

**The Nature of Scientific Inquiry and
Evolutionary Science**

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Tonight

"Only a Theory? Evolution and the Battle for America's Soul"

Dr. Kenneth R. Miller,
Professor of Biology and Royce Family Professor for Teaching
Excellence, Brown University

When: Thursday, January 8, 2009
7:00 PM - 8:30 PM

Where: Technological Institute,
Ryan Family Auditorium
2145 Sheridan Rd.

Contact: One Book Staff 847-467-1894
<onebook@northwestern.edu>

Reading:

■ Primary Text:
Appleman, P. 2001. Darwin. A Norton Critical
Edition. 3rd Edition. W.W. Norton & Co. Inc.
New York. 695 pp.

- For next week:
 - Part I. Introduction- pages 1-20
 - Part II. Who was Darwin, pages 21-29
 - Part III. Scientific Thought: Just Before Darwin. PP 33-64
 - Part IV. Darwin and Natural Selection. PP 67-174.

Does Peanut Butter Disprove Evolution?

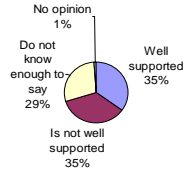
- <http://www.youtube.com/watch?v=FZFG5PKw504&feature=related>



Gallup News Service, November 2004

"Do you think that Charles Darwin's theory of evolution is a scientific theory that has been well-supported by evidence, just one of many theories and one that has not been well-supported by evidence, or don't you know enough about it to say?"

Gallup News Service, Nov. 2004



The New York Times

June 18, 2005
Eighty Years After Scopes, a Professor Reflects on Unabated Opposition to Evolutionists
By **PETER STEINFELS**

August 3, 2005
Bush Remarks Roil Debate on Teaching of Evolution
By **ELISABETH BUMILLER**

August 20, 2005
Frist Urges 2 Teachings on Life Origin
By **DAVID STOUT**

August 21, 2005 Politicized Scholars Put Evolution on the Defensive
By **JODI WILGOREN**

August 22, 2005
In Explaining Life's Complexity, Darwinists and Doubters Clash
By **KENNETH CHANG**

August 23, 2005
Scientists Speak Up on Mix of God and Science
By **CORNELIA DEAN**

Tell the story of science

- Beware of false controversy
- Be honest about uncertainty
- Encourage people to think

Philosophy

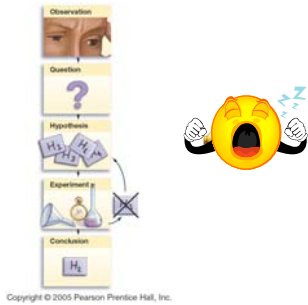
- Epistemology
 - The study of the nature of knowledge
 - There are different types of knowledge
 - There are many ways of gaining knowledge
 - E.g.
 - Empiricism -all human knowledge comes from first hand experience
 - Rationalism - discovery of truth by reason and analysis of facts
 - Mysticism - discovery of truth through personal communion with the divine

Epistemology and Knowledge Systems

(definitions from <http://en.wikipedia.org/>)

- **Philosophy**
 - involves the investigation, analysis, and development of ideas at a general, abstract, or fundamental level
- **Religion**
 - Faith or belief system- is commonly defined as belief concerning the supernatural, sacred, or divine; and the moral codes, practices, values, institutions and rituals associated with such belief
- **Science**
 - is most commonly defined as the investigation or study of nature through observation and reasoning.

"The Scientific Method"



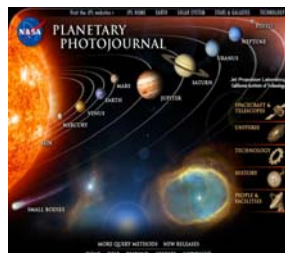
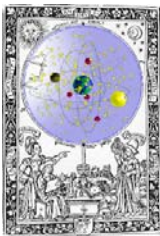


A brief History of Western Science

(Francis Bacon 1561-1626, Empiricist)

- Scientific Revolution (@1500-1700)
- Age of Enlightenment (1700-early 1800's)
- Outcomes:
 - The use of rationality to explain the workings of the physical world
 - All phenomena in the physical world can be explained by a set of natural laws
 - The use of experiments and measurements to test ideas about the laws.
 - "materialism"

Astronomy



<http://library.thinkquest.org/18188/english/explore/famous/ptolemae.htm>

Geology

2006 Sep 20 21:24 UTC
<http://www.fourmilob.ch/cgi-bin/Earth/action?opt=plang%NOA&topo.evif>

Chemistry

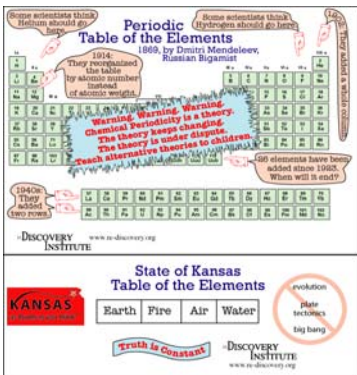
<http://www.webwinds.com/myth/elemental.htm> <http://www.chemicalelements.com/>

Science is a "Way of Knowing"

- Philosophically
 - Empirical
 - Rational
- Methodologically
 - Materialistic
 - Based on evidence
- Science is a process as well as a body of knowledge

Characteristics of Science

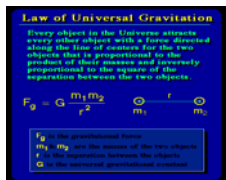
1. Repeatable
2. Parsimonious
 - > Economy and elegance of logic
3. Measurable
 - > Objective measurement
 - > Universally accepted scales
4. Falsifiable
 - > It must be possible to state conditions under which an hypothesis would fail.
5. Heuristic
 - > stimulates further inquiry
6. Conciliatory
 - > in the end all things fit together
7. Pragmatic
 - > It solves problems



http://www.wordsoup.com/blog/2007/05/kansas_periodic_table.html

Facts, Hypotheses, and Theories

- **Fact-**
 - A statement of an event or condition where the statement can be proven and shown to be correct
 - A logical "claim"
- **Hypothesis-**
 - Tentative, testable explanation for an observed phenomenon
- **Theory -**
 - A statement explaining the relationships among facts and from which we can draw conclusions.
 - Describes the relationships between cause and effect
 - Has withstood rigorous testing.



Conceptual Structure of Scientific Theories

1. **Central Principle**
 - The "Big Idea"
 - Explanatory Narrative
2. **Pattern or Result**
 - How are different observations related to each other?
3. **Process**
 - What mechanism(s) cause(s) the pattern to appear?

Example: Theory of Evolution

1. **Central Principle**
 - Descent with modification from a common ancestor
2. **Pattern or Result**
 - Historical record of living organisms can be represented as a branching tree
3. **Mechanism or Process**
 - Adaptive processes
 - Natural selection
 - Sexual selection
 - Non-adaptive processes
 - Genetic drift
 - Mutation

Does the Theory of Evolution conform the first principles of science?

- | | |
|---|--|
| Central Principle <ul style="list-style-type: none">□ Descent with modification from a common ancestor | ■ Does not invoke the supernatural - Yes |
| Pattern or Result <ul style="list-style-type: none">□ Historical record of living organisms can be represented as a branching tree | ■ Falsifiable - Yes |
| Mechanism or Process <ul style="list-style-type: none">□ Adaptive processes<ul style="list-style-type: none">■ Natural selection■ Sexual selection□ Non-adaptive processes<ul style="list-style-type: none">■ Genetic drift■ Mutation | ■ Repeatable - Yes |
| | ■ Parsimonious - Yes |
| | ■ Mensurable - Yes |
| | ■ Heuristic - Yes |
| | ■ Conciliatory - Yes |

Evidence for Evolution

- 1) The fossil record
- 2) Similarities of modern organisms
 - anatomy (morphology)
 - embryonic development
 - molecular structure (DNA and proteins)
- 3) Artificial selection
 - agriculture, pets, etc.
- 4) Geographic trends
- 5) Direct observation of adaptations in natural populations
 - drug resistance
 - Pesticide resistance

Components of Intelligent Design

- Philosophy
 - Ability to detect elements of design in nature
 - Irreducible complexity
 - Because all pieces have to be together you cannot built it by natural selection
 - Leading proponents are engineers, not biologists
- Cultural Renewal
 - Heart of ID position
 - Return to a proper theism
 - Turn away from secularism
 - Science is a "materialistic" way of knowing
 - Contend it promotes a philosophical as well as methodological materialism

Intelligent Design

- | Central Principle | Does it Conform to the First Principles of Science? |
|---|---|
| <ul style="list-style-type: none">□ Life is so complex it could not exist as a result of natural processes; therefore, there is an Intelligent Designer. | <ul style="list-style-type: none">■ It invokes the supernatural. - No■ Falsifiable - Yes.<ul style="list-style-type: none">□ Is regularly falsified.■ Repeatable - No.<ul style="list-style-type: none">□ No repeatable experiments have been conducted. |
| <ul style="list-style-type: none">■ Pattern or Result<ol style="list-style-type: none">1. Irreducible complexity2. Things are so improbable they could not have happened according to natural laws | <ul style="list-style-type: none">■ Parsimonious - No.<ul style="list-style-type: none">□ Invokes additional factors to explain observations that can be explained by reference only to natural laws of chemistry and physics.■ Mensurable<ol style="list-style-type: none">1. Complexity<ul style="list-style-type: none">■ No. No objective scale for complexity.2. Probability<ul style="list-style-type: none">■ Yes-but, the probability arguments are incorrect and falsify the hypothesis. |
| <ul style="list-style-type: none">■ Mechanism or Process<ul style="list-style-type: none">□ Divine creation□ Possible modification by microevolution | <ul style="list-style-type: none">■ Heuristic<ul style="list-style-type: none">□ No. Antithesis of inquiry.□ Denies that we can understand things.■ Conciliatory<ul style="list-style-type: none">□ No. It imposes blocks between levels of understanding.□ Insists that people cannot understand nature. |

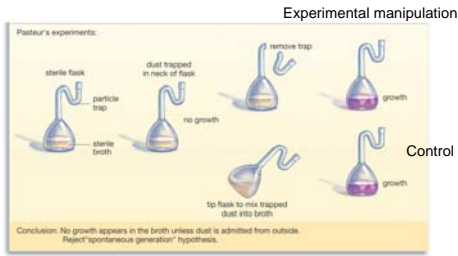
How do you test a hypothesis?

- What is a hypothesis?
 - Tentative, testable explanation for an observed phenomenon
 - Empirical hypotheses - "The classic"
 - Historical or comparative hypothesis
 - Models as hypotheses
 - Statistical hypotheses

*Giere, Bickle, and Mauldin. 2006. Understanding Scientific Reasoning. Thomson/Wadsworth. Belmont, CA. 320 pp.

Testing an "Empirical" Hypothesis

Experimental Tests

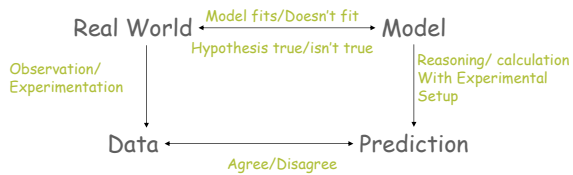


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*Giere, Bickle, and Mauldin. 2006. Understanding Scientific Reasoning. Thomson/Wadsworth. Belmont, CA. 320 pp.

Hypotheses based on Models ("Theoretical Hypotheses"

e.g., global climate change)

- A statement about the relationship between a model and some aspect of the world.

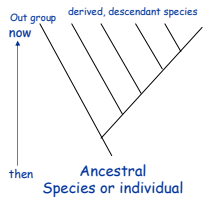


*Giere, Bickle, and Mauldin. 2006. Understanding Scientific Reasoning. Thomson/Wadsworth. Belmont, CA. 320 pp.

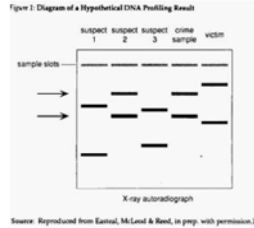
Evolutionary Science Uses Empirical Methods to Test Hypotheses

The Comparative Method

Phylogeny

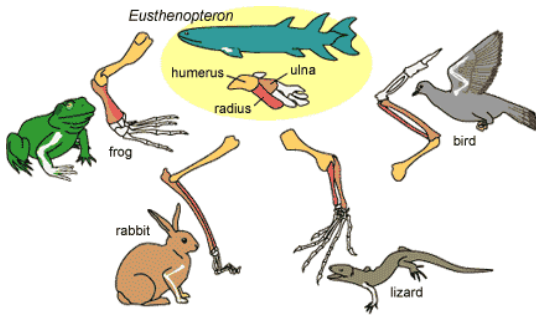


Forensics, Biodiversity, Disease tracking



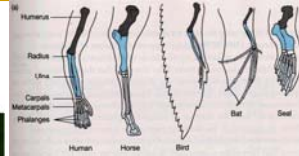
*Giere, Bickle, and Mauldin. 2006. Understanding Scientific Reasoning. Thomson/Wadsworth. Belmont, CA. 320 pp.

Homology



Homologous Structures

(b) Carib martinique pollinating a flower



(c) Lesser long-nosed bat pollinating a cactus



Analogous Characters



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(c) Lesser long-nosed bat pollinating a cactus



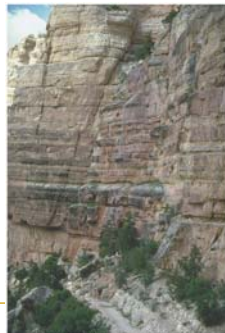
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 - anatomy (morphology)
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 - agriculture, pets, etc.
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Geological Record

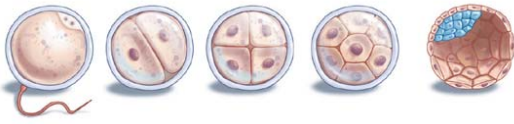
- **Stratigraphy**
 - Principle of superposition
- **Isotopic ratios**
 - Carbon 13/12 (stable isotopes)
- **Radiometric Dating**
 - Long term dating
 - E.g. Uranium
 - @ 3 billion years
 - Short term dating
 - E.g. Carbon
 - @ 5,000 yrs

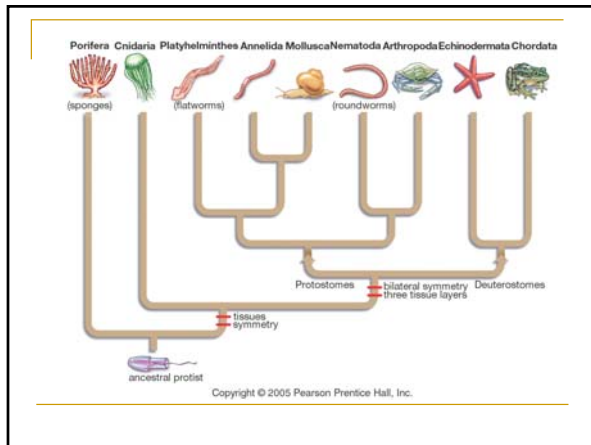


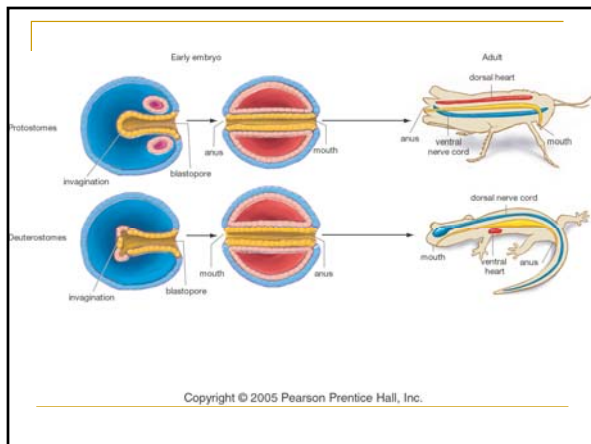
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Blastocyst:

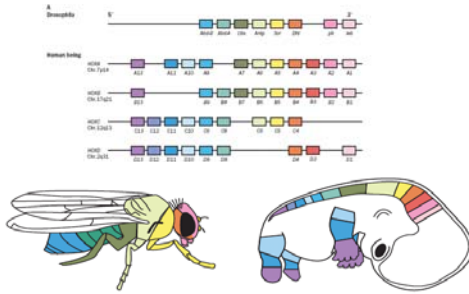
Universal character of animals







Hox (homeobox) Genes and Body Axis



Lancet. 2003 Aug 23;362(9384):651-62.

Suggested Reading:

- Appleman, P. 2001. Darwin. A Norton Critical Edition. 3rd Edition. W.W. Norton & Co. Inc. New York. 695 pp.
- Bryson, B. 2003. A Short History of Nearly Everything. Broadway Books. New York 544 pp.
- Lindberg, D.C. 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. 455 pp.
- Quammen, D. 2006. *The Reluctant Mr. Darwin. An Intimate Portrait of Charles Darwin and the Making of His Theory of Evolution*. W.W. Norton & Co. New York.
- The National Center for Science Education <http://ncseweb.org>. Their website provides extensive information on the history of the Creationist and Intelligent Design movements in the United States.
- The University of California Evolution Wing Website <http://www.ucmp.berkeley.edu/history/evolution.html>. This website provides extensive tutorials and information on all aspects of evolution.
- One Book One Northwestern Website. The links page contains links to educational websites and many other websites that may be of interest to students in this class, including the complete works of Charles Darwin. <http://www.northwestern.edu/onebook/links.html>

Ken Miller on Colbert Report

http://www.brown.edu/Courses/BI0020_Miller/talks/colbert-miller.mov
