

COURSE OUTLINE A S T 105IN Life in the Universe

Fall 2011 and after

Science and Astronomy

- I. Goals for this course (Intro Notes, Unit I., covered in Foundational Homework Ass't.)
 - A. Increase awareness of, and interest in, your celestial neighborhood
 - B. Improve your "scientific literacy"
 - C. Instill a "Cosmic Perspective" on your world
 - D. Contribute to your personal and professional growth through critical thinking

- II. Origins of science and astronomy
 - A. Origin of Astronomy (ca. 550 B.C.E. to ca. 400 C.E.)

 - B. Origin of science
 1. fundamental importance: a new way to understanding
 - a. naturalistic vs. supernaturalistic
 - b. Thales
 2. some astronomical contributions
 - a. Democritus
 - b. Eratosthenes
 - c. Aristotle and geocentrism vs. heliocentrism
 3. The significance of Aristotle's approach
 4. The demise of the Greek philosopher-scientists

 - C. From the Greeks to the Scientific Revolution — the Islamic Contribution

- III. The Scientific (Copernican) Revolution (ca. 1600 c.e.)
 - A. Nicolaus Copernicus and his challenge to geocentrism
 - B. Tycho Brahe and his observations of Mars
 - C. Johannes Kepler and the Three Laws of Planetary Motion
 - D. Galileo Galilei
 1. Telescopic discoveries
 2. Clash with the Church

- IV. Newton and Motion
 - A. Isaac Newton (ca. 1700 C.E.)
 1. Laws of Motion
 2. Law of Gravity

- V. The Introductory Course Notes Set (Notes are already in outline form, so only the major units are given here.)
 - A. A Personal Statement on Teaching (Intro Notes, Unit II., covered in Foundational Homework Ass't.)
 - B. U.S. Scientific Illiteracy (Intro Notes, Unit III., covered in Foundational Homework Ass't.)
 - C. Science – a learning process (Intro Notes, Unit IV., covered in class)
 - D. Critical Thinking (CT) Skills (Intro Notes, Unit V., covered in class)
 - E. Pseudoscience/Superstition/Anti-intellectualism (Intro Notes, Unit VI., covered in class)
 - F. The Popularity of Pseudoscience (Intro Notes, Unit VII., covered in Foundational Homework Ass't.)

- G. Dangers of Pseudoscience (Intro Notes, Unit VIII., covered in Foundational Homework Ass't.)
- H. Non-psychological Reasons for the Acceptance of Pseudoscience (Intro Notes, Unit IX., covered in Foundational Homework Ass't.)
- I. Psychological Reasons for Acceptance of Pseudoscience (Intro Notes, Unit X., covered in Foundational Homework Ass't.)
- J. Tests of Psychic Claims (Intro Notes, Unit XI., covered in Foundational Homework Ass't.)

VI. Light

- A. Starlight--what the naked eye can see
 - 1. brightness and magnitudes
 - 2. color and the electromagnetic spectrum
 - 3. direction and coordinate systems (brief)
- B. Using light to know the universe
 - 1. Temperature
 - a. definition
 - b. scales
 - 2. Kirchhoff's absorption line spectrum
 - a. How and where formed in stars
- C. Observing methods
 - 1. imaging
 - 2. spectroscopy
 - 3. photometry

TEST 1 covers to here and Assignments 1 - 3

The Cosmic Perspective

VII. The Cosmic Perspective

- A. Cosmic Perspective—Space
 - 1. The Solar System
 - a. Sun at center
 - b. the 8 major planets and their satellites
 - (1) the Astronomical Unit distance unit
 - c. the minor planets
 - (1) asteroids
 - (2) comets
 - 2. Hierarchical structure of the universe
 - a. the light year distance unit
 - b. VIDEO—"Powers of Ten"
 - 3. Our Milky Way galaxy--a typical spiral galaxy
 - a. size and our location
 - (1) activity: the "penny solar system"
 - 4. Galaxies (brief slide show)
 - a. morphological types
 - b. Most conducive to complex life
 - c. clusters and superclusters
 - d. quasars
- B. Cosmic Perspective—Time
 - 1. Bishop Ussher (17th century)
 - 2. The Great 19th century Age of the Earth Debate
 - 3. The age of the solar system

4. Relative age dating
 - a. crater counts
 - b. surface geological processes
 - c. crustal rock layers
 - d. fossils
5. Absolute age dating
 - a. radioactive decay of unstable isotopes in rocks
 - b. astrophysical estimates of the age of the sun
 - (1) from its gross properties
 - (2) from its internal oscillations
6. Age of the universe
7. VIDEO—The “Cosmic Calendar” from *Cosmos* #1

VIII. The Universe—nature and origin

- A. Important cosmic discoveries of the 20th century to date
 1. expansion of the universe
 - a. The Hubble Relation
 2. 2.7 K cosmic background radiation (CMB)
 3. Very minute, but important, fluctuations in the CMB
- B. Theory—The Big Bang
 1. the first few minutes
 2. the plasma universe
 3. The “Dark Time”
 4. the origin of the stars and galaxies
- C. What about life in the early universe?

IX. Star basics

- A. Spheres of matter
 1. Chemical composition
 2. Mass range
 3. Size range
- B. Temperature—key property
 1. Range
 2. Luminosity (power)
 - a. Intensity
 - b. Size (specifically, surface area)
 3. Spectrum—result of
 - a. Temperature
 - b. chemical composition
 - c. Size (atmospheric pressure)
 - d. other properties
- C. The types of stars—Spectral Classification
- D. A quantitative look at the major properties of stars
 1. Masses
 2. Luminosities
 3. Temperatures
 4. Sizes
- E. Double stars - physical vs. optical
 1. visual binaries
 2. spectroscopic binaries and the Doppler Effect
 3. astrometric binaries
 4. benefits to astronomy of double stars

- F. Luminosity Function
- G. Stellar populations (brief)
 - 1. Population 1
 - 2. Population 2
 - 3. The development of the terrestrial planet class

- X. Star & Planet Formation (Pre-main sequence phase)
 - A. The role of gravity
 - B. Step by step

 - C. How stars shine
 - 1. nuclear fusion and Einstein's famous equation: $E=mc^2$
 - 2. nucleosynthesis and the range of stellar masses
 - D. Evidence from outside and within solar system

- XI. The Lives and Importance of Stars
 - A. Main Sequence Phase
 - B. Post-main Sequence Phase

 - C. Closer looks at
 - 1. Heavy-weight stars
 - 2. The range of stellar masses
 - 3. Range of stellar lifetimes

 - D. Astrobiological impacts of stars
 - 1. Births of stars
 - 2. Stellar energies
 - 3. Stars and cosmochemistry
 - 4. A second look at Spiral-type galaxies

TEST 2 covers to here and Assignments 4, 5

Unit Three—Life!

- XII. Life on Planets around other Stars
 - A. Habitable Zones
 - 1. Description
 - 2. Key roles of water
 - 3. The effect of differing stars on HZs
 - 4. Possible life outside HZs

 - B. Extra-solar planets
 - 1. How to detect?
 - 2. Doppler effect
 - 3. The discovery
 - 4. What are we learning?
 - 5. Hot Jupiters
 - 6. Implications for terrestrial planets
 - 7. Double star planets
 - 8. Independent confirmation
 - 9. First photographs
 - 10. Space telescopes

XIII. Earth and Moon

- A. The Moon
 - 1. Origin
 - 2. History of early solar system
- B. Planet Earth
 - 1. Early development and resulting structure
 - 2. Its dynamic nature
 - 3. Geology
 - 4. Atmosphere
- C. Cosmic Perspectives on Earth and life
 - 1. Atmospheric matters
 - 2. "Snowball Earth"
 - 3. Cosmic Perspective
 - a. Description
 - b. Examples
 - c. Rare Earth

XIV. Life on Earth

- A. The nature of life
 - 1. Physical entity engaged in processes
 - 2. What enables the metabolic and other biological processes?
 - a. DNA, deoxyribonucleic acid
 - (1) structure
 - (2) functions
 - b. Clarification: The role of RNA
 - 3. Cells—the basic chemical factory unit
 - a. Three basic levels of life's complexity
 - b. Cell structure
 - c. Cell division—mitosis
 - 4. The four compounds of life
 - 5. Three-part working definition of Life
 - a. bounded micro-environments
 - b. capable of transforming energy and the environment
 - c. capable of information encoding and transmission
- B. Origin of Life on Earth—seeking the chemical evolution which led to the biological evolution
 - 1. one of the fundamental mysteries of life, as it were
 - 2. Numerous Creation Myths
 - 3. First scientific hypothesis—Spontaneous Generation
 - 4. 20th century ideas
 - a. Cool early Earth
 - b. Hot early Earth
 - c. deep in the surface and ocean depths
 - (1) hot, dark, no oxygen
 - d. "They came from outer space!"
 - (1) Panspermia, in several versions

TEST 3 covers to here and Assignment 6 - 8

- C. Evolution of Life on Earth
 - 1. Two aspects—theory or fact?
 - 2. Evidence
 - a. Paleontology
 - b. Phylogeny/cladistics

- c. Biogeography
 - d. Embryology
 - e. Molecular biology
 - f. The ongoing occurrence of evolution
 - g. Extinctions of flora and fauna
 - h. human-directed evolution
 - i. The development of absolute age-dating of rock strata
 - j. The “meta-proof” of evolution
3. The Theory of Evolution
- a. Charles Darwin and his epochal book is *On the Origin of Species by Means of Natural Selection*
 - b. “The survival of the fittest.”
 - c. Evolution in thought—a self-demonstration of evolution at work on our minds
4. Final point
- a. The limited role of chance
- D. “Scientific” Creationism (SC) and its recent upgrade, Version 2.0, “Intelligent Design”
1. The “Argument from Design” A theological interpretation of nature
 - a. Rev. William Paley, *Natural Theology*, 1803
 2. American Christian fundamentalism
 3. Reasons why SC and ID are not intellectually respectable
 - a. science, a purely naturalistic pursuit of knowledge and understanding of the physical world, cannot prove nor disprove supernaturalistic claims
 - (1) “Scientific” Creationism is an oxymoron
 - (2) an example of SC writing on this point
 - b. The either/or fallacy
 - c. The incompetency of their alleged “scientific research”
 4. Intelligent Design (ID)
 - a. Plus: acknowledges problems with the “argument from design”
 - b. Another plus: accepts scientifically determined ages for the universe and objects within it
 - c. Minus: still has no good science in it
 - (1) no real research
 - (2) ideas have long been rebutted w/o effective response
 - (3) brings up the old, refuted “watchmaker” analogy of William Paley’s
 - d. publically, seems more reasonable to inject into science classes than was SC; is raising the level of news coverage on the Creationism v. Evolution controversy and attempts to get SC and ID taught in public school science courses
 5. So how could the eye evolve?
- E. The Geologic Time Scale and the Evolution of Life on Earth—Pre-Cambrian
1. Four major units of geological time
 - a. eon
 - b. era
 - c. period
 - d. epoch
 2. Hadean eon—the period of heavy bombardment
 3. The rise of the Domains and Kingdoms of Earth’s life
 - a. Archaean eon and the rise of
 - (1) Prokaryotes
 - b. Proterozoic eon and the rise of
 - (1) Eukaryotes
 - (2) Archaea
 - (3) complex life-rise of the Animal Kingdom
 - (4) other eukaryotic Kingdoms
 - (5) sex at the cellular level
 - c. Snowball Earth
 - d. ediacaran animals
- F. The Geologic Time Scale and the Evolution of Life on Earth—Pre-Cambrian
1. The Cambrian Explosion of fossilizable animal life and the start of the current eon, the Phanerozoic
 - a. Creation of the phyla
 2. Paleozoic era—“Old life”
 - a. Life changed the atmosphere by creating free oxygen

- b. Cambrian period
- c. Ordovician period
- d. Silurian period
- e. Devonian, “the age of fishes”
- f. Carboniferous period
- g. Permian period
- 3. Mesozoic era—“middle life” a.k.a. “The age of the dinosaurs”
 - a. Triassic period
 - b. Jurassic period
 - c. Cretaceous period
- 4. Cenozoic era “recent life” a.k.a “The age of mammals”
 - a. Tertiary period
 - b. Quaternary period
 - (1) Pleistocene epoch
 - (2) Holocene epoch “The age of man”

NOTE: For these last two units, XV and XVI, the textbook input may be greater than the classroom input

XV. Life in the Solar System

- A. Mars
- B. Icy Satellites
 - 1. Europa
 - 2. Titan
 - 3. Enceladus

XVI. Life in the Universe

- A. What are the odds? The Drake Equation
 - 1. “Rare Earth”
 - 2. An estimate for the probability of simple life forms
 - 3. An estimate for the probability of complex life forms
 - 4. An estimate for the probability of intelligence
- B. SETI—the Search for Extraterrestrial Intelligence
 - 1. History
 - 2. Ideas for communication
 - 3. Current work and future ideas
- C. UFOs and Ancient Astronauts
 - 1. Review of the evidence and claims
 - 2. Scientific results
- D. Space Travel
 - 1. Interstellar
 - a. The universal speed limit posed by relativity
 - b. How to?
 - (1) future rocketry
 - (2) future physics
 - 2. Interplanetary
 - a. How to?
 - (1) future rocketry
- E. The “Fermi Paradox”
- F. The Impact of First Contact (Epilogue)

TEST 4 covers to here and Assignments 9 - 10N, possibly also 11

Assignment 12—due with Test 4, but not included on it.