

Inventing Reality: The Human Search for Truth Spring 2004, Hampshire College

Lecture Time: M 7:00 - 10:00 PM; W 1:00 - 2:20 PM

Place: Room 333, Cole Science Center

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Office Hours:

Monday 10:00 – 11:00 PM

Wednesday 2:30 – 4:30 PM

Website: <http://helios.hampshire.edu/~dclNS/inventingreality>

Course Description

Creating order out of our universe has been a perennial human pastime. Accepted truths have had a history of transience, with the models of each age yielding to the paradigm shifts of the next. Here we examine this continuing human dialogue, tracing a crooked line from ancient Babylonia to the present, accompanied along the way by such powerful thinkers as Aristotle, Aquinas, Newton, and Einstein. We will explore the physical world on all scales, from the fundamental constituents of matter to the origin, evolution, and fate of the universe. Though the focus will be on astronomy, related topics in classical physics, quantum mechanics, religion, music, art, and philosophy will not be avoided.

No prior background in astronomy or physics is assumed, and math will be limited to high school algebra and geometry. Students will directly confront the original writings of the philosophers, scientists, and theologians studied, and there will be frequent short writing assignments in addition to one longer paper. Class will meet twice a week, with one session held in the evening.

General Notes on the Course Reader

The course Reader consists of four parts. The first, *Primary Writings*, contains the original (sometimes translated) writings of many of the scientists/philosophers that we will study. By reading their original words, I hope you'll gain a better feel for the minds, personalities, and ideas of the people we'll be discussing. At the risk of lacking continuity (but with the desire for brevity), I have included only those selections that are crucial to the lines of thought we'll be following in this course. The second part of this Reader contains *Contemporary Writings* from a variety of sources, including popular books as well as texts. The third section contains copies of many of the *Class Overheads* that will be shown in class; this way, you don't have to scribble things down during class, but can instead *focus on what is being said*, and just annotate the notes. Finally, there is a small *Appendix*, containing some maps and star-charts for your nighttime viewing pleasure.

A note on notation: whenever you see a set of 3 dots (in the first part of the Reader)

this means that some of the original text has been skipped.

Course References

Recommended Books (On Reserve at the Library Center)

Kuhn, T. 1957, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought* (Harvard University Press: Cambridge).

A classic work on the history of science, with a very good account of the ancient celestial models that were replaced in the Renaissance. The first four chapters are especially relevant, and well worth reading.

Lindberg, D. 1992, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, 600 B.C. to A.D. 1450* (The University of Chicago Press: Chicago).

A unique work that will closely parallel the first part of this course. Though it looks dangerously like a dry textbook, don't be fooled: Lindberg writes with a broad perspective and a passionate vision. For a nice, coherent read, I highly recommend paging through this book.

Munitz, M. K. 1957, *Theories of the Universe: From Babylonian Myth to Modern Science* (Macmillan: New York).

Provides additional primary source material and commentary.

Toulmin, S. & Goodfield, J. 1961, *The Fabric of the Heavens: The Development of Astronomy and Dynamics* (Harper & Brothers: New York).

Exhaustive account, from the ancients through Newton, addressing implications for the modern era of the early thinkers. Unlike most works of its kind, this one allows the original thinkers to do much of the talking.

Wolf, F. 1989, *Taking the Quantum Leap: The New Physics for Non-Scientists* (Harper & Row: New York).

The story of how we struggled, resisted, and ultimately accepted the modern view of physical reality is beautifully told in this readable account of 20th century physics. This book is especially relevant in the last half of the course.

Morrison, D., Wolff, S., & Fraknoi, A. *Abell's Exploration of the Universe* (Saunders: Philadelphia). The 7th edition of the classic, comprehensive astronomy text by George Abell. Contains a thorough treatment of the history of astronomy in addition to the latest discoveries.

Ferris, T. 1988, *Coming of Age in the Milky Way* (Doubleday: New York).

A nice, easygoing work, the first two chapters on the Greeks being especially good. Though the later chapters delve a bit further into modern physics than we will, the first dozen chapters provide a good overview of topics up to the twentieth century.

Koestler, A. 1989, *The Sleepwalkers: A history of Man's Changing Vision of the Universe* (Penguin: New York).

A thorough, irreverent work, with especially good descriptions of Copernicus, Brahe, Kepler, Galileo, and Newton. Very amusing and filled with Koestler's opinions.

Course Syllabus

Week 1 (January 28): A Beginning

Topics covered – Introduction and overview.

Readings and Activities – Pick a Universe: Hesiod, Plato or Lucretius.

Week 2 (February 2 & 4): Inventing Nature's Language

Topics covered – The study of *ideas*. Prehistoric attitudes towards nature, and the Children of Woot; beginnings of science in Egypt and Mesopotamia; ancient Greece, and the development of writing -- the world of Homer, Hesiod, and the rise of philosophy; the Ionian School and the question of ultimate reality; the validity of the senses. The discovery of the invisible: Empedocles and the ‘‘water thief’’. A grain of sand and the 2-sphere cosmology.

Readings and Activities – Hesiod: Theogony. Lucretius: The Nature of the Universe. Empedocles: Love and Strife. Nighttime star-gazing (weather permitting): A special star.

Week 3 (February 9 & 11): A Question of Freedom

Topics covered – Lucretius, free-will, and determinism. Ionian philosophy in action: The Hippocratic writings. Harmony in music: An introduction to Pythagoras and the Pythagorean Brotherhood. Unity behind diversity -- numbers or atoms. Retrograde motion and the problem of the planets. The meaning of a conceptual scheme. The death of Socrates.

Readings and Activities – Socrates. Ferris: ‘‘The Dome of Heaven.’’

Week 4 (February 16 & 18): A Leap of Faith

Topics covered – A different perspective: Socrates, Plato. The beauty of a sphere. The power of pure thought. Euclid's axiomatic method. A Timid Monk solves the problem: Copernicus, and the last gasp of Plato.

Readings and Activities – Plato: The Simile of the Caves; Theory of Art. Euclid: Elements. Abell: Copernicus and the Heliocentric Hypothesis. Copernicus: On the Revolutions of the Heavenly Spheres.

Week 5 (February 23 & 25): Understanding Everything

Topics covered – Aristotle explains it all. Violent motion and an idealized cosmos. Tycho's island. Galileo's telescope.

Readings and Activities – Aristotle: Physics and On the Heavens. Tycho Brahe: A pictorial salute. Abell: Kepler, Copernicus, and Galileo. Telescopic viewing of sunspots.

Week 6 (March 1 & 3): *Having Eyes but Refusing to See*

Topics covered – The entrenchment of Aristotelian thought: Anasazi pictographs, and the invisible supernova of 1054. Galileo, falling bodies, and the death of Aristotle. The marriage of Kepler and Pythagoras, and the struggle to smash the sphere. Kepler's 3rd law. Once per civilization: Introduction to Isaac Newton and the physics of motion.

Readings and Activities – Kepler: The moment of his conception, and the Harmonies of the World. Newton: Certain Philosophical Questions. Wolf on Galileo and Newton. Hewitt: Motion and Inertia.

Week 7 (March 8 & 10): *Newton's New Language I – The End of Explanation*

Topics covered – The Newtonian synthesis and a glimpse into the world of genius: Newton's laws, gravity, the *Principia*, the secret life of an alchemist, the search for truth and his fundamental reality, theory of light, the immutable nature of time, theology and spiritualism. Momentum. Newton's version of Kepler's 3rd law.

Readings and Activities – Hewitt: Force and acceleration; universal gravitation.

Week 8 (March 15 – 19): *Spring Break*

Topics covered – Matter at rest.

Week 9 (March 22 & 24): *Newton's New Language II – The Nightmare*

Topics covered – Newton's legacy: The nightmare of determinism. Fuzzy patches hold the key -- The question of the nebulae: Island universes or solar systems forming?

Readings and Activities – Newton: Principia, Letters to Richard Bentley, and his alchemical notebooks. Laplace: On Probability. Wolf: The Nightmare of Determinism.

→First paper due by Wed., March 24.

Week 10 (March 29 & 31): *Light: It's All We Have*

Topics covered – How does energy get from here to there? The union of physics and astronomy, and the study of particles and waves. It sure looks like a wave: Young's experiment and Maxwell's discovery. The science of spectroscopy -- Kirchoff's Laws and the fingerprints of the elements. The Doppler effect and discovering black holes.

Readings and Activities – Hewitt: Vibrations and Waves; Diffraction and Interference. Gibbon: Light. Ferris: Island Universes.

Week 11 (April 5) [note: no Wed. class]: *Finding Our Place in the Universe*

Topics covered – The controversy rages, and the mystery is solved. Hubble discovers a law; the expanding universe; looking back to the Big Bang, shadows of creation; the unity of physics and cosmology. The fate of the universe.

Readings and Activities – Hubble: The Realm of the Nebulae. Abell: The Big Bang. Lab: The Expansion of the Universe.

Week 12 (April 12 & 14) : *Smashing Certainty*

Topics covered – Electromagnetic waves. Einstein draws a picture: The photon is born. A new look at Young's double-slit experiment. Einstein's "biggest blunder": The Cosmological Constant. An invisible universe: Dark matter. Inside the atom.

Readings and Activities – Gribbon: The Atom. Wolf: The End of the Mechanical Age. Pasachoff & Filippenko: The Dark Side of Matter.

Week 13 (April 19 & 21): *Inventing a New Language*

Topics covered – Bohr takes a quantum leap; a Prince imagines a wave; the end of pictures: Schrodinger's unimaginable world; God's dice and uncertainty; Einstein's hidden orders.

Readings and Activities – Feynman: Quantum Behavior. Wolf: The End of Mechanical Models; Einstein and Bohr. Griffiths: The Wave Function.

Week 14 (April 26 & 28): *A Paradoxical World*

Topics covered – Einstein's challenge -- The EPR paradox and Bell's stunning discovery.

Readings and Activities – Griffiths: What is a measurement? Harrison: The Stern-Gerlach Experiment, Electron Spin, and Correlation Experiments. Felder: Spooky Action at a Distance.

Week 15 (May 3 & 5): *An Ending*

Topics covered – Supernovae and dark energy; Sisyphean nightmares and happiness.

Readings and Activities – Albert Camus: The Myth of Sisyphus.

Week 16 (May 10 – 14) [exam week]: *The Last Word*

→Final student presentations. Final project due by Fri., May 14.