This statement is false"). They will need first to isolate the assumptions upon which the paradox rests and then determine which assumption they want to give up and the consequences of doing so. In the latter part of the class groups will be asked to present their proposals for debate and discussion.

Thursday, October 3

Lecture 8: Perceptual Knowledge and the Problems of Induction

Questions and Topics Raised and Discussed: Inferential and non-inferential justification in the context of observation. Perception as a foundation of knowledge. Seeing and Seeing-as. Theory vs. Data. The Problem of Induction. Types of Inductive Arguments: Enumerative, Statistical, Analogical, Parsimony. Inductive skepticism. Inductive fallacies: Overlooked Evidence, Hasty Generalization, Base Rate Neglect, Overuse of the Availability Heuristic. "Faith" vs. Reason. Francis Bacon, John Stuart Mill and the "Method of Induction".

Tuesday, October 8

Discussion & Review Day

Main Topic: Identifying Inductive Arguments

After reviewing material from Lecture 8, students will be asked to get into groups. The groups will be given several passages from science textbooks, scientific articles, and other sources. The groups will need to analyze the passages, identifying arguments, distinguishing them from explanations and other non-arguments, and determining if the arguments are inductive, deductive, or fallacious, and further determining what sort of inductive, deductive, or fallacious arguments they are. Groups will then be asked to present their analyses for discussion and debate.

Thursday, October 10

Lecture 9: Bayes' Theorem and Bayesian Confirmation Theory

Questions and Topics Raised and Discussed: Probability and Induction. Conditional Probability and Prior Probability. Kolmogorov's Definition of Conditional Probability. "Likelihood" Bayes' Theorem. Bayesian Updating. Confirmation vs. Falsification. The role of Bayesian updating in the resolution of perceptual uncertainty. Background assumptions in Confirmation. The Quine-Duhem Thesis. Wiggling out of Falsification. Why people hold onto dead theories. The Hypothetico-Deductive Model of Scientific Theory Testing. Hume's Argument against believing in Miracles and the Response of the Reverend Thomas Bayes.

Applications of Bayes' Theorem: Alan Turing and the Enigma Code, the "Bayesian Brain" Paradigm. Bayesianism vs. Frequentism.

Tuesday, October 15

Main Topic: When is a theory truly dead?

After reviewing material from Lecture 9, students will form into groups. There will be two main groups. One will be given a set of statements (constituting a theory) to defend (e.g., that the earth is flat, or that the world is governed by a secret society, or that NASA never sent people to the moon, or that the stars are fundamentally different from our sun). The other group will be given the task of raising objections to and finding evidence against the theory held by the advocating group. A third group of students will constitute a jury, and fourth, smaller group will constitute judges who will serve, in effect as referees. After some preparation, the class will hold a mock trial. The objecting group will present evidence and arguments against the theory. The advocating group will offer replies to the objections. The judges will make sure that the replies are not fallacious, do address the objection, and that they are logically coherent responses. The advocating group will then offer new objections or objections to the replies. And the process will be iterated. The job of the jury will be to determine of the objecting team raised deep and important objections (versus merely superficial ones) and to determine how theoretically "costly" or implausible the replies are.

Thursday, October 17

Lecture 10: Models and Argument to the Best Explanation

Questions and Topics Raised and Discussed: Different uses of the term "model" in Mathematics, Logic, and Science. Models and Analogies. What makes an explanation "best"? Consilience. Richness. Testability. Parsimony. Predictive Power. C.S. Pierce and "Abduction". The Copernican vs. Ptolemaic Models of the Solar System—myths and realities. Empty explanations. Explanatory Regresses. What is Science? The "demarcation problem". Kuhn and "Normal" vs. "Revolutionary" Science.

Tuesday, October 22

Discussion & Review Day

Main Topic: Competing Explanations

After reviewing material from Lecture 10, students will divide into groups. Groups will be given a set of "data" (e.g., a set of astronomical observations concerning the movements of the planets, or a set of geological observations about unconformities, or a set of neurological symptoms and lesion data). Groups will formulate different models of the underlying processes that could account for the data. Each group will present its proposed model and explanation, while the other groups raise objections and present counter-evidence. We will then attempt to evaluate the explanatory power of each of the models on the basis of the criteria discussed in the lecture.

Thursday, October 24

Lecture 11: The Design Argument and Evolutionary Thinking Prior to Darwin

Questions and Topics Raised and Discussed: Kinds of Design Arguments. The Design Argument and its Critics in Antiquity. The Epicurean Alternative to Design Theory. Evolutionary Thinking in Antiquity. Hume's Criticisms of the Design Argument. Paley's Response to Hume. Kant's Criticism of the Design Argument and his views on its relation to the other theistic "proofs". Other criticisms of the Design Argument. Ultimate Explanations. The Design Argument and the Problem of Evil. Randomness, coincidence and seeing signals in the noise. Theories compatible with all observations.

Tuesday, October 29

Discussion & Review Day

Main Topic: How can we tell if something has been designed by an intelligence? Can we always tell?

After reviewing the material from Lecture 11, students will divide into groups. We will look at videos and pictures of various sorts of patterned phenomena (e.g., the "face" on Mars, markings on rock faces) and consider various stories and scenarios (e.g., a day in the life of a synchronicity seeker). Each group will come to a reasoned decision about whether each phenomenon (etc.) is best explained as a product of intelligent design or as a product of non-intelligent processes. Then as a class we will consider and debate the answers proposed by each group.

Wednesday, October 30 ***Last Day to Drop Classes***

Thursday, October 31

Lecture 12: The Fossil Record, the Geologic Column, and the Age of the Earth

Questions and Topics Raised and Discussed: What are fossils and what did people think they were? Steno's stratigraphic principles. The Principle of Faunal Succession. The rise and demise of Flood Geology. Cultural factors shaping thought about the age of the earth and universe. Attempts to date the earth from antiquity to radiometric dating. How "thick" is the Geologic Column? Transitional Forms in the Fossil Record. Mass Extinctions. Charles Lyell's Uniformitarianism vs. Catastrophism—myths and realities. A Brief History of Creationism and its varieties.

Tuesday, November 5

Discussion & Review Day

Main Topic: The high cost of a young earth.

After reviewing material from Lecture 12, students will divide into groups. One group will be given the task of defending the idea that the earth is no more than 10,000 years old. Another group will be given actual evidence for the real age of the earth (e.g., evidence from radiometric dating, plate tectonics, paleontology, astrophysics). The young earther group will be tasked with figuring out some logically coherent (even if totally implausible) way to account for the evidence they are presented while maintaining the young earth view. A third group will attempt to determine "cost" of the responses the young earthers make. That is, just how implausible and *ad hoc* does the young earth theory become in its responses to the counter evidence? For example, if the young earth theory has to accept the idea that the speed of light was radically different just 10,000 years ago from what it is now, just how much does that count against the theory?

Thursday, November 7

Lecture 13: Darwin and Common Descent—The Tree of Life

Questions and Topics Raised and Discussed: The Tree of Life and the Great Chain of Being: A Brief History. From Faunal Succession to Common Descent. From Darwin's Diagram in the *Origin of Species* to contemporary 3D interactive "trees". "Analogies" and "Homologies". Basic principles of Systematics. Basic Taxonomic Terminology. When is Common Ancestry the best explanation of similarities and when not? From gross anatomical similarities to genomic similarities. The Origin of Life. The Distribution of Life in the Cosmos.

Tuesday, November 12

Main Topic: Similarity and Common Ancestry

After reviewing material from Lecture 13, students will divide up into several groups. Each group will be given a data set consisting of sentences in several languages. The goal will be to attempt to determine which sentences are in ancestor languages and which in descendant languages, how closely related the descendant languages are to each other, and whether some of the represented languages appear to be completely unrelated. Each group must also attempt to articulate the principles they used in coming to their conclusions. Each group will present their results for open discussion and debate.

Thursday, November 14

Lecture 14: Darwin and Natural Selection

Questions and Topics Raised and Discussed: The idea of natural selection (or something close to it) before Darwin: Hume and Maupertuis. Darwin's extrapolations and crucial observations. Myths about how Darwin got the idea of Natural Selection. Darwin and Wallace. Natural Selection as an Algorithmic Process. Variation and Mutations: Beneficial, Neutral, and Deleterious. Random Genetic Drift vs. Natural Selection. Fitness

Curves. The Path Dependence of Evolution. Examples of Natural Selection at Work. What Natural Selection can explain and what it was never intended to explain. Confusions about Natural Selection. Natural Selection and Predation, Parasitism, Pathogens, and Mass Extinctions. The Directionlessness of Mutations. The quasi-intelligent look of the products of Natural Selection. Why we should not be surprised by sub-optimal design and useless vestigial organs. Why we should not be too surprised by absurdly inefficient reproductive strategies. The "No Designer Worth Its Salt" Argument.

Tuesday, November 19

Discussion & Review Day

Main Topic: The Game of Selection

After reviewing material from Lecture 14, each student will create an "organism" (instructions will be given on how exactly to do so). Each "organism" will have a set of characteristics chosen by the student. These imaginary organisms will be dropped into an "environment" determined by the instructor. There will be several rounds or "generations". During each round a certain percentage of organisms with certain characteristics will be eliminated due to their lack of comparative fitness in the environment. Students whose organisms have not been eliminated will then have the chance to change (mutate) some characteristic of their organism producing the next generation, while students whose organisms had been eliminated will have to "adopt" a copy one of the more successful organisms from those that remain—with modification if desired. The process will be reiterated for as long as time allows. At the end of the game, the student(s) whose organism(s) have the highest representation in the "population" will be declared the winner(s)—though they'll have no reason to be proud since nothing depended on their skill. Other students will be given Darwin Awards as consolation prizes. (That is a joke, by the way.)

Thursday, November 21

Lesson Plan Presentations

Tuesday, November 26

Lesson Plan Presentations

Thursday, November 28 ***Thanksgiving Day Holiday, No Class***

Tuesday, December 3 ***Last Day of Class***

Lesson Plan Presentations

Tuesday, December 10 1:30 PM Papers Due