

July 2010 Induction Seminar 1

## Induction in Science

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**Conceptual Literacy Project**

*Summer Seminar*

*Chicago Illinois RIF July 24, 2010*  
*www.StatLit.org/pdf/2010Schield1Seminar6up.pdf*

July 2010 Induction Seminar 2

## Induction versus Deduction

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*Philosophy: Induction and deduction are two distinct methods of reasoning:*

- *Deduction: From general to particular*  
*All swans are white, thus my swan is white.*
  
- *Induction: From particular to general, from observed to unobserved, from present to future.*  
*All swans I've seen are white.*  
*So, all swans are white*

July 2010 Induction Seminar 3

## Inductions in Deductive Reasoning

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All valid deductions involve a generalization – a universal – as a premise.

AI-A Valid: *All men are mortal*; Socrates is a man. Thus, Socrates is mortal.

OI-I Valid: *No men are immortal*; Socrates is a man. Thus Socrates is not immortal.

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II-I Invalid: Some men are tall; some tall things have four legs. So, some men have four legs.

July 2010 Induction Seminar 4

## Deduction may be Valid but Unsound

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1. *All men are immortal.*
2. Socrates is a man.
3. Thus, Socrates is immortal.

The universal is false so the argument is unsound.

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1. *All men are mortal*
2. Socrates is a man
3. Socrates is [will be, must be] mortal

Q. How can we tell if a universal is true?

July 2010 Induction Seminar 5

## Induction versus Deduction

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If a deduction is valid then the truth of the premises guarantees (is sufficient for) the truth of the conclusion.

In cases of inductive reasoning, it is *possible* for the conclusion to be false even though the premises are true [because the premises are not universals].

July 2010 Induction Seminar 6

## Problem of Induction Wikipedia

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the philosophical question of whether inductive reasoning leads to knowledge. That is, **what is the justification** for either:

- **generalizing** about the properties of a class of objects based on some number of observations of particular instances of that class? [All swans are white]
- **presupposing** that a sequence of events in the future will occur as it always has in the past? For example, for presupposing that the laws of physics will hold as they have always been observed to hold. Hume called this the Principle of Uniformity of Nature.

July 2010 Induction Seminar 7

**Critiques of Induction:**

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Pyrrhonian skeptic Sextus Empiricus first questioned the validity of inductive reasoning.

David Hume: *In general, it is not necessary that causal relation in the future resemble causal relations in the past, as it is always conceivable otherwise.*

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“Hume was actually advocating a practical skepticism based on common sense, wherein the inevitability of induction is accepted. Someone who insists on reason for certainty might, for instance, starve to death, as they would not infer the benefits of food based on previous observations of nutrition.” Wikipedia

July 2010 Induction Seminar 8

**Induction:  
Modern Philosophy**

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**Is-ought dilemma (the fact-value dilemma):**  
Arguing that something is good based on related observable facts.

**The naturalistic fallacy:** Arguing that something is good based on related natural properties.

Problem of Induction in Ethics:  
No amount of factual particulars are sufficient to guarantee the truth of an evaluative universal.

July 2010 Induction Seminar 9

**3. Induction:  
Success in Physics**

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Success in Astronomy: The Big Four

1. Tycho Brahe,
2. Johannes Kepler
3. Galileo
4. Isaac Newton.

Let's review their achievements.

July 2010 Induction Seminar 10

**Induction in Science:  
1. Tycho Brahe (Denmark)**

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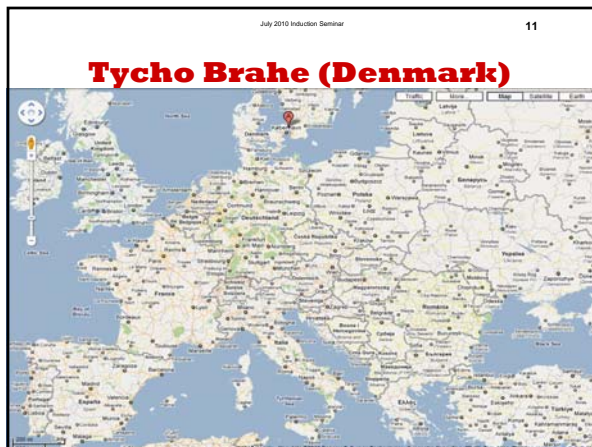
Aristotle:

1. Heavens are immutable.
2. Earth is center of the heavens

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Tycho Brahe (*Nova Man*): 1573

1. Star appears; heavens change
2. **All** planets revolve around sun
3. Moon and sun revolve around earth



July 2010 Induction Seminar 15

**Tycho Brahe  
Stjerneborg: Castle of the Stars**

Underground observatory:

Measurement accuracy:  
10 - 30 sec

1 part in  
700 - 2,100

July 2010 Induction Seminar

**Induction in Science  
2. Johannes Kepler**

Aristotle:

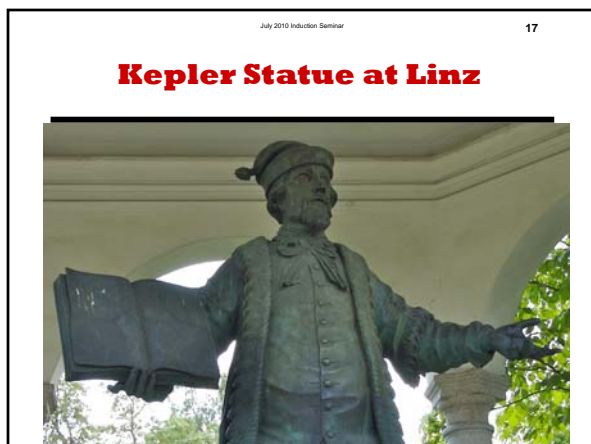
1. Heavenly bodies move in circles
2. Earth is the center of the heavens

Ptolemy:

1. Some circular orbits have epicycles.

Kepler:

1. *All* orbiting bodies have elliptical orbits.
2. Earth revolves around the sun







July 2010 Induction Seminar 21

### Induction in Science

#### 3. Galileo Galilei

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Aristotle:

1. Heavier bodies fall faster
2. Natural state of things is rest

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Galileo:

1. **Every** body's fall is independent of weight
2. **All** bodies in motion stay in motion
3. **Every** pendulum's period is independent of angle and varies with the square of the length



July 2010 Induction Seminar 23

### Galileo Florence

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Galileo Museum  
Newly opened

Downtown Florence

July 2010 Induction Seminar 24

### Galileo Describing Falling Motion

July 2010 Induction Seminar 25

### Galileo Comparing Falling Motions

July 2010 Induction Seminar 26

### Galileo's Telescope A small piece of glass ...

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### Correcting Jupiter moon data with analog Parallax Computer

July 2010 Induction Seminar 28

### Induction in Science: 4. Isaac Newton

Isaac Newton was born in 1642 in Lincolnshire, England. His genius soon became obvious and an uncle declared it would be wrong 'to bury so extraordinary a talent in rustic business'. In 1661 Isaac Newton left Lincolnshire to continue his studies at Cambridge. However, in 1665 and 1666 he was forced to return to Woolsthorpe to escape the plague.

It was at Woolsthorpe Manor that Isaac Newton formulated three great discoveries - **the principle of differential calculus, the composition of white light and the law of gravitation.**

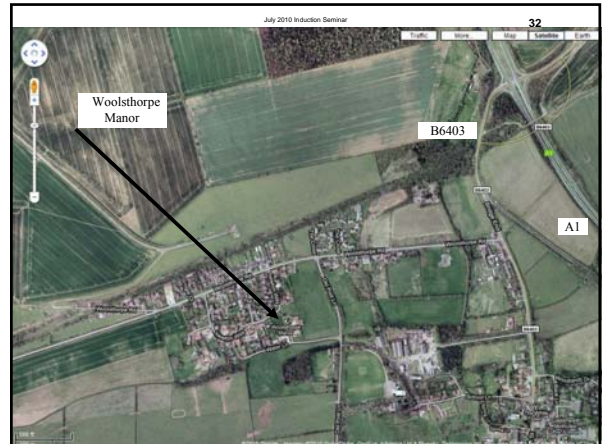
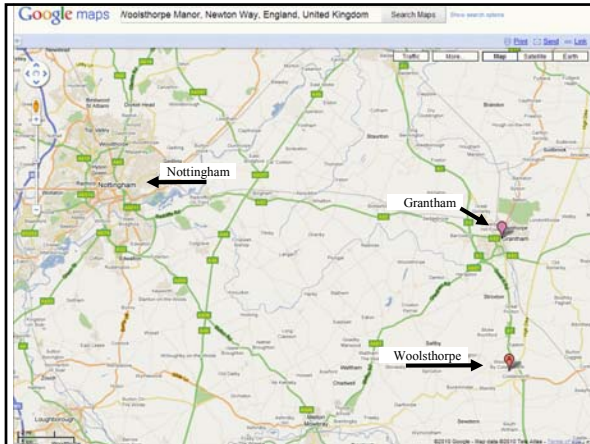
He later observed, *'In the two plague years I was in the prime of my age for invention and minded mathematics and philosophy more than at any time since'.*



July 2010 Induction Seminar 30

### Isaac Newton: Lived near Nottingham in Lincolnshire





July 2010 Induction Seminar 33

**Isaac Newton  
Law of Gravity**

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Thesis: Force of gravity  $\sim m / R^2$   
 Proof (for circular orbits):

1. Kepler's Third Law:  $R^3 \sim T^2$
2. Circular acceleration:  $F = m \cdot a = m (v^2/R)$

A.  $v = \text{Circumference} / \text{period} = 2 \Pi R / T$   
 B.  $F_{\text{gravity}} = m [2 \Pi R / T]^2 / R = m R [2 \Pi / T]^2$   
 C.  $F_{\text{gravity}} \sim m R [2 \Pi]^2 / R^3$   
 D.  $F_{\text{gravity}} \sim m / R^2$                       QED

July 2010 Induction Seminar 34

**Induction in Science:  
Birth of the Social Sciences**

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Economics, psychology, sociology, etc.

- Differences in subject matter
- Empirically-based (scientific)
- Similar in their use of statistics (statistical inference) to validate generalizations

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Advantage: "Scientific"

Problems:

- Limited scope: Unable to make relevant statements about the human condition

July 2010 Induction Seminar 35

**Philosophy of Science:  
20<sup>th</sup> Century Conclusion**

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Very weak evidence in support of induction.  
 Definitions are man-made (socially constructed).  
 Definitions are arbitrary.  
 Posited "laws" that fit the data. (curve fitting)

Scientists no longer speak of "laws"  
 Einstein's theory of relativity is not a law  
 Darwin's theory of evolution is not a law.

July 2010 Induction Seminar 36

**Web references**

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**Tycho Brahe Museum on Swen/Ven** [Tycho Brahe museet, Hven, Landsvågen, Landskrona, Sweden]:  
[http://www.sfv.se/cms/sfv/english/holiday/The\\_Tycho\\_Brahe\\_Museum\\_on\\_Ven.pdf](http://www.sfv.se/cms/sfv/english/holiday/The_Tycho_Brahe_Museum_on_Ven.pdf)  
<http://www.tychobrahe.com/UK/index.html>

**Kepler Museum in Prague:**  
<http://www.keplerovomuzeum.cz/en/>

**Galileo Museum in Florence:**  
<http://www.museogalileo.it/en/visit.html>

**Galileo Project:** <http://galileo.rice.edu/>