

COURSE OUTLINE A S T 105IN Life in the Universe

Mechler, Fall 2006

Unit One—Science and Astronomy

- I. Goals for this course (Intro Notes, Unit I.)
 - 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 science and the ancient Greek astronomers (ca. 550 B.C.E. to ca. 400 C.E.)
 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
 - B. 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
 - B. Two proofs for the motions of the Earth
 1. Stellar parallax
 2. Foucault pendulum

- V. Science) a learning process (Intro Notes, Unit IV.)
 - A. Definition of Science
 - B. The practice of Science and its pragmatic, naturalistic nature
 - C. Facts, theories and "the heart of science"
 - D. The Scientific Attitude
 - E. Science vs. dogma & myth (Read.)
 - F. Science as it relates to other areas (Read.)

VI. Critical Thinking (CT) vs. Black/White thinking (Intro Notes, Unit V.)

- A. Eight aspects of CT
- B. Scholarship
- C. Impact on the world and reflections (Read.)

VII. Pseudoscience/Superstition/Anti-intellectualism (Intro Notes, Unit VI.)

- A. Characteristics
- B. Contrasts with science (the Black Knight at the Bridge)
- C. Some astronomically related examples & brief personal perspective

VIII. 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. Planck's Radiation Law for ideal (black body) radiators
 - a. Wien's Law (color as a fn. of temp.)
 - b. Stefan-Boltzmann Law (brightness as a fn. of temp.)
 - 3. Luminosity as a function of size and temp.
 - 4. Star spectra and what they tell us
 - a. quantum mechanics and atomic structure
 - b. temperatures
 - c. chemical composition
 - d. the spectral classification system
 - 5. The Doppler Effect--A major key to understanding the universe
- C. Observing methods
 - 1. imaging
 - 2. spectroscopy
 - 3. photometry

TEST 1 covers to here and Assignments 1

Unit Two—The Cosmic Perspective

IX. The Cosmic Perspective

- A. The Solar System
 - 1. General characteristics--clues to its origin
 - 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
- B. Cosmic Perspective—Space
 - 1. Hierarchical structure of the universe
 - a. the light year distance unit
 - 2. VIDEO—"Powers of Ten"

- C. 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. VIDEO—The “Cosmic Calendar” from *Cosmos* #1

X. Galaxies

- A. our Milky Way galaxy--a typical spiral galaxy
 - 1. size and our location
 - 2. the galactic year
 - 3. explanation of stellar population types
- B. other galaxies (brief slide show)
 - 1. morphology types
 - 2. clusters and superclusters
 - 3. quasars

XI. 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
 - 4. Recent discovery of an acceleration of the expansion of the universe—what does this mean?
 - 5. Age of the universe settled
- B. Theory—The Big Bang
 - 1. the first 3 minutes
 - a. speculation that the origin was a QM statistical fluctuation from a non-zero "energy vacuum"
 - b. speculation that the origin was a result of a collision of universe “branes”
 - c. origin of the fundamental forces
 - (1) Grand Unification Theories (GUTs)
 - d. origin of the elementary particles
 - e. the brief period of fusion
 - 2. the time of "recombination"
 - a. the de-ionization of the universe and the decoupling of matter and light energy
 - 3. The “Dark Time”
 - 4. the origin of the galaxies
 - a. discovery of the earliest fluctuations
 - b. recent and continuing discoveries of the earliest galaxies and star bursts
 - 5. Evidence supporting the Big Bang/Inflation

XII. Star basics

- A. the sizes and masses of the stars (brief)
- B. Double stars - physical vs. optical
 - 1. visual binaries

2. spectroscopic binaries
 - a. putting the Doppler effect to use
3. astrometric binaries
4. benefits to astronomy of double stars

C. Stellar populations (brief)

- D. How do stars shine?
1. The “Yin” and “Yang” of stars—gravity and pressure
 2. nuclear fusion and Einstein's famous equation: $E=mc^2$
 3. nucleosynthesis and the range of stellar masses

XIII. Star & Planet Formation (Pre-main sequence phase)

- A. The role of gravity
- B. Step by step
- C. Evidence from outside and within solar system

XIV. The Lives and Importance of Stars

- A. Main Sequence Phase
- B. Post-main Sequence Phase
- C. Astrobiological impacts of stars
- D. Extra-solar planets
- E. Habitability Zones
- F. Rare Earth?

TEST 2 covers to here and Assignments 2

Unit Three—Life!

XV. Earth and Moon

- A. The Moon
 1. General info/surface features
 2. Origin
- 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
 4. Cosmic influences

XVI. 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
- 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. A closer look at the above lines of evidence
 - 4. 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
 - 5. Final point
 - a. The limited role of chance
- D. “Scientific” Creationism (SC)
 - 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
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
 4. The Cambrian Explosion of fossilizable animal life and the start of the current eon, the Phanerozoic
 - a. Creation of the phyla
 5. 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
 6. Cenozoic era—“middle life” a.k.a. “The age of the dinosaurs”
 - a. Triassic period
 - b. Jurassic period
 - c. Cretaceous period
 7. 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”

TEST 3 covers to here and Assignment 4, 5

NOTE: For these last two units, XVII and XVIII, the textbook input is greater than the classroom input

XVII. Life in the Solar System

- A. What are we finding?
 1. Mars

2. Europa
3. Titan

XVIII. Life in the Universe

- A. The Habitable Zone
- B. Extra-solar Planets
- C. 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
- D. SETI—the Search for Extraterrestrial Intelligence
 1. History
 2. Ideas for communication
 3. Current work and future ideas
- E. The "Fermi Paradox"
- F. 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
- G. UFOs and Ancient Astronauts
 1. Review of the evidence and claims
 2. Scientific results
- H. The Impact of First Contact

TEST 4 covers to here and Assignments 6-10