



J. Kaufmann III

Universe

9th Edition

CHAPTER 4

Gravitation & the SCIENTIFIC METHOD

SOCIETY OF PHYSICS STUDENTS
STUDENTS FOR THE EXPLORATION &
DEVELOPMENT OF SPACE

SPS/SEDS Events

**1st Meeting of the spring semester:
Wednesday, Jan 16th 7:00pm
Skurla 102**

EVERYONE WELCOME!

**For more information feel free to contact:
jrobertson2009@my.fit.edu**

or

jhavu2009@my.fit.edu

New Student Astronomical Society T-shirts!
Contact Alissa Oppenheimer
aoppenheimer2010@my.fit.edu





A dark, star-filled background representing space, filled with numerous galaxies of various sizes and colors, including blue, yellow, and white.

Why People Believe Weird (Astronomical) Things

WEEKLY WORLD

NEWS®

October 26, 1999

\$1.49 U.S.

\$1.99 CANADA

Why some women fall in love
with nerds and geeks!

GIANT ASTEROID THREATENS EARTH!

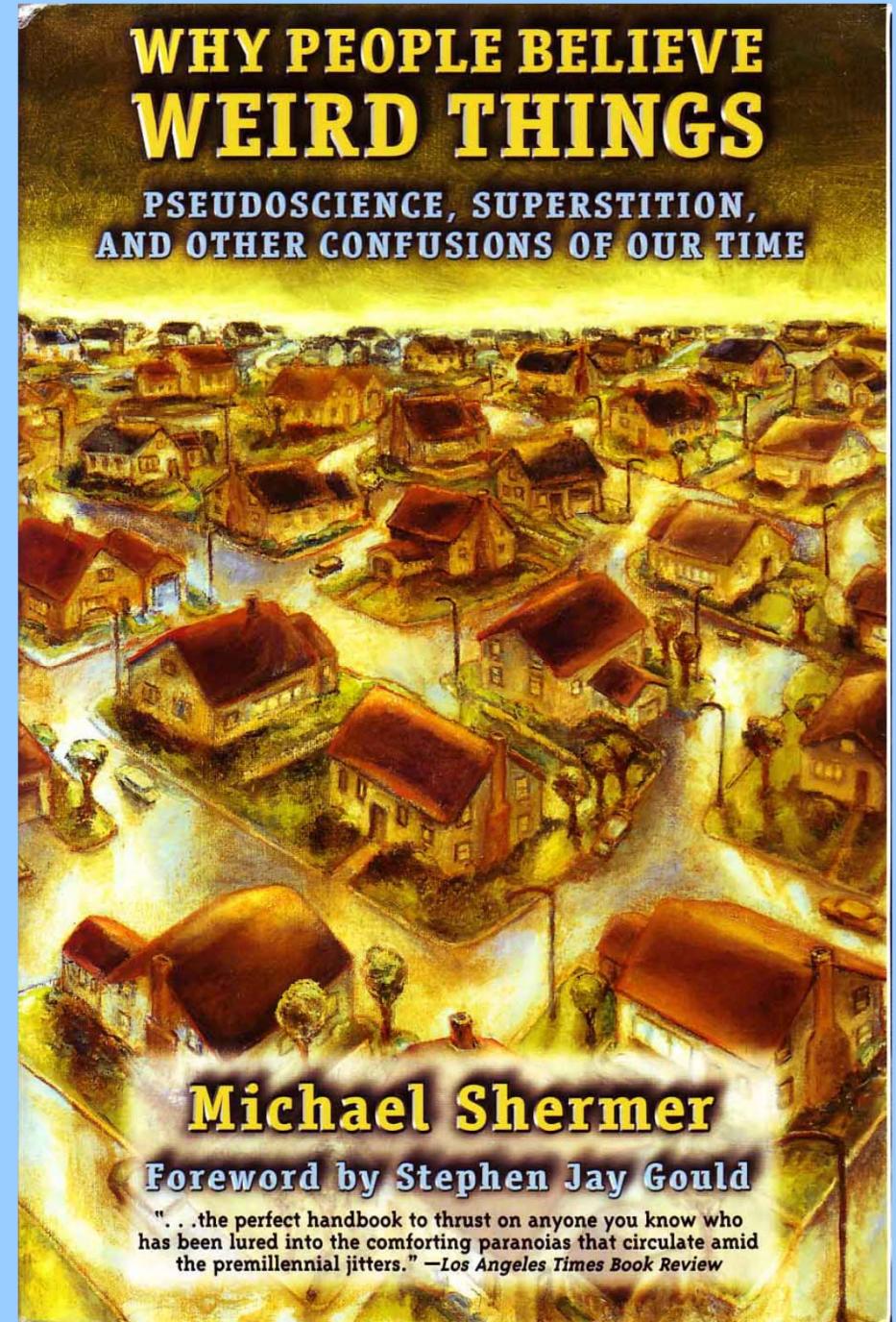
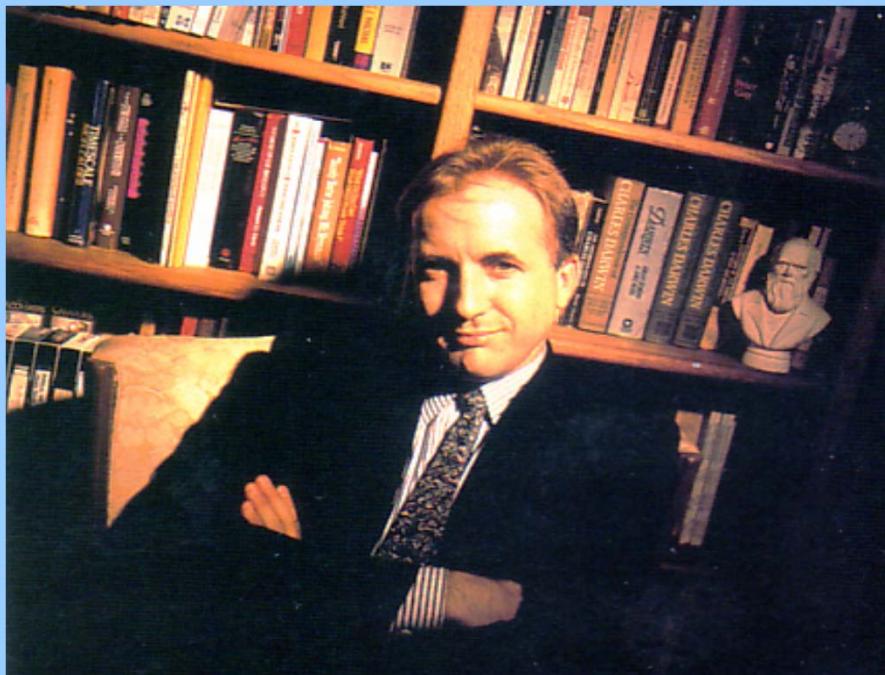
What men
hate MOST
about their
wives!

REAL-LIFE BATMAN!

MEET . . .



Michael Shermer



The Importance of Critical Thinking

Which vehicle is safer to drive?

Toyota Avalon



Jeep Cherokee

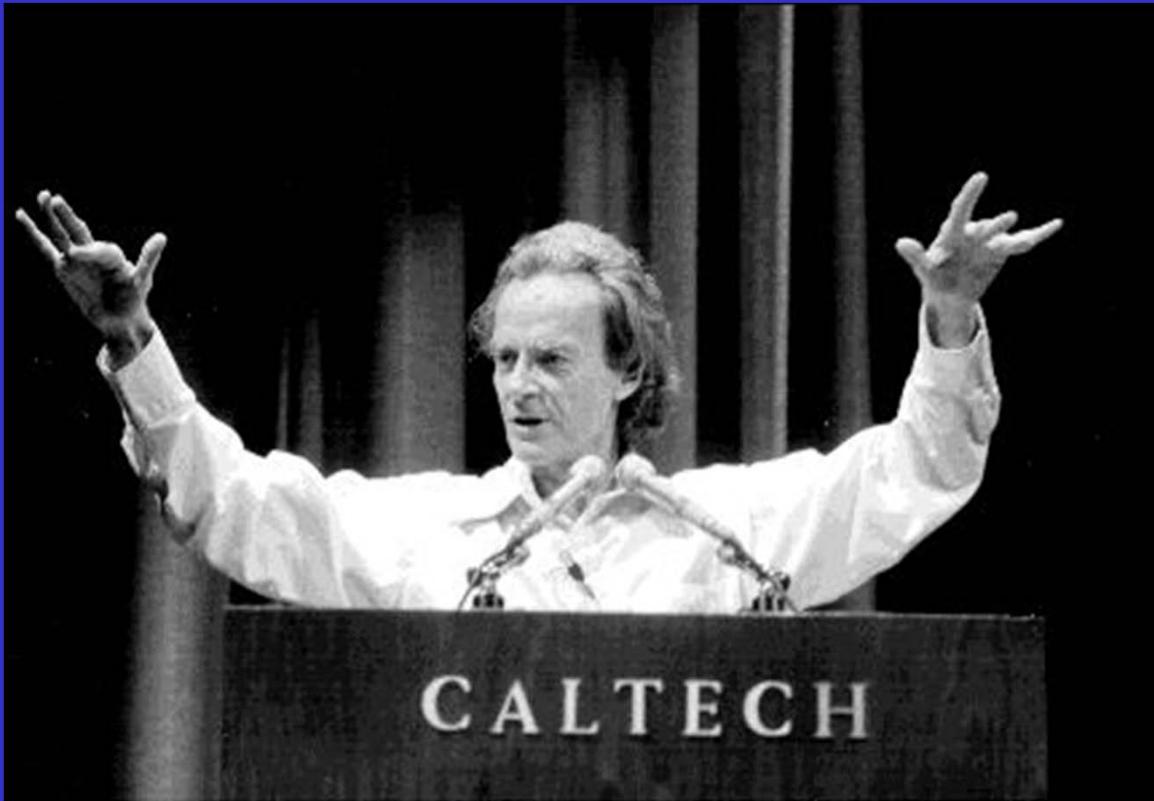


Ford F-series pickup



“Science is a way of trying not to fool yourself.”

--Richard Feynman



***“We do not claim that the portrait we are making is the whole truth,
Only that it is a resemblance.”***

--Victor Hugo 1739

“Don’t have such an open mind your brain falls out.”

Origins of the Scientific Method: Occam's Razor

“Pluralitas non est ponenda sine necessitate”

“Plurality should not be posited without necessity.”

William of Occam (Ockham, England)
Franciscan friar & philosopher, 1288-1348



Occam's original razor, from the Ideal Equipment Company museum.

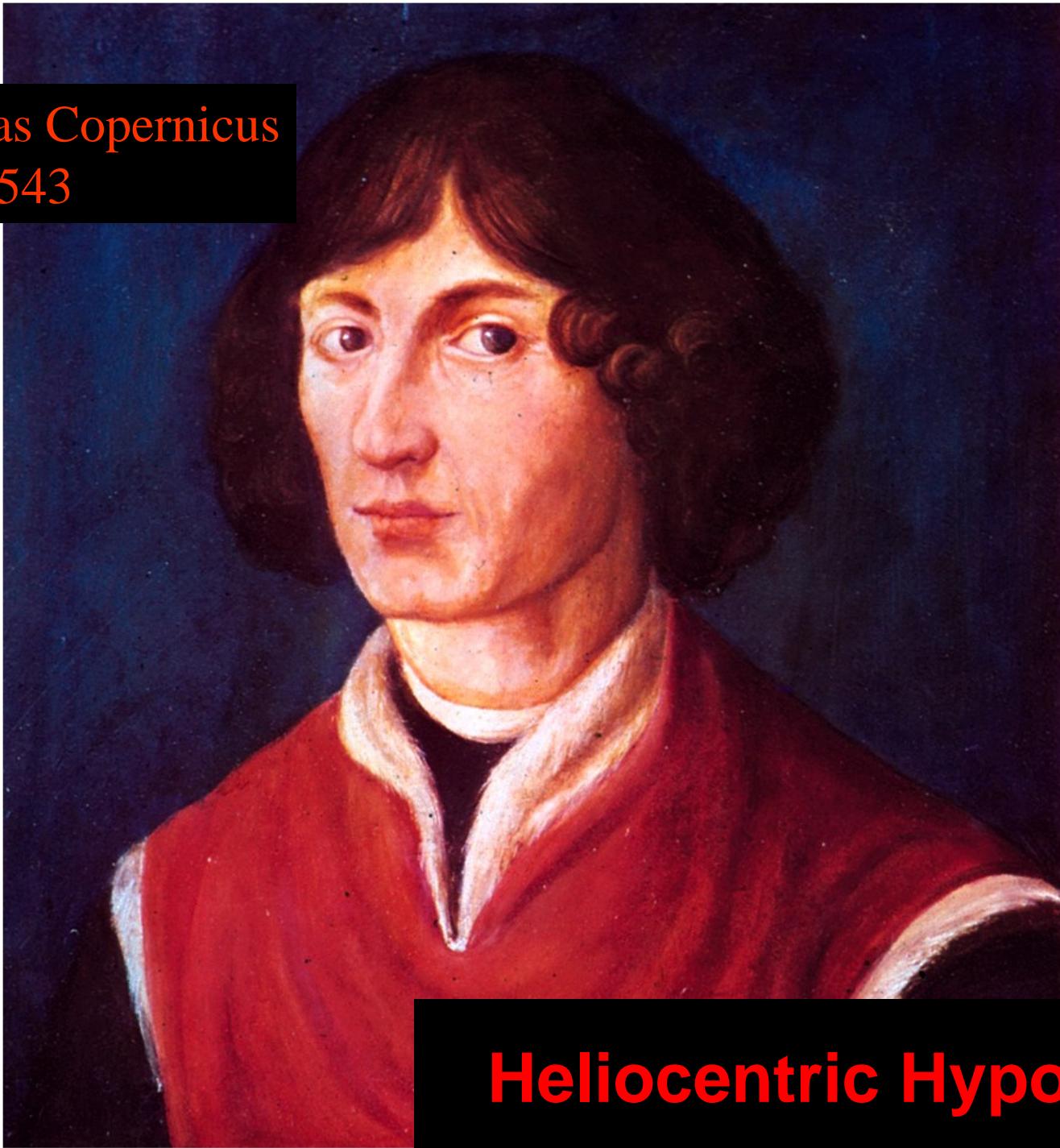
Occam's razor

The basic model introduced by Occam has been greatly improved by the Swiss craftsmen in our Hong Kong manufacturing facility. Blades of finest Swedish surgical steel (imported from Japan). Perfect for slicing through obfuscation, severing red tape, and cutting up a colleague's pet theory.

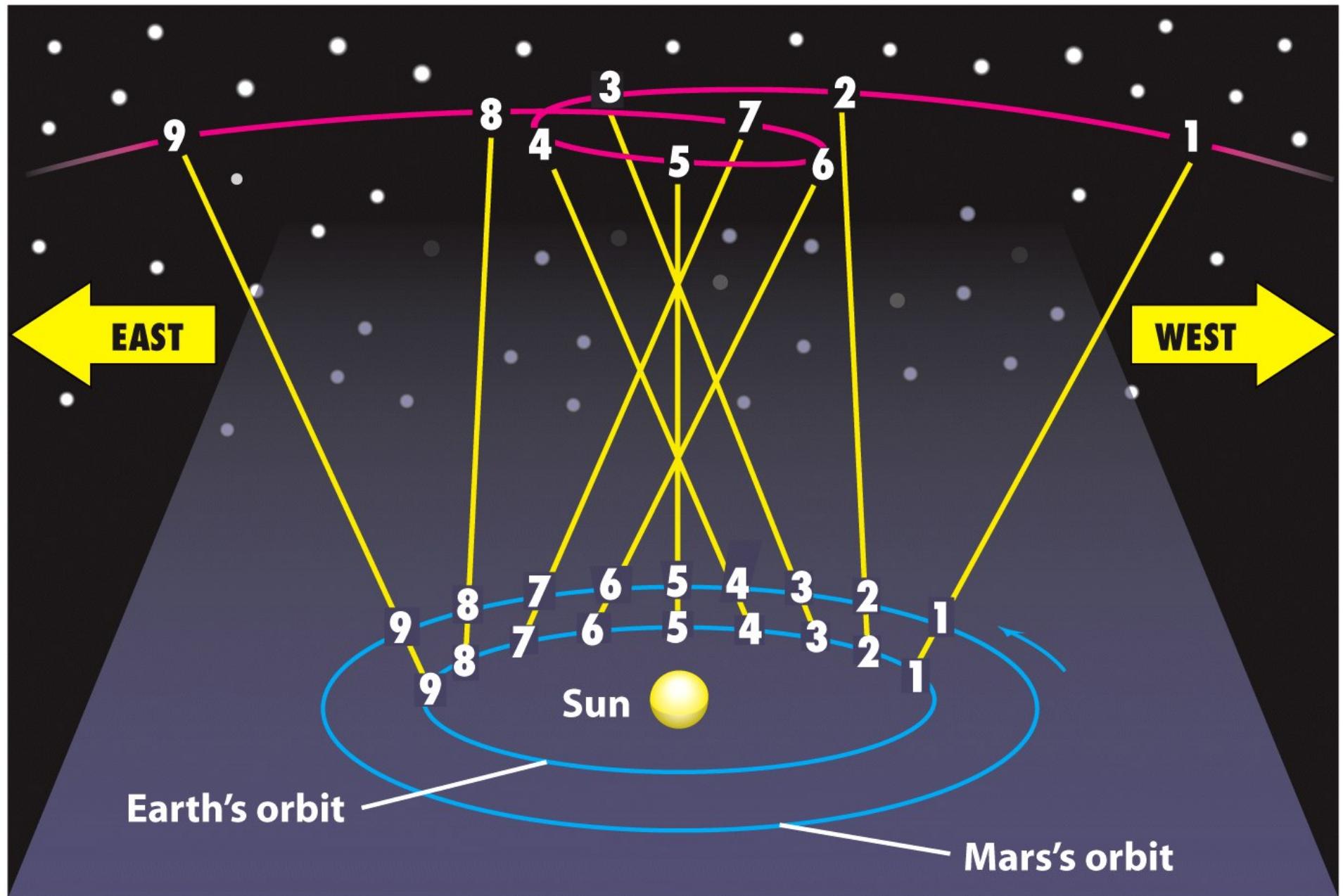
\$75.00 ea. Extra blades \$5/doz.

Occam's razor has many uses.

Nicholas Copernicus
1473-1543

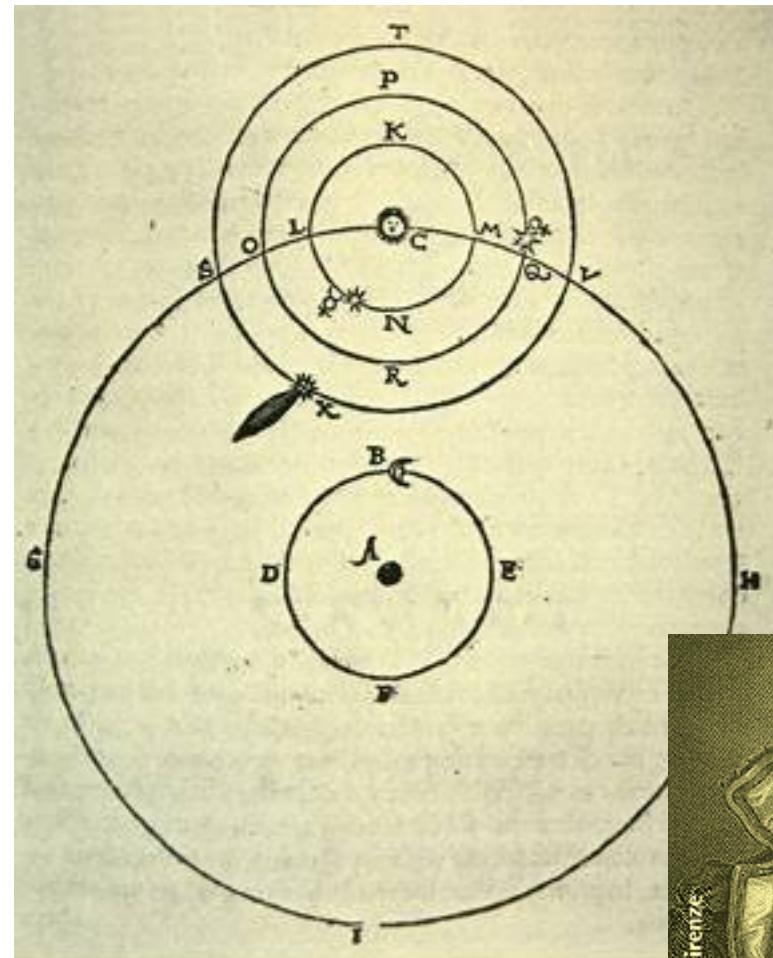
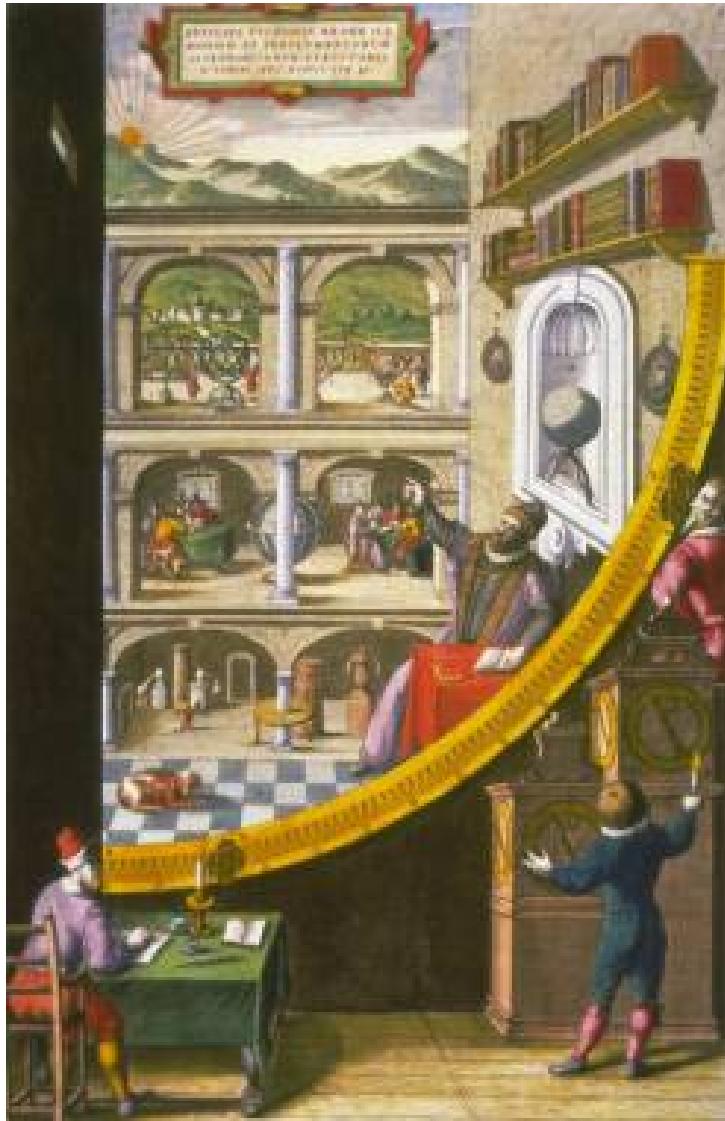


Heliocentric Hypothesis



How Copernicus explained retrograde motion

Tycho Brahe: Observation



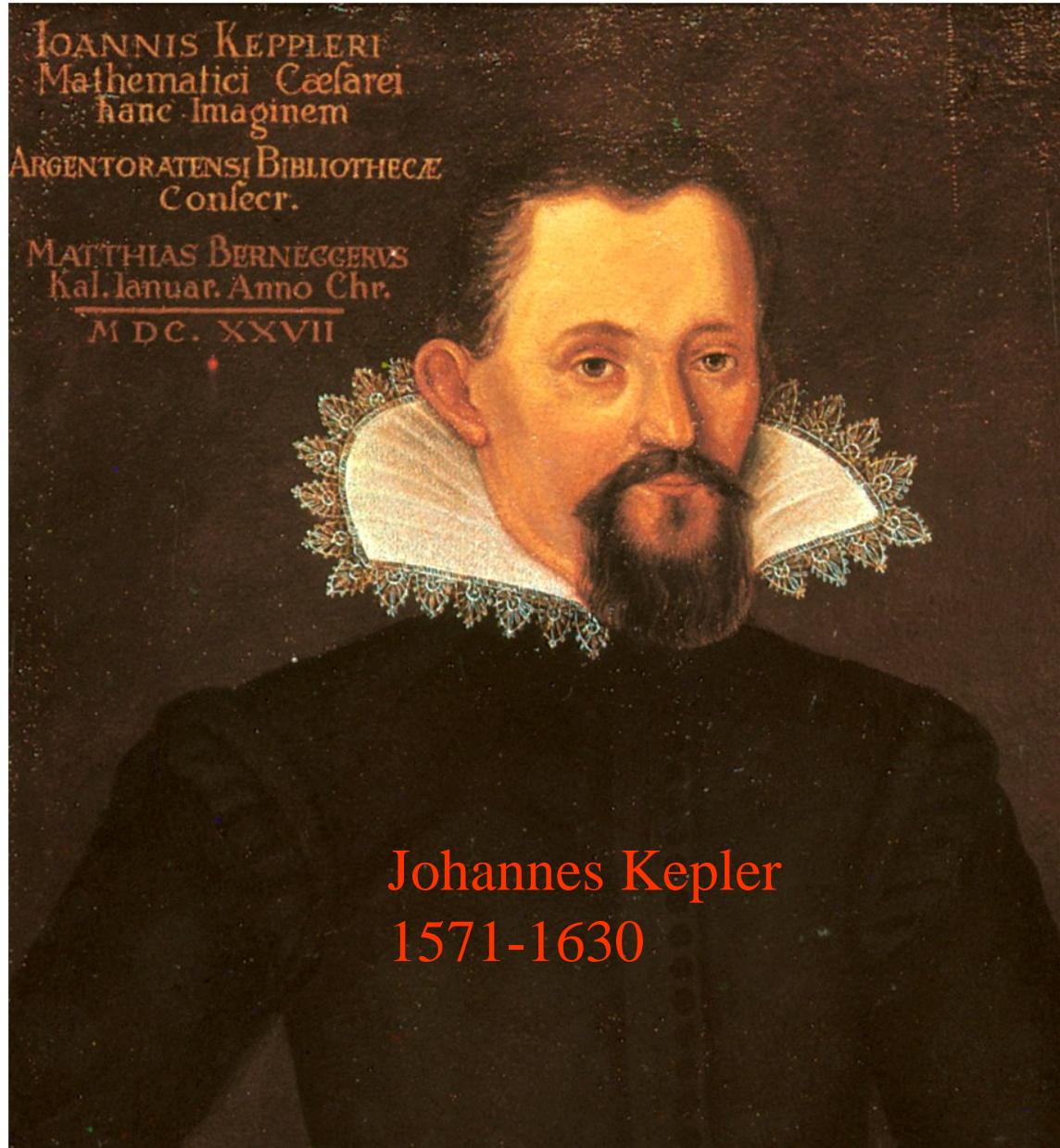
Tycho Brahe
1546-1601



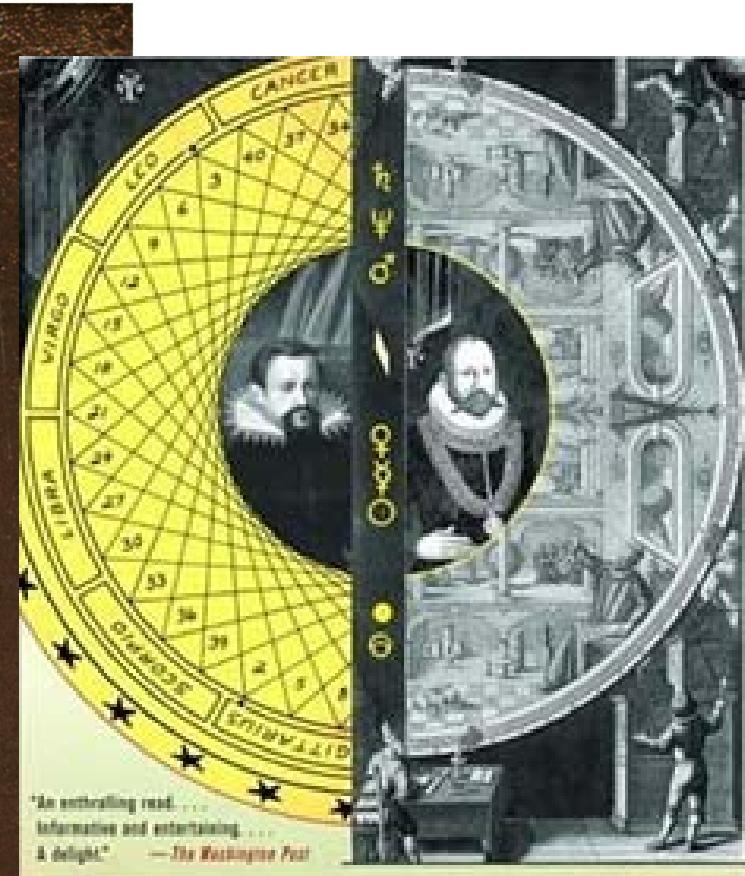
©IMSS - Firenze

Visit

Johannes Kepler: Hypothesis



Johannes Kepler
1571-1630

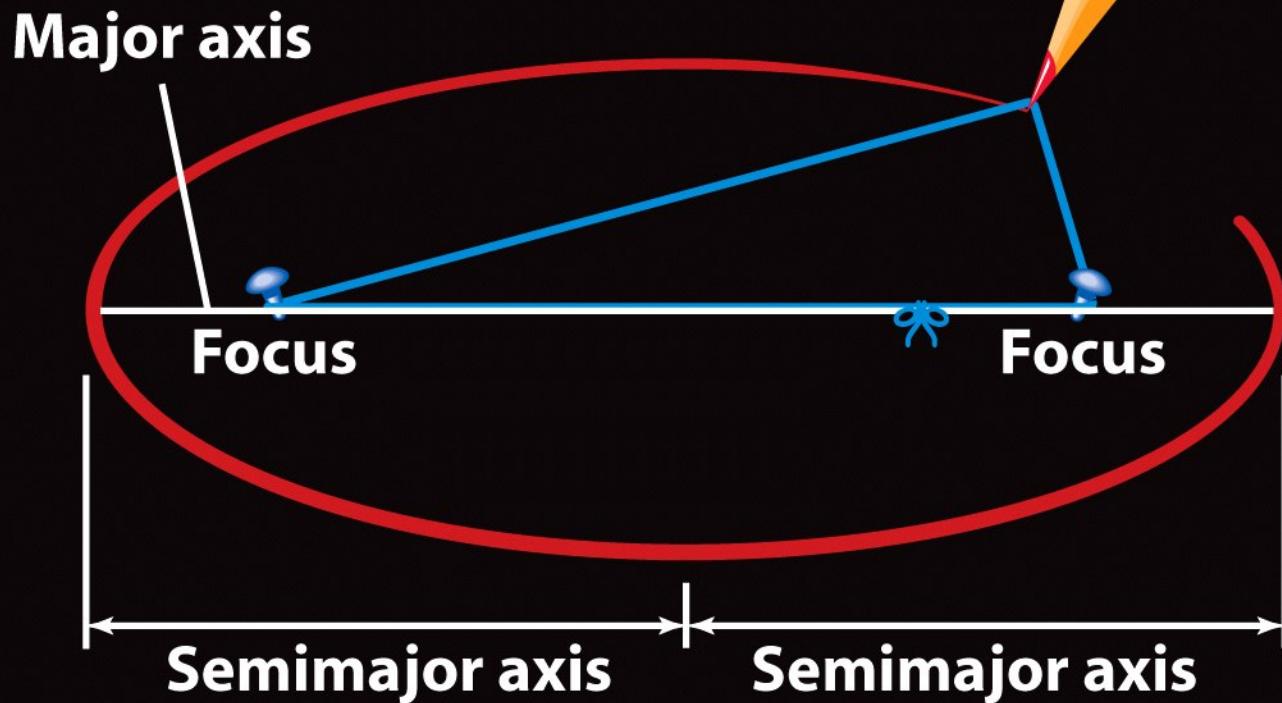


HEAVENLY INTRIGUE

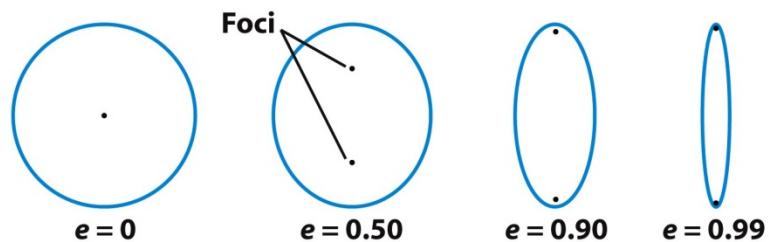
Johannes Kepler, Tycho Brahe, and the Murder
Behind One of History's Greatest Scientific Discoveries

JOSHUA GILDER AND ANNE-LEE GILDER

Kepler's 1st Law: Ellipses



The geometry of an ellipse



Ellipses with different eccentricities

Figure 4-10b
Universe, Eighth Edition
© 2008 W.H. Freeman and Company

Galileo Galilei
1564-1642

2009:
International
Year of
Astronomy

The Telescope = Revolution!



OBSERVATION

Galilean satellites of Jupiter

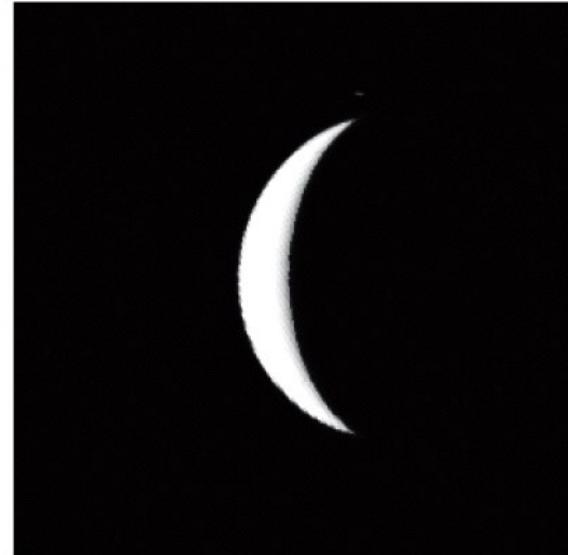


	Observations Janvair 1860		
2. J. 7pm.			
marcl H. 12	O ***		
3. monr	** O	*	
2. Febr.	O ***	*	
3. monr	O * *		
3. Febr. 5.	* O	*	
4. monr.	* O	**	
6. monr	** O	*	
8. marcl H. 13.	* * * O		
10. monr.	* * * O *		
11.	* * O *		
12. H. 4mgs.	* O *		
13. monr'	* * O *		
14. febr.	* * O *		

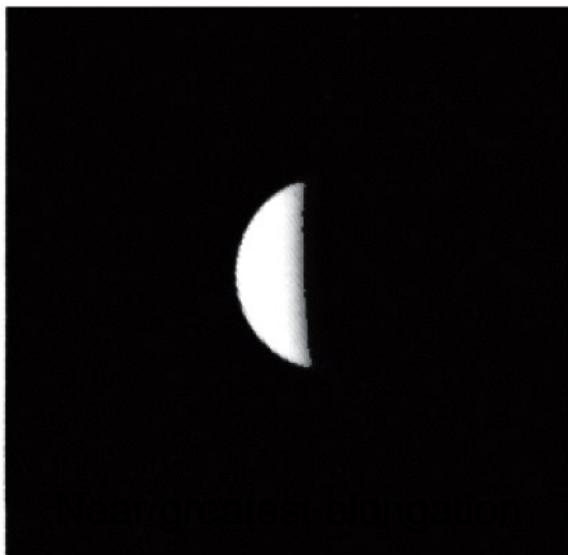


Near inferior conjunction

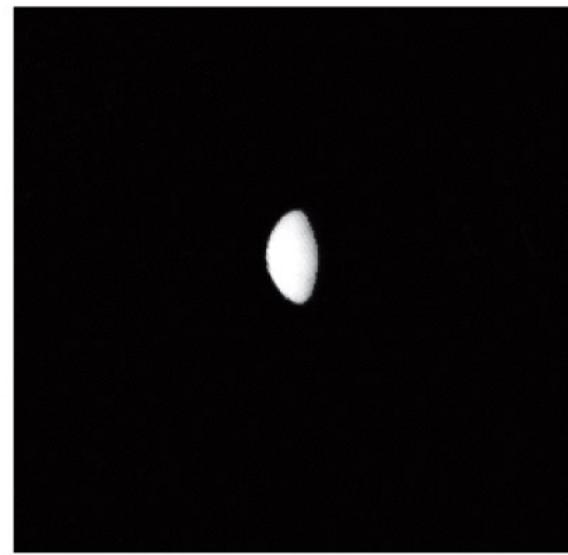
$\alpha = 58^\circ$



$\alpha = 42^\circ$



$\alpha = 24^\circ$



$\alpha = 15^\circ$

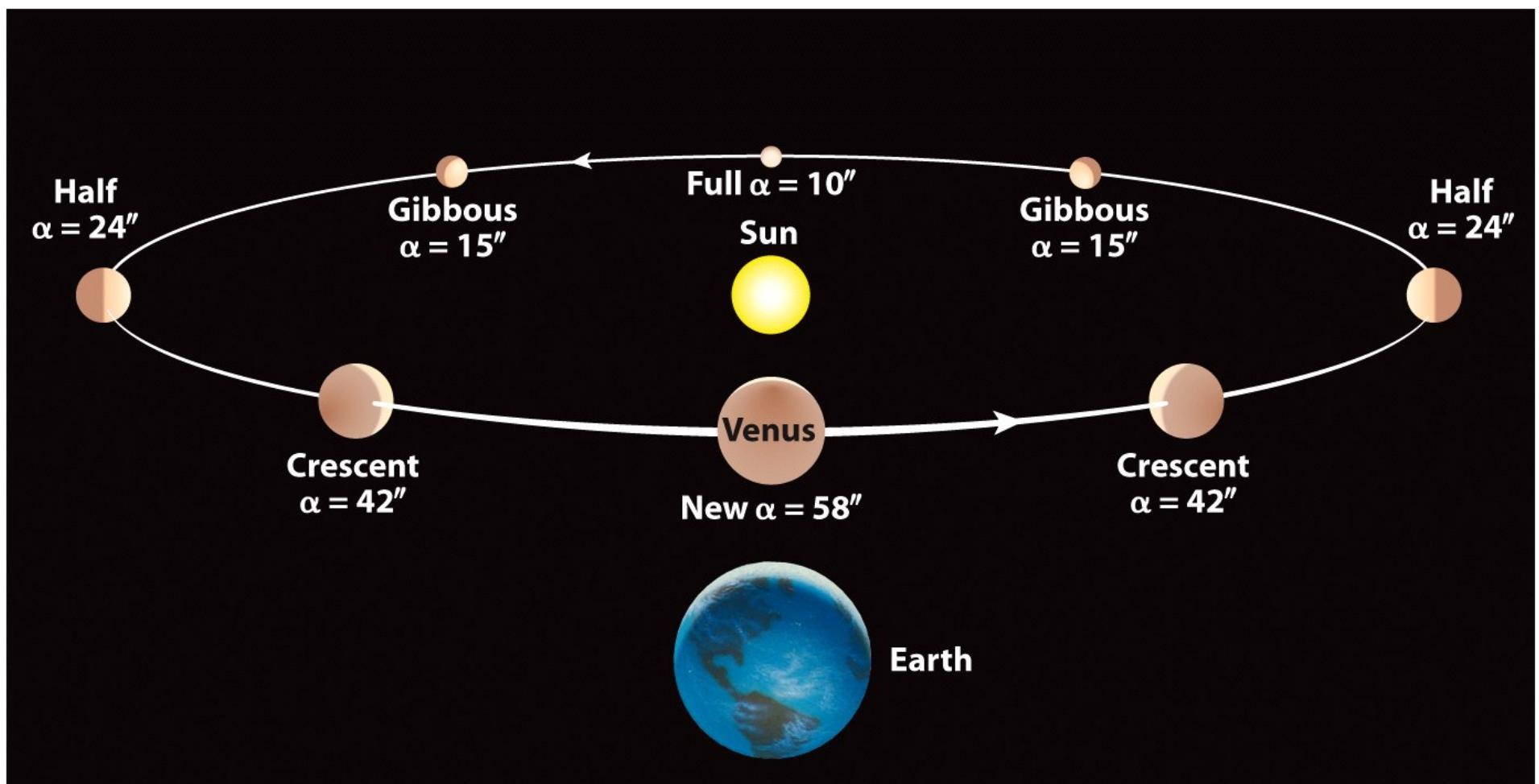
OBSERVATION Phases of Venus



$\alpha = 10^\circ$

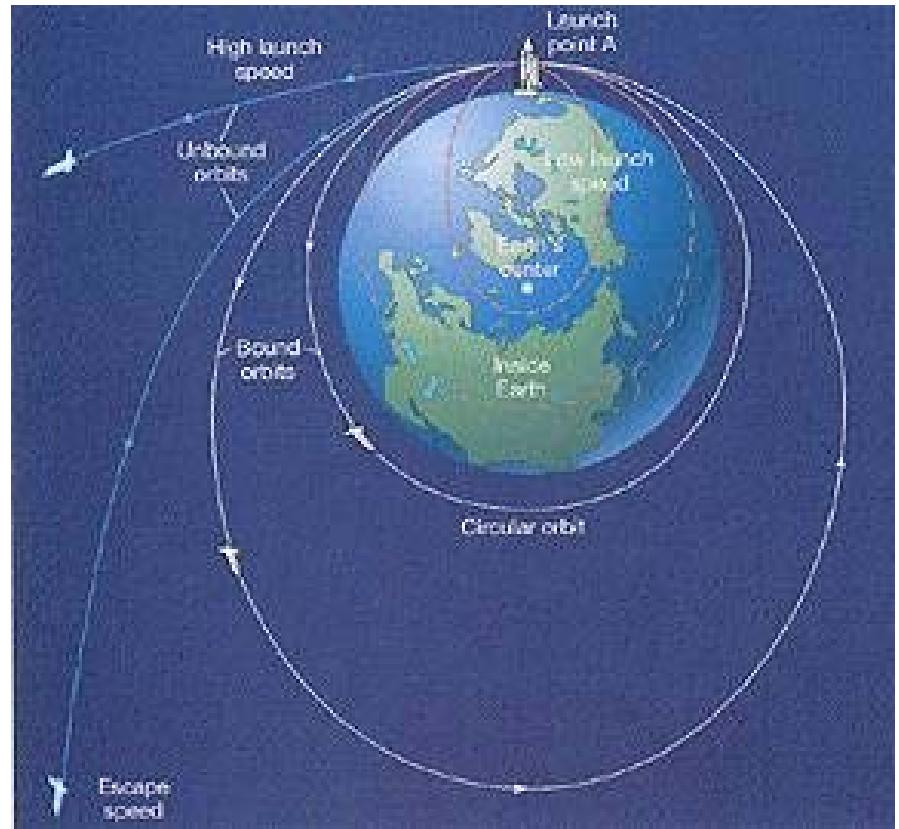
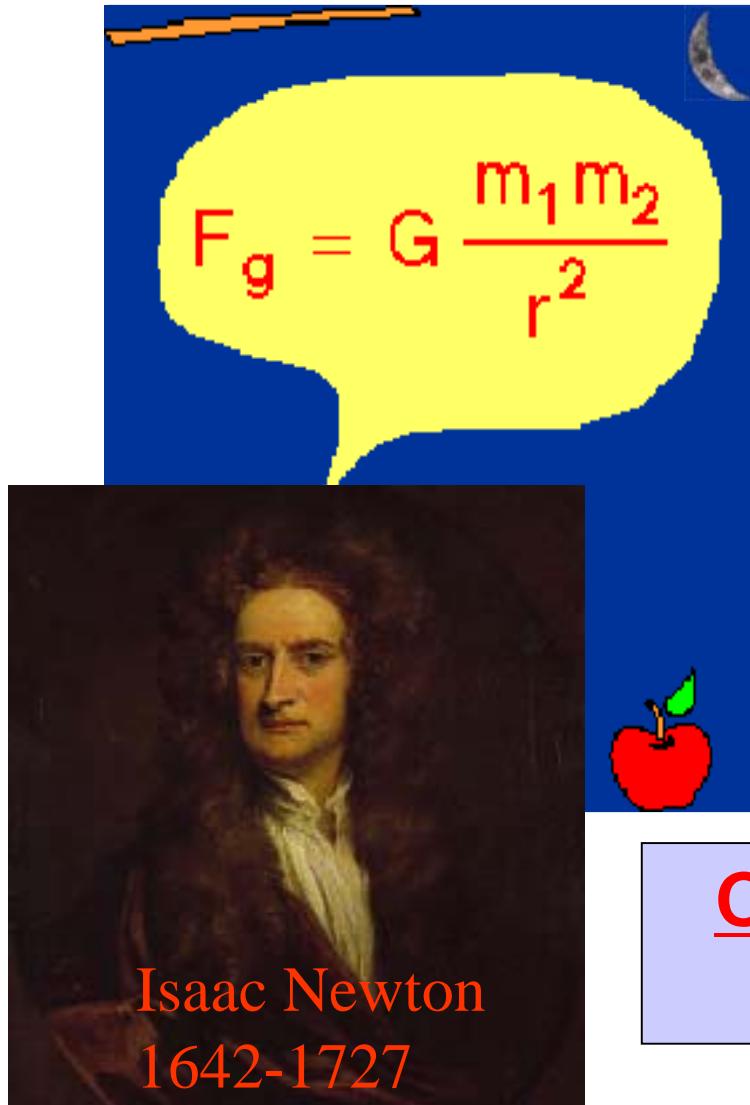
Galileo's explanation of Venus' phases

(you can verify this tomorrow morning!)



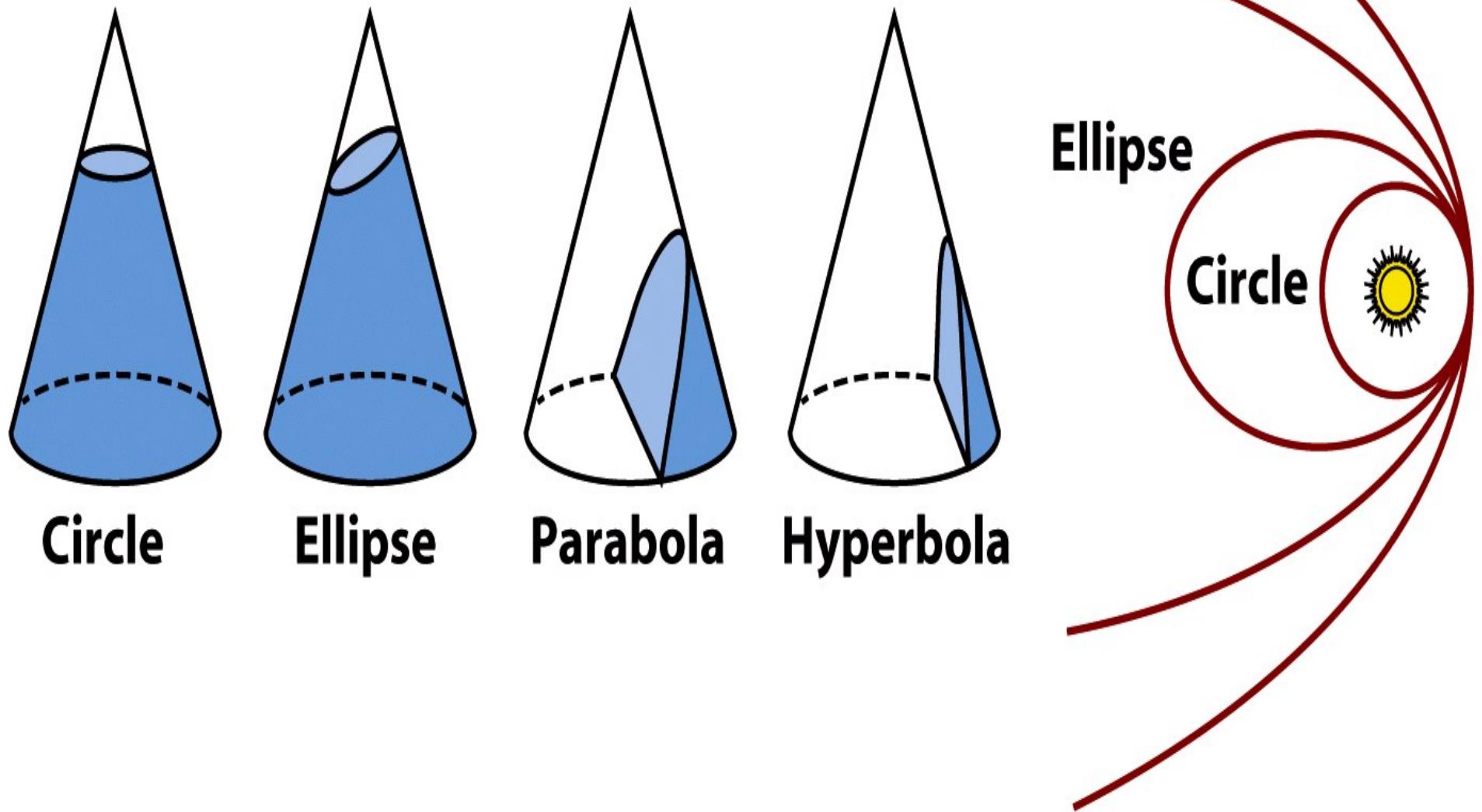
Isaac Newton

THEORY: Universal Law of Gravity

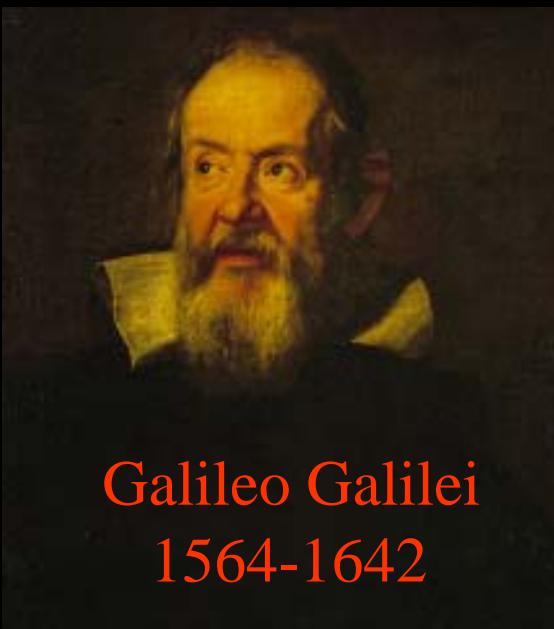


Correction to Kepler's 3rd Law:
 $(m_1 + m_2)P^2 = a^3$

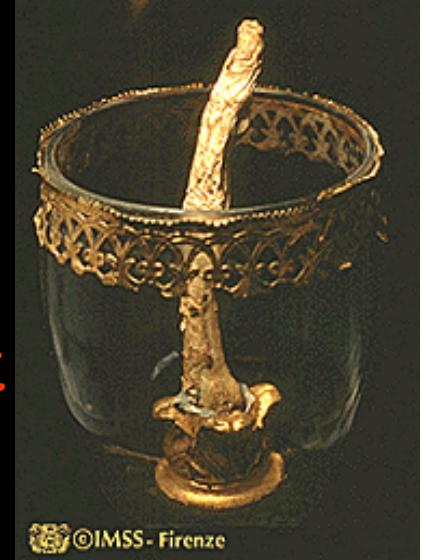
Orbits are conic sections



Key to the Truth: THE SCIENTIFIC METHOD



Observation/Experiment



Theory

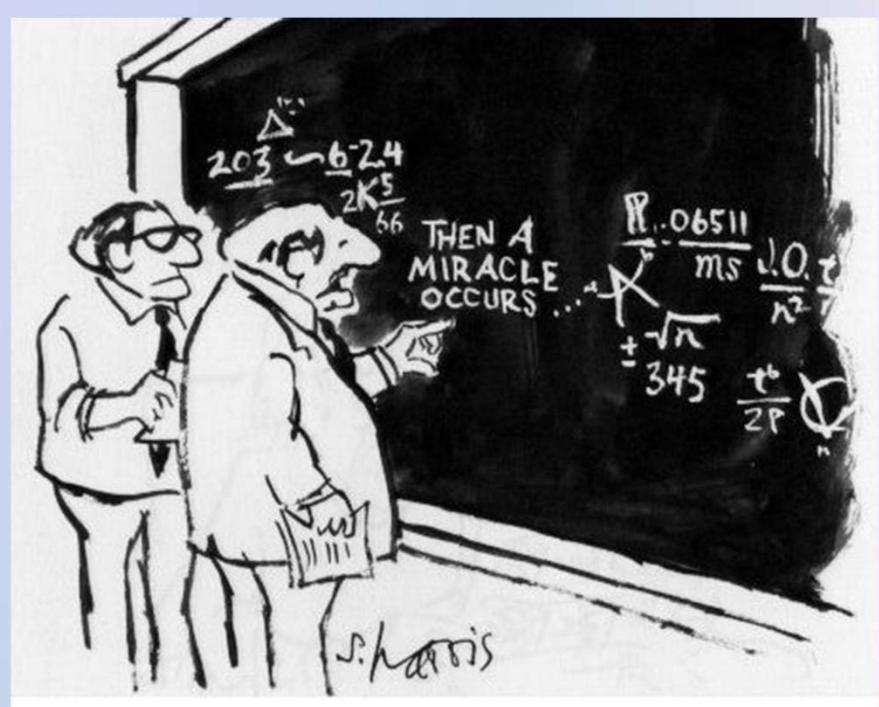
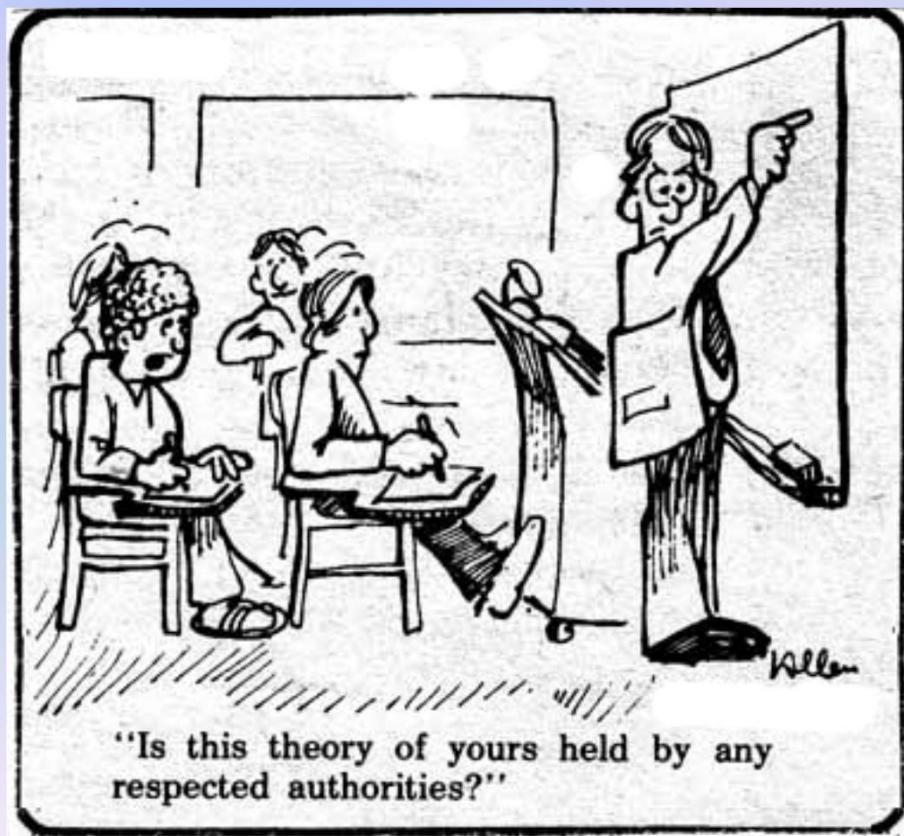
Hypothesis

PUBLISH!



Characteristics of a Good Theory:

- It must explain all the facts *quantitatively*.
- It must agree with accepted *physical principles*.
- It must be *simpler* than what it seeks to explain.
- It must be *falsifiable* (testable).



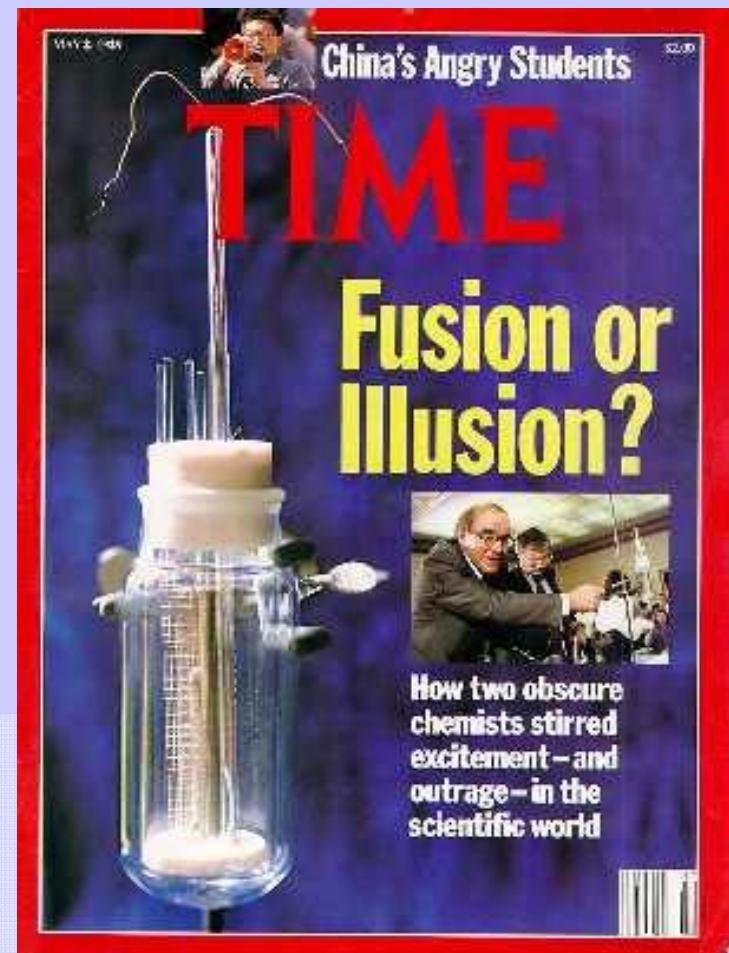
"I think you should be more explicit here in step two."

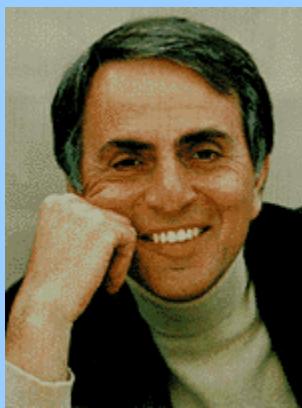
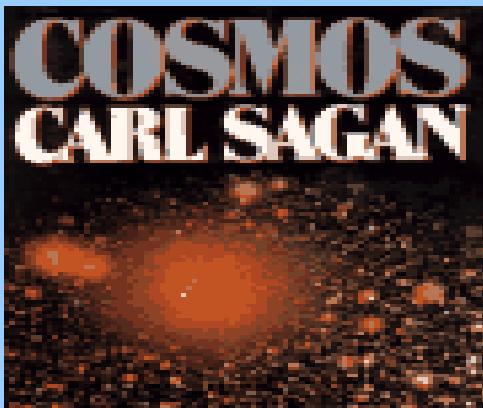
from *What's so Funny about Science?* by Sidney Harris (1977)

A Case Study in the Misuse of the Scientific Method: Cold Fusion



March 29, 1989
Martin Fleischman & Stanley Pons
University of Utah





Baloney Detection Kit

"Extraordinary claims require extraordinary proof."

--Carl Sagan



THE NEW YORK TIMES BESTSELLER

CARL SAGAN

THE DEMON-HAUNTED WORLD

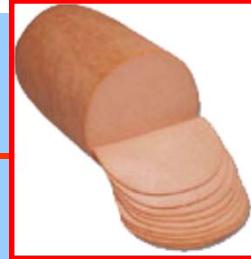


SCIENCE AS A CANDLE IN THE DARK

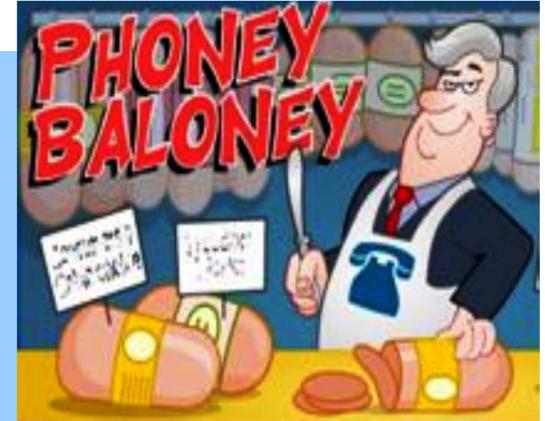
"A glorious book...From the first page to the last, this book is a manifesto for clear thought." —Los Angeles Times

"Wonder-saturated." —The Washington Post

The Detection Kit



(see Sagan, Chapter 12)



- Independently confirm all facts
- Consider more than one hypothesis
- Encourage debate among the experts
- Ignore “authority” or emotional arguments
- Apply Occam’s Razor
- Quantify your explanation when possible
- Test every step in your explanation
- Can your hypothesis be falsified?



Some Errors in Reasoning

(see Shermer, Chapter 3 for 25 ways to go wrong!)

- *Ad hominem* arguments

e.g. Joe believes in astrology, so ignore his opinions

- Arguments from adverse consequences

e.g. ban books claiming aliens built the pyramids because they mislead the public

- Appeals to ignorance

e.g. we cannot explain all UFOs, so they must be visiting aliens

- Begging the question

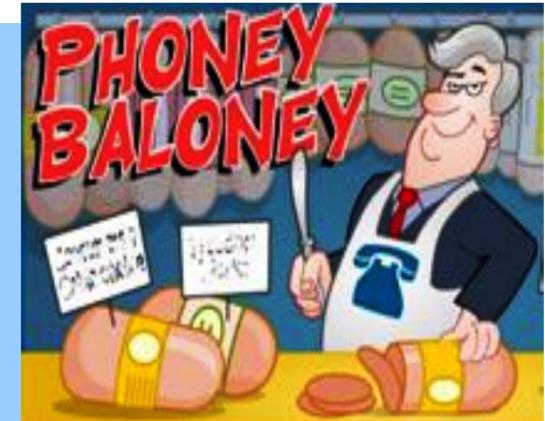
e.g. we must have as many streetlights as possible in order to discourage crime

- Counting hits and forgetting misses

e.g. that mountain on Mars looks like a face (although thousands of others don't)

- Confusing correlation and cause

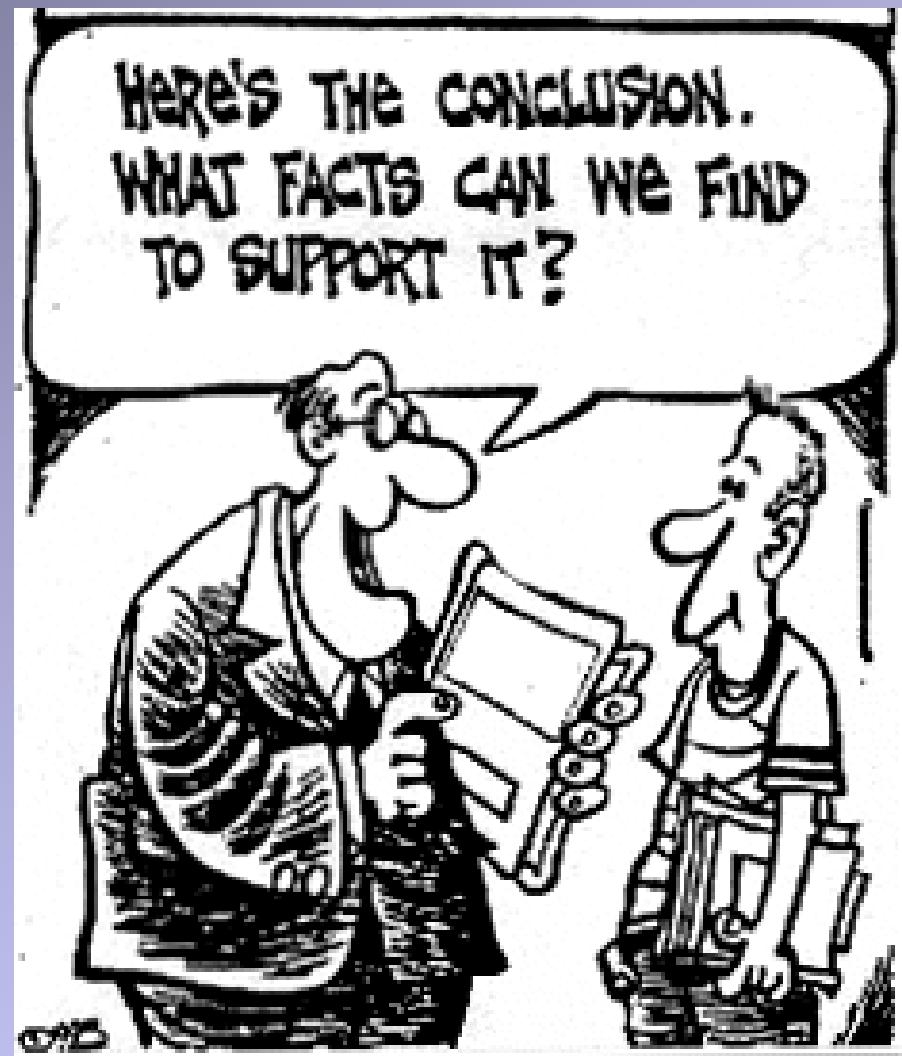
e.g. sunspot numbers correlate with the stock market index



Pseudo = fake

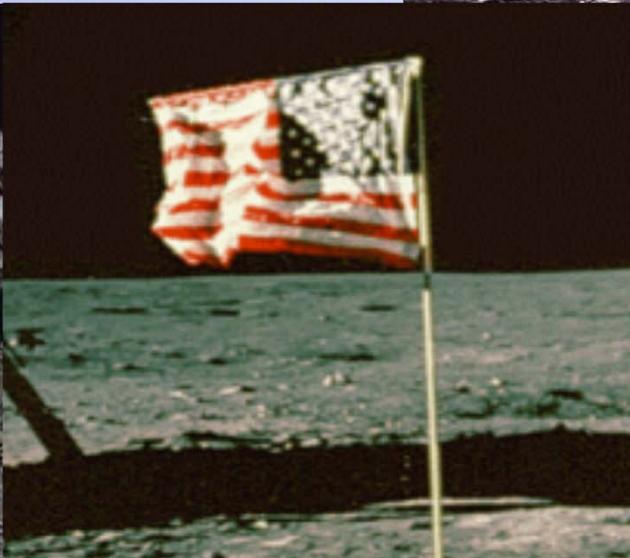
Pseudoscience describes any field that reflects some of the practices associated with science, however offers false confidence in its claims as a result of not applying others.

Science vs. Pseudo-Science



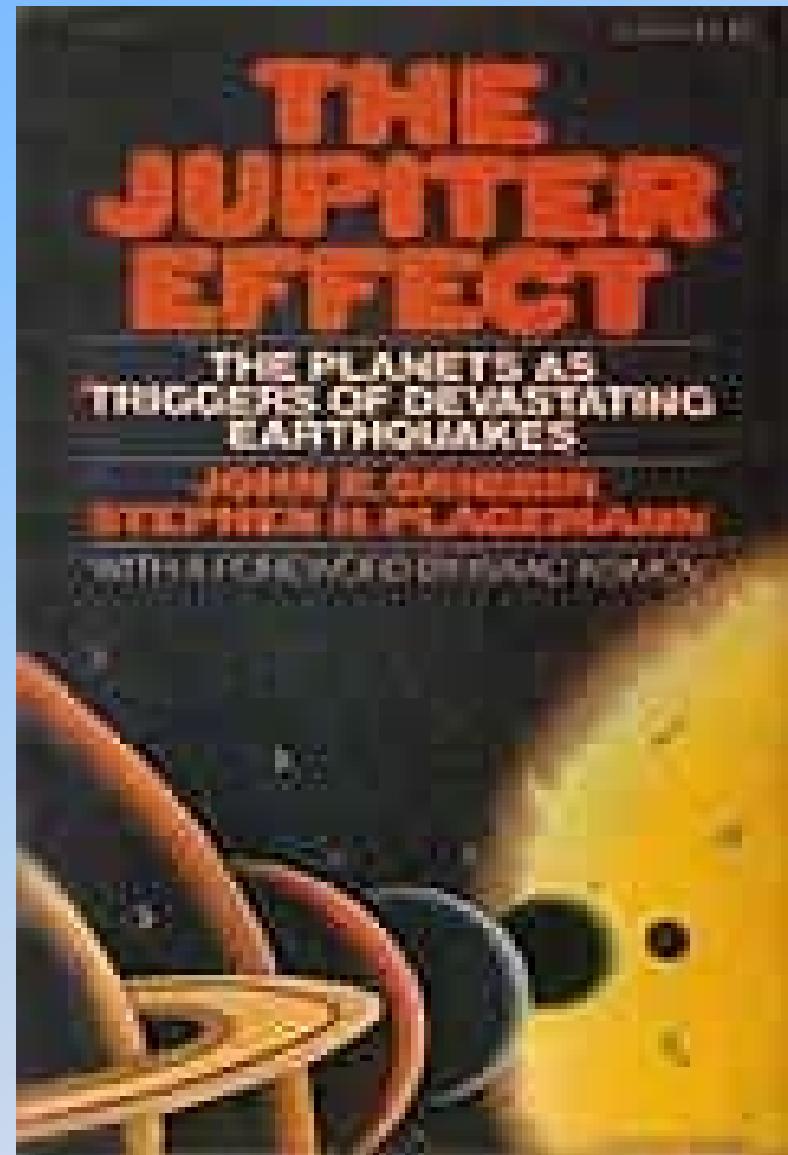
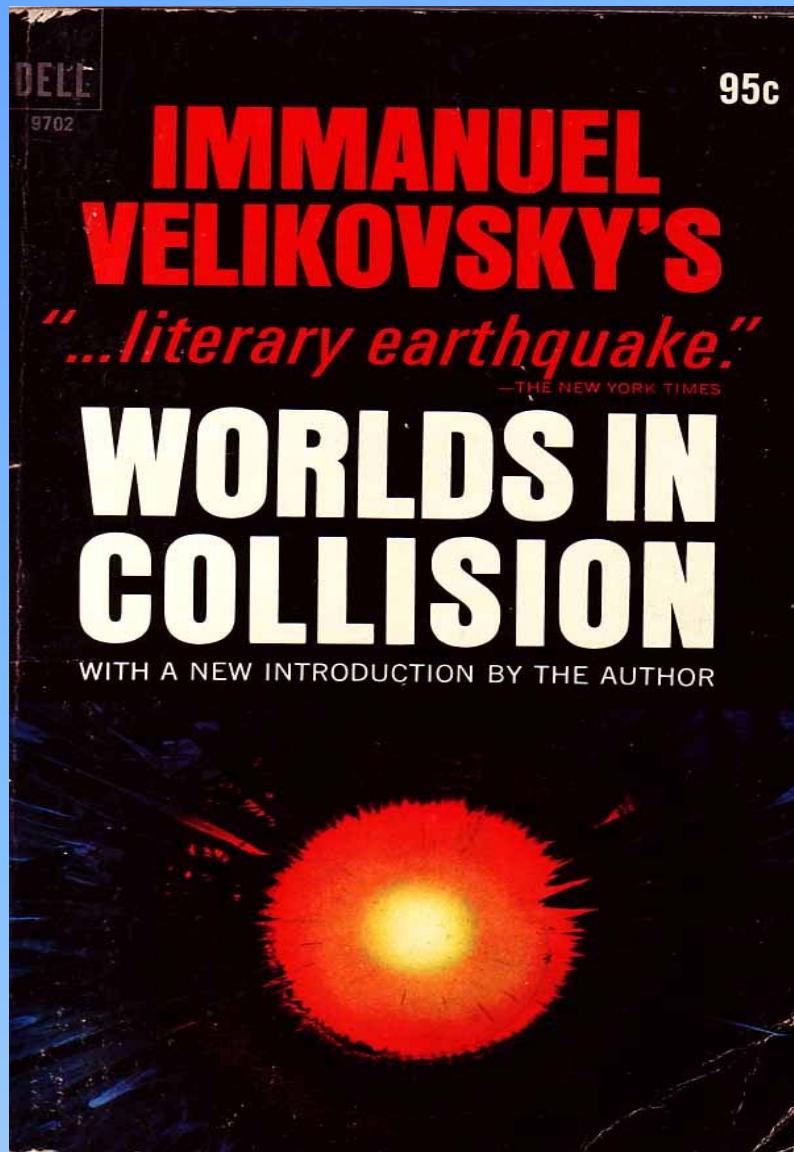
THE MOON LANDINGS WERE FAKE!

- (1) Why would the American Government fake the moon landings?
- (2) How many would need to be involved?
- (3) Why would no one who worked on the project come forward in 40 years?
- (4) What would it mean for science in general if the claims were true?
- (5) Are there clear answers to specific claims?
- (5) Is this a good hypothesis?

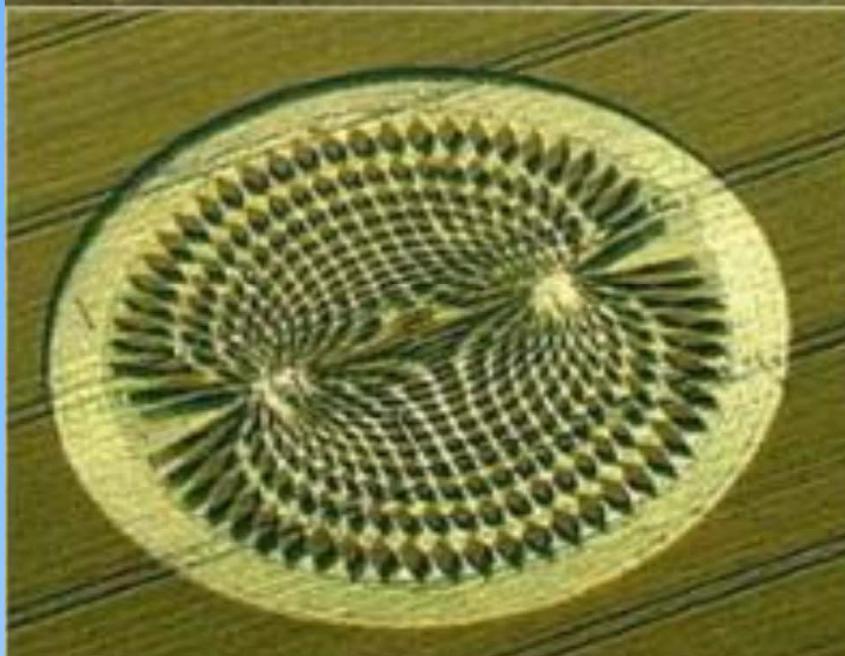


see “NASA - Apollo Moon Landings: A Resource for Understanding the Hoax Claims”

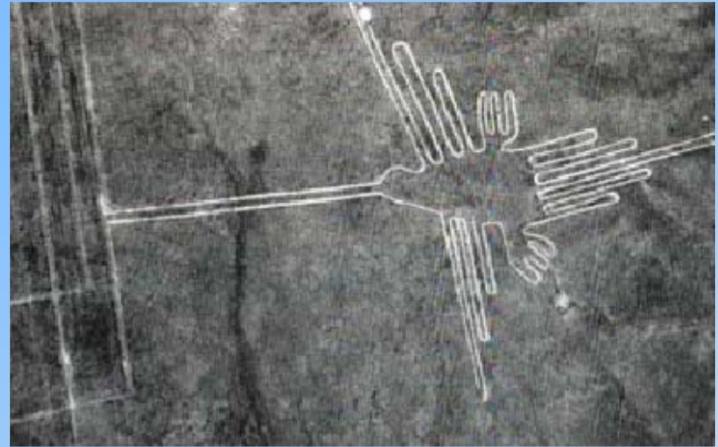
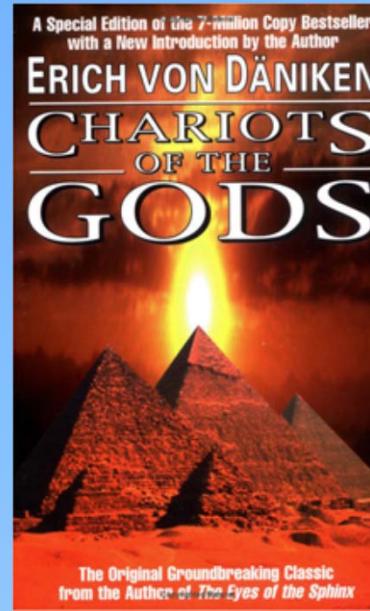
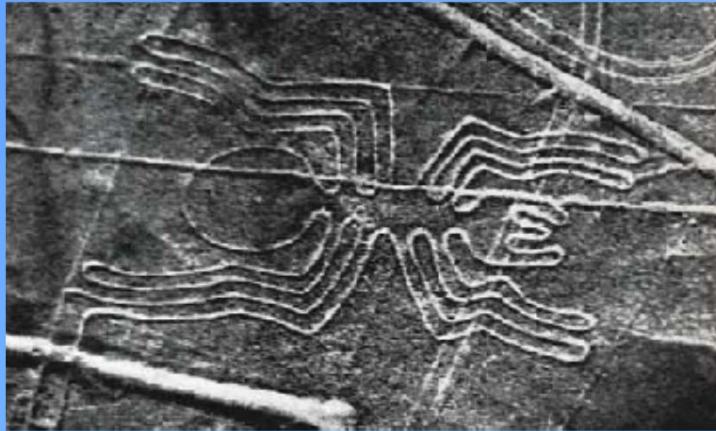
Pseudoscience in the Popular Press



Crop Circles

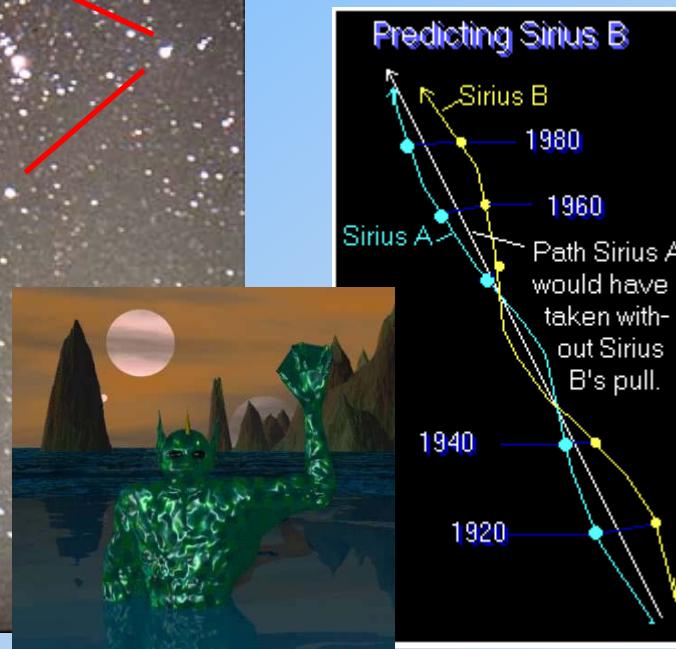
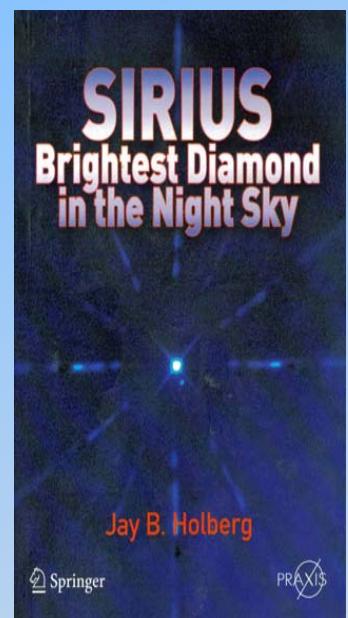
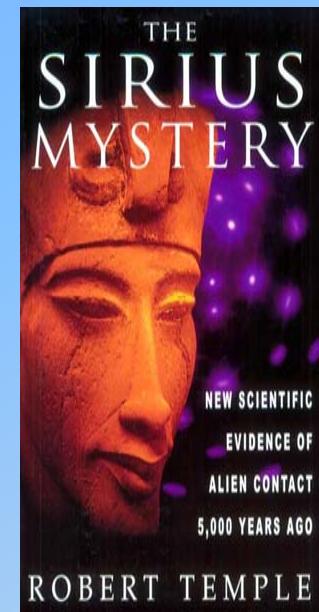
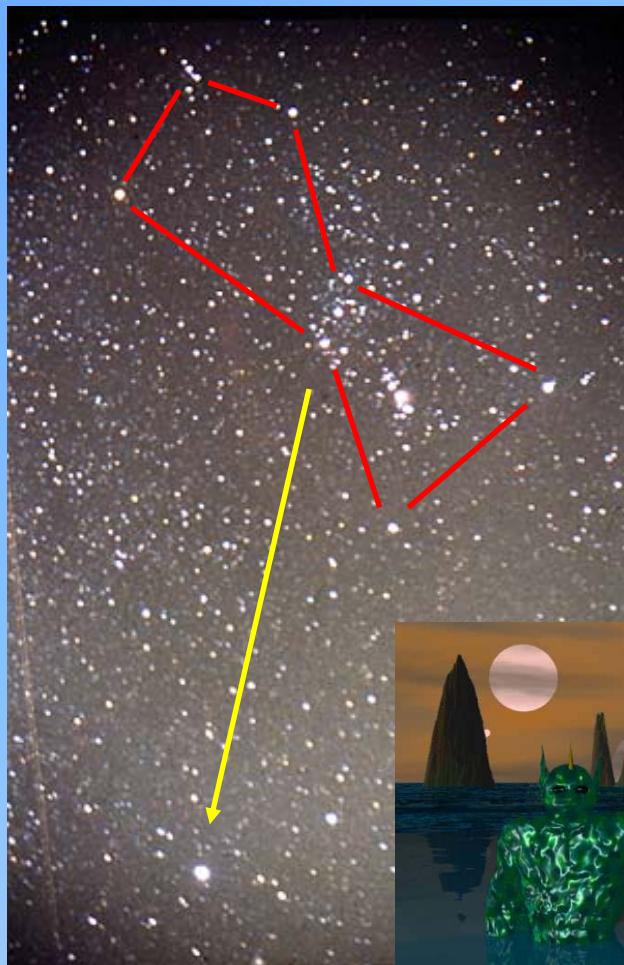


The Nascan Lines (Peru)



The Dogons & Sirius B

Marcel Griaule & Germain Dieterlen
c. 1930, Mali, West Africa



Physics and Space Sciences Department Colloquium:

Kepler, Microlensing, and Direct Imaging:

New Constraints on Exoplanet Formation Theories



Dr. Alan Boss
Dept. Terrestrial Magnetism
Carnegie Institute of Washington

Friday, January 25th
4:00–5:00 PM
OPS Room 140

Astronomy & Astrophysics Public Lecture Series

**“The Crowded Universe:
The Search for
Living Planets”**

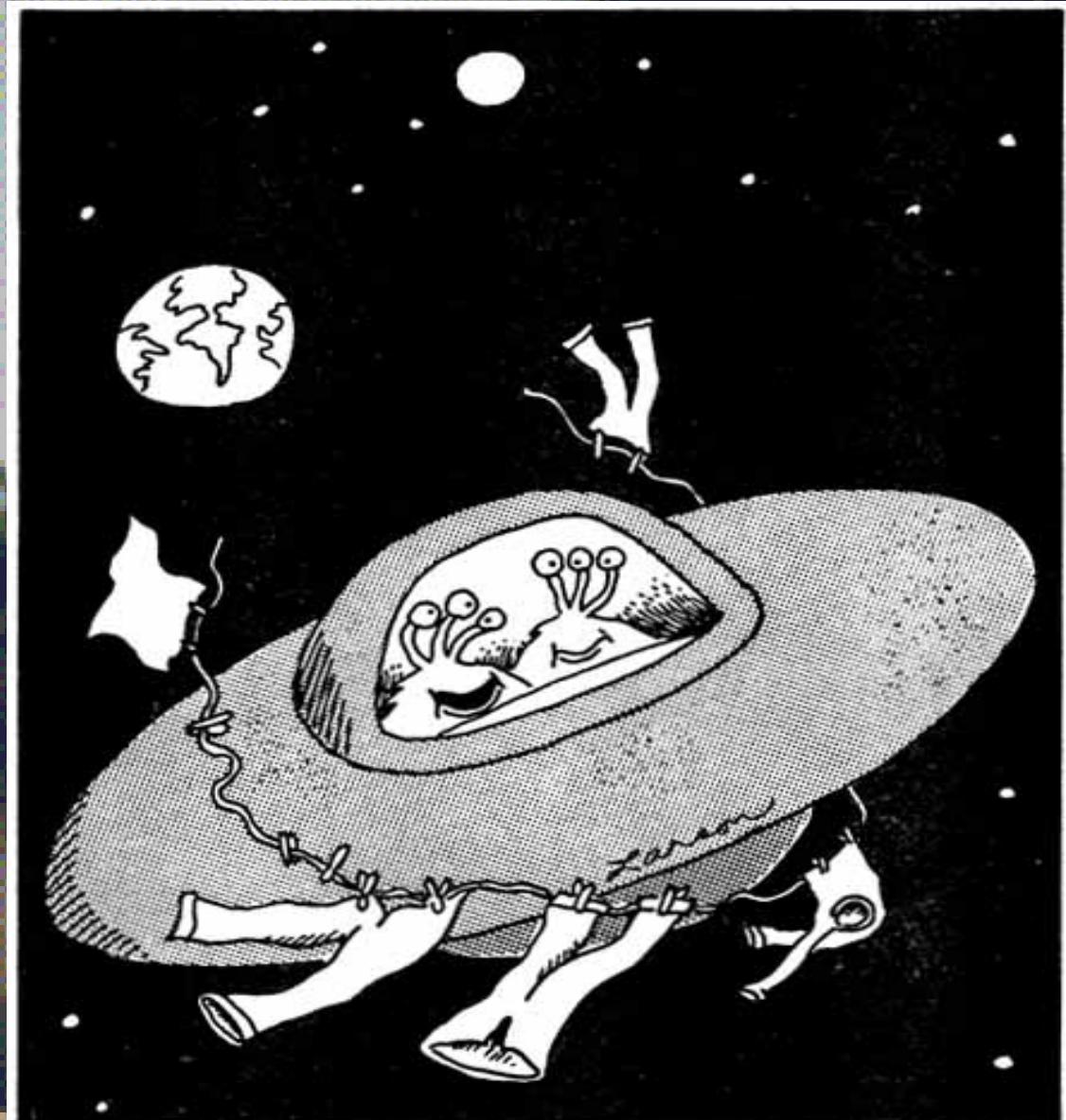
**Friday, January 25th
8:00—9:00 PM
OCE Room 118**



**Alan Boss
Dept. Terrestrial
Magnetism**

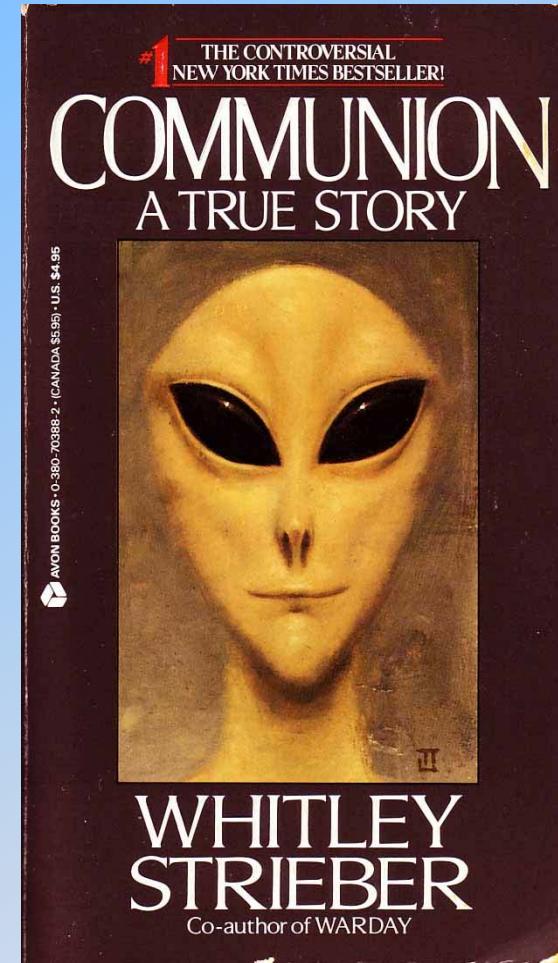
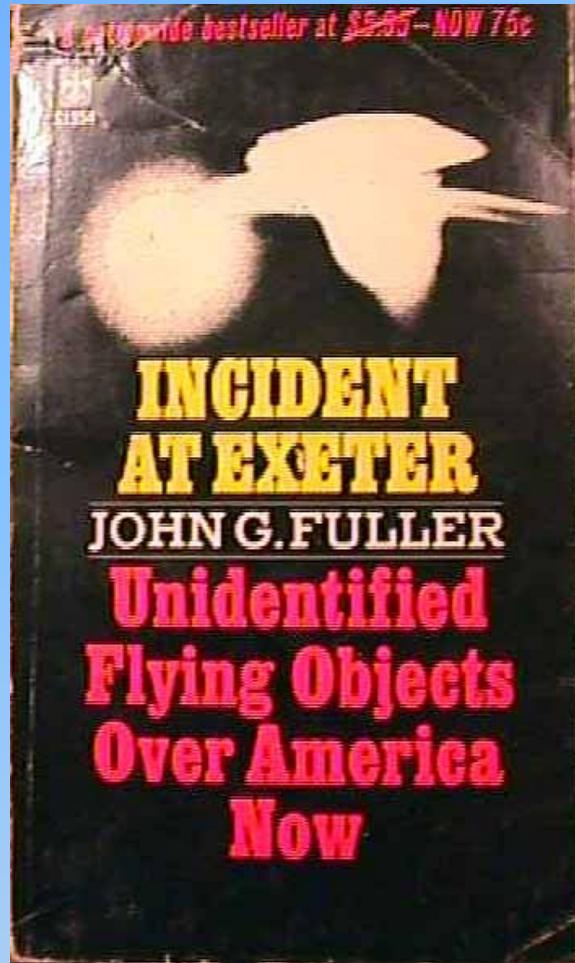
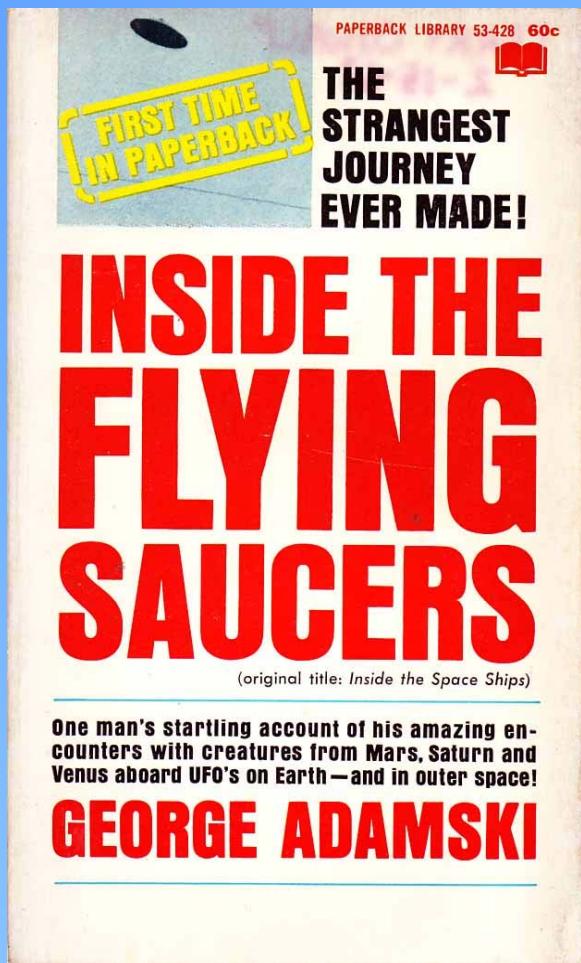
Carnegie Institute of

UFOs: Visiting ETs?



**"Well, I daresay there's a woman in Mayfield,
Nebraska, who believes in UFOs."**

Aliens in the Popular Press



*“Perhaps we should hold a contest and collect the best
“Ten Questions to Ask an Alien”*

--Carl Sagan, in "Demon-Haunted World"

Recent UFO Sightings

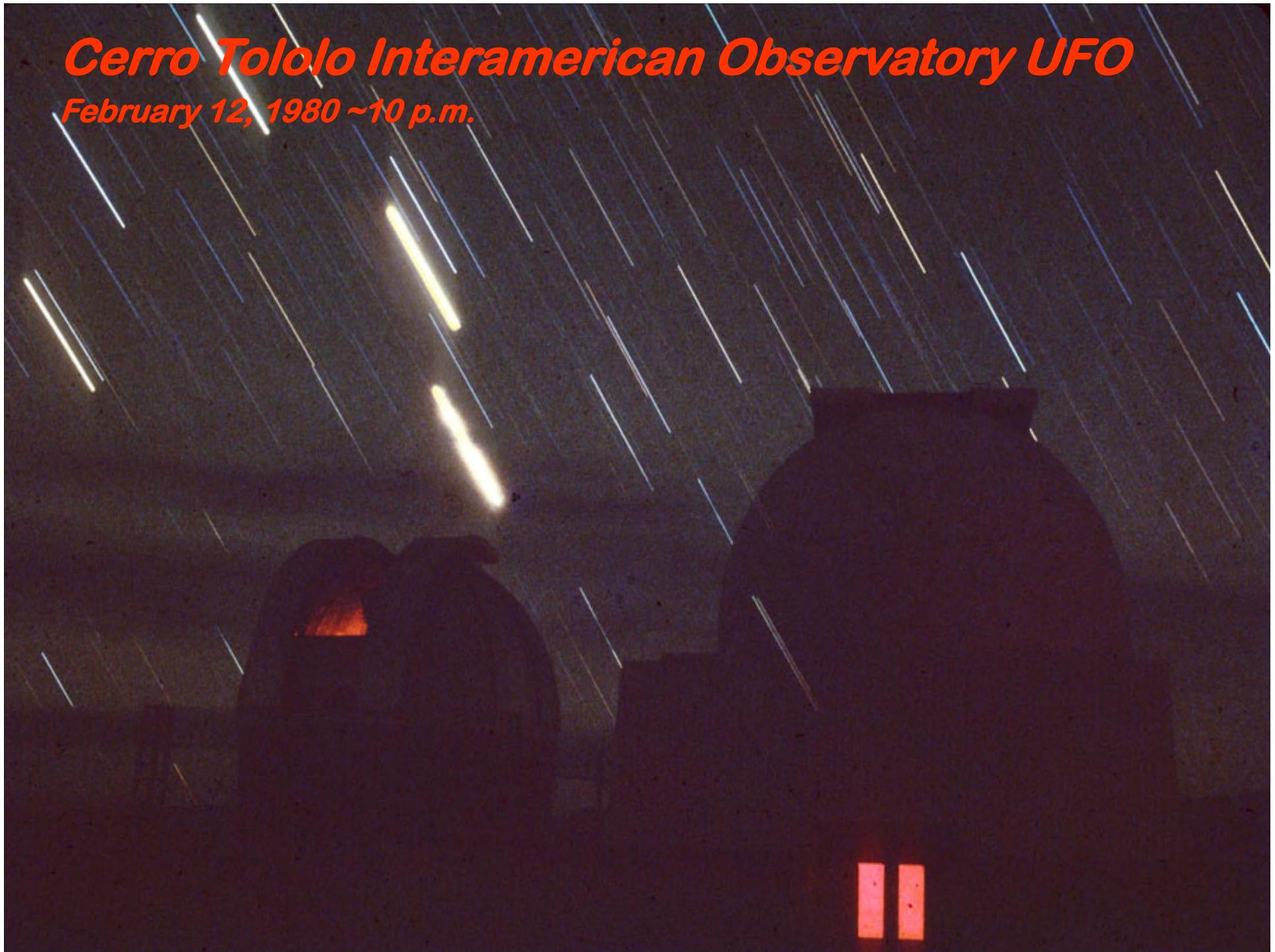
Mexic airline pilots
Russian Mig interception
STS-83

Courtesy: Zach Lush



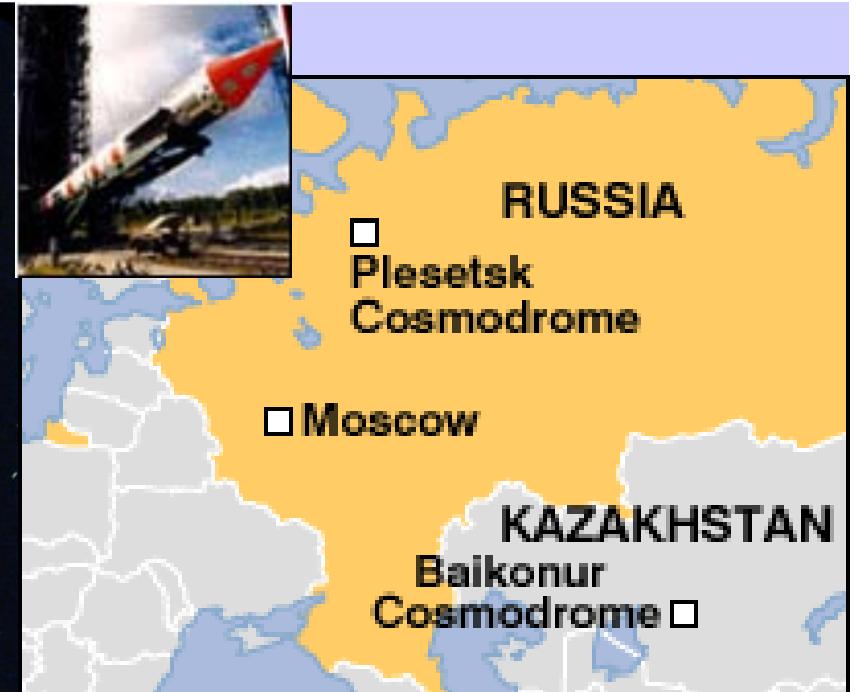
Cerro Tololo Interamerican Observatory UFO

February 12, 1980 ~10 p.m.



Kosmos-1164

Launched from
Plesetsk USSR, 8:56 CDT





Applying the Scientific Method to SETI

December 31:

9:00 pm:

Early hominids evolve

11:58 pm:

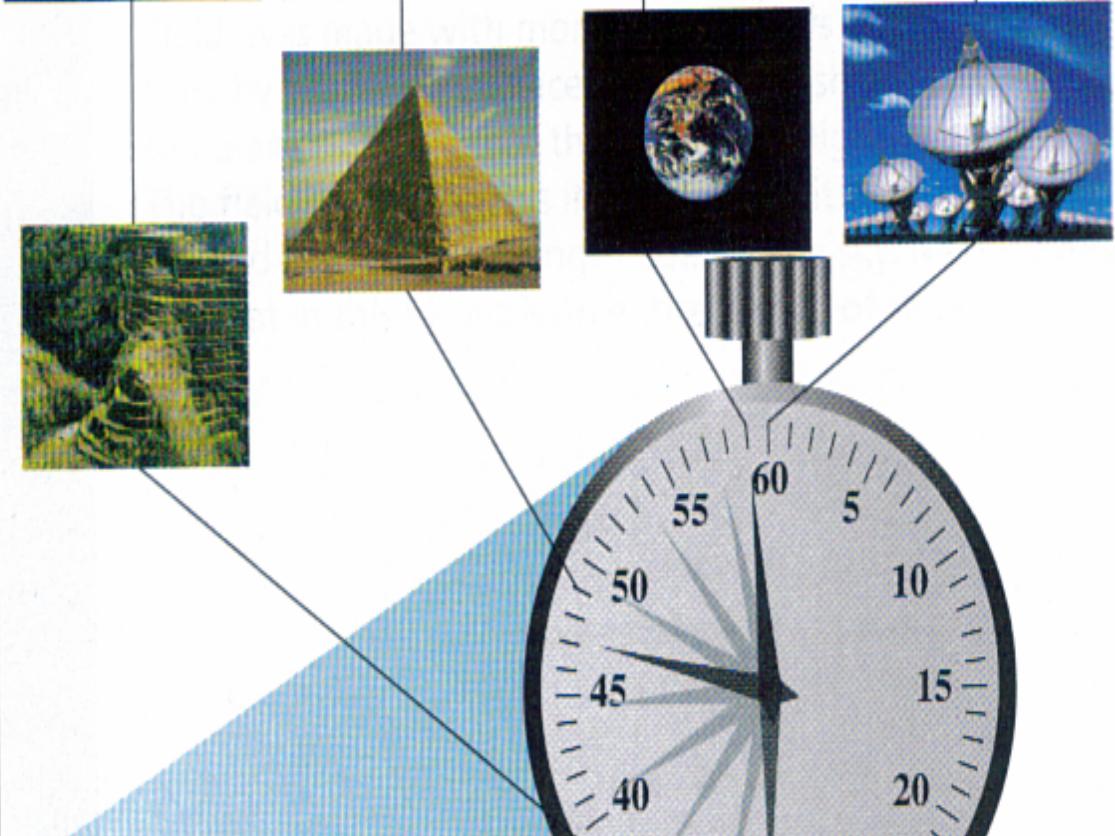
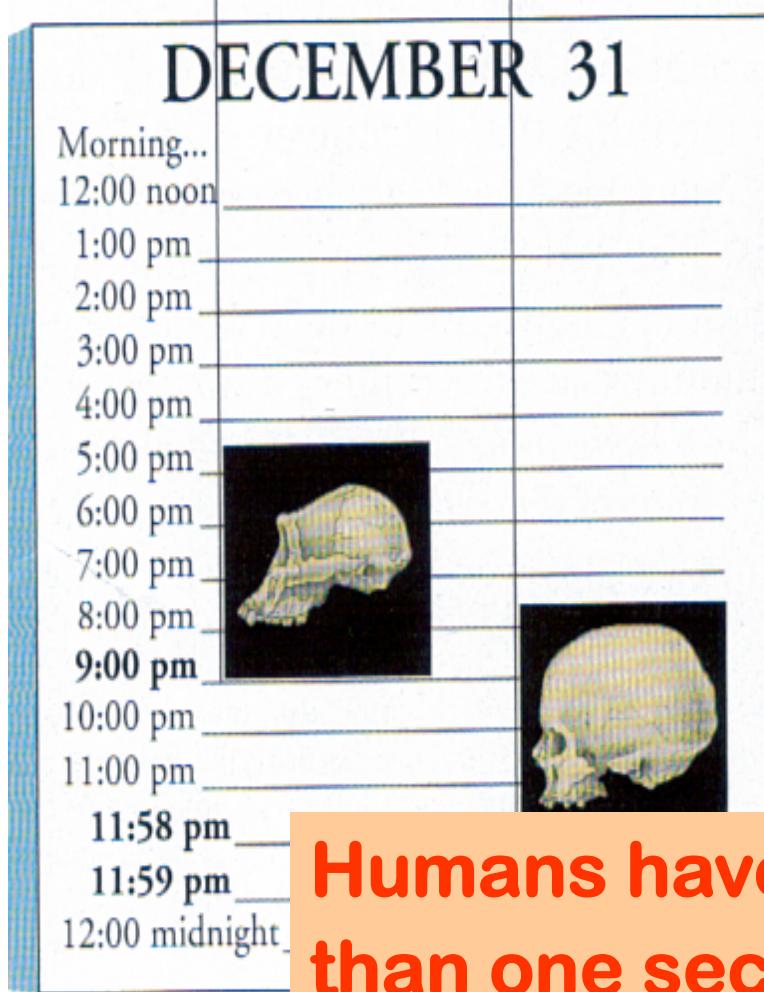
Modern humans evolve

25 seconds ago:
Agriculture arises

11 seconds ago:
Pyramids built

1 second ago:
Kepler and Galileo
show that Earth
orbits the Sun

Now



Humans have been technological for less than one second on the Cosmic Calendar!

Why People Believe Weird Things

- *Hope springs eternal*

e.g. “The truth is out there...”, what sells more newspapers?

- *Thinking often goes wrong*

e.g. reality is a matter of perception and cultural influence (see “Zen & the Art of Motorcycle Maintenance”).

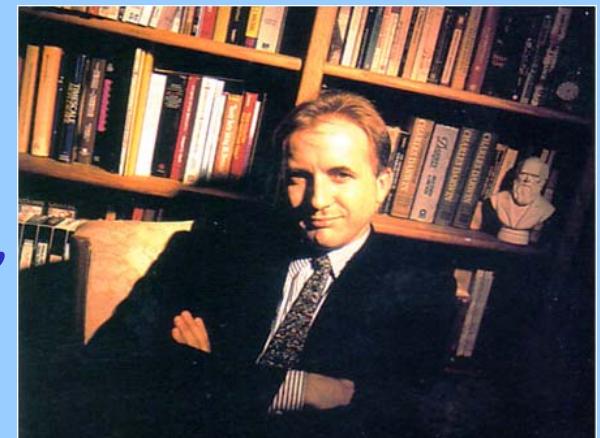
It is perfectly OK to “leave the case open,” pending future compelling evidence

Skeptic ≠ Cynic

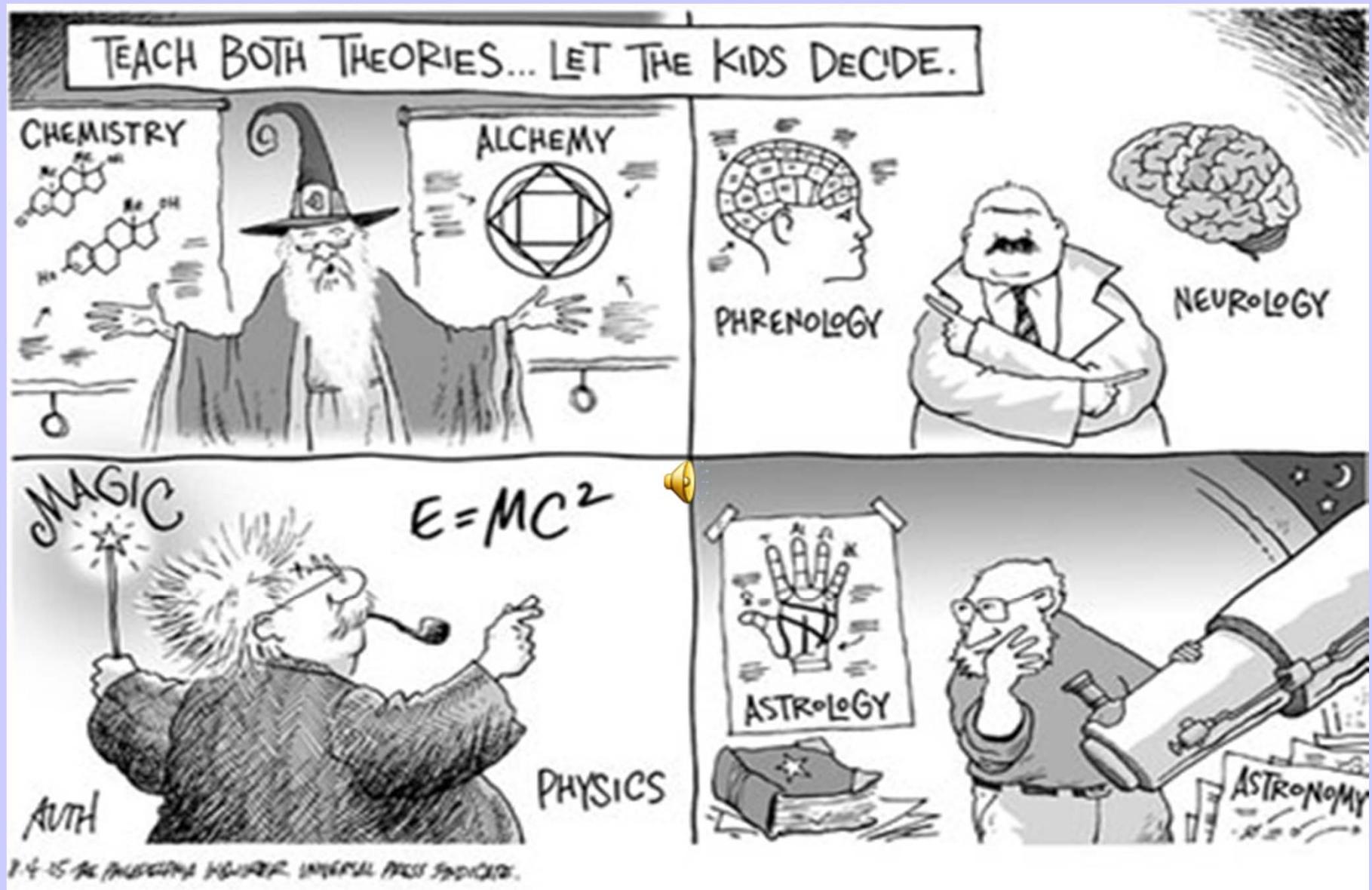
The Skeptic’s Manifesto:

“*I am, therefore I think.*” (*Cogita tute*). ”

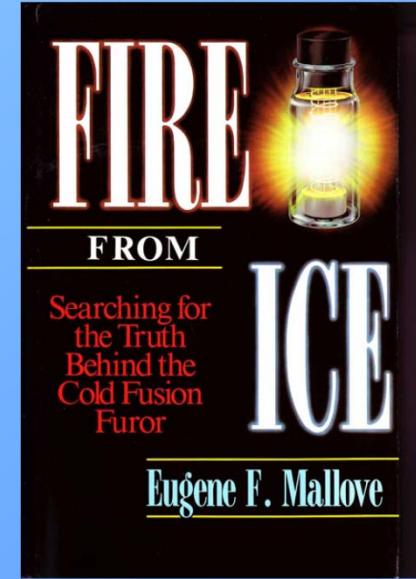
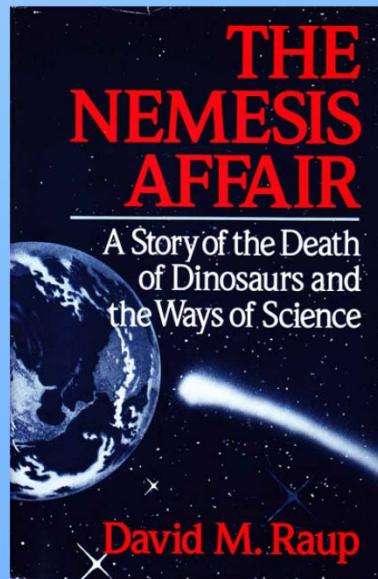
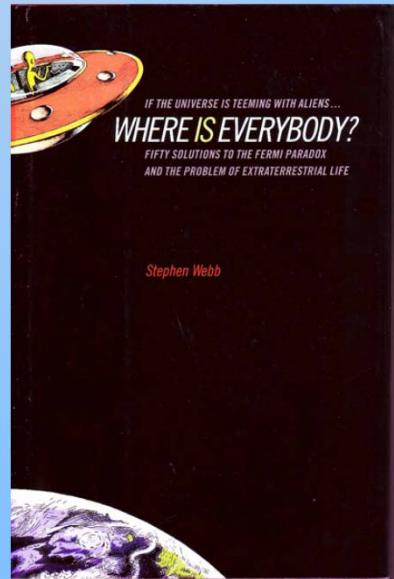
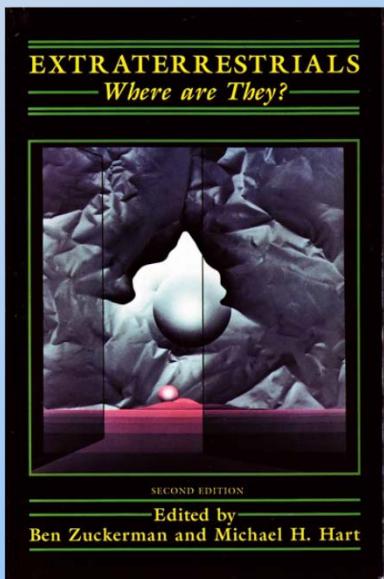
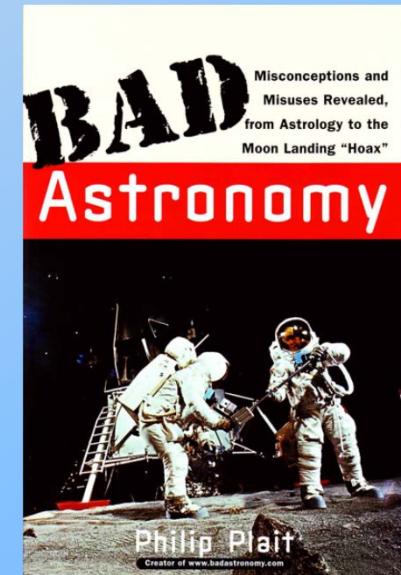
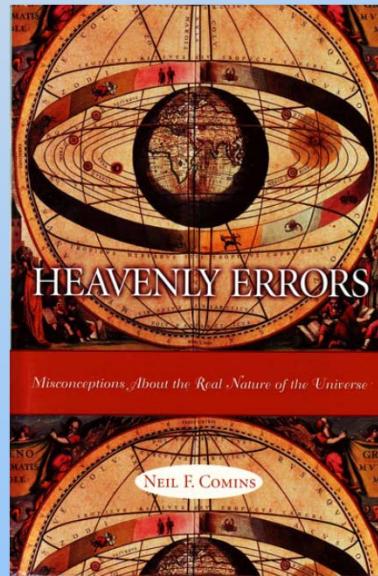
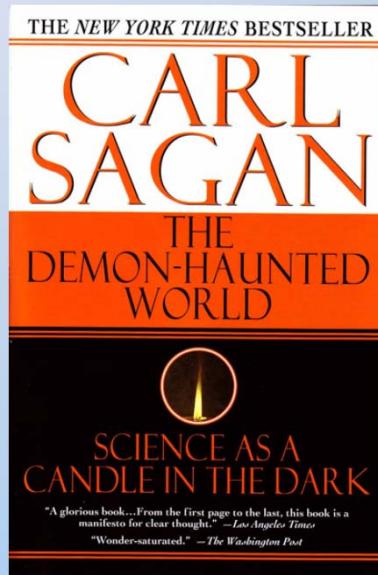
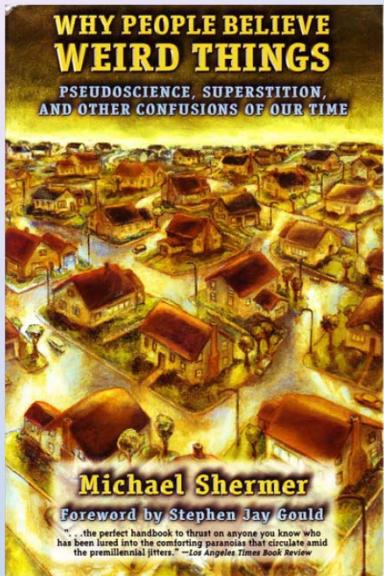
--M. Shermer (with apologies to Renée Descartes)



The “Teach the Controversy” Hoax



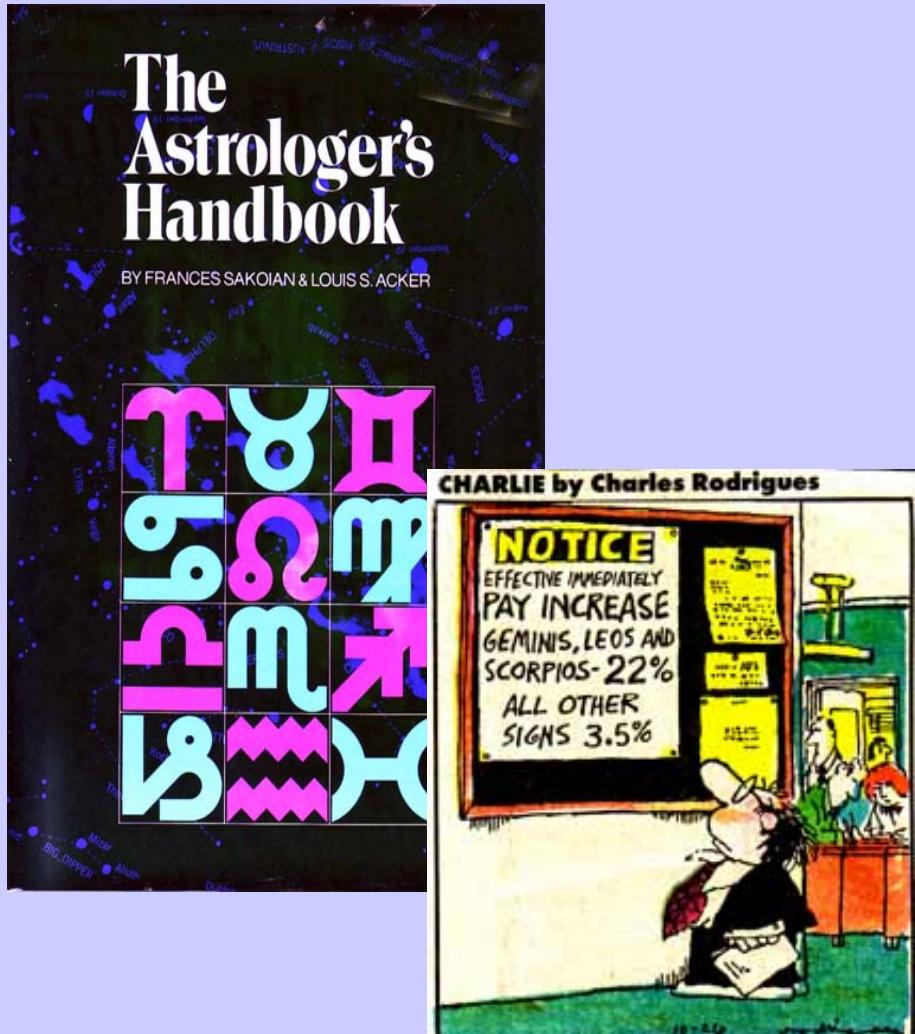
References Worth a Look



Is astrology valid?

Let's apply the
Scientific Method

Astrology



INTRODUCTORY ASTRONOMY QUIZ #1

Dr. Oswalt

TODAY'S DATE..... BIRTHDATE.....

Please rate how accurately each of the following statements apply to you right now on a scale of 0=absolutely false to 10=absolutely true. Then tally up the total score.

GENERAL CHARACTERISTICS:

1. Characterized by thinking and acting swiftly
 2. Tends to identify and classify everything
 3. Speaking and writing are very strong attributes
 4. Highly developed learning capacity, eager to study
 5. Seeks variety in life, tends to be a non-conformist
 6. Tends to be high-strung
 7. Quite popular with others
-

SUBTOTAL

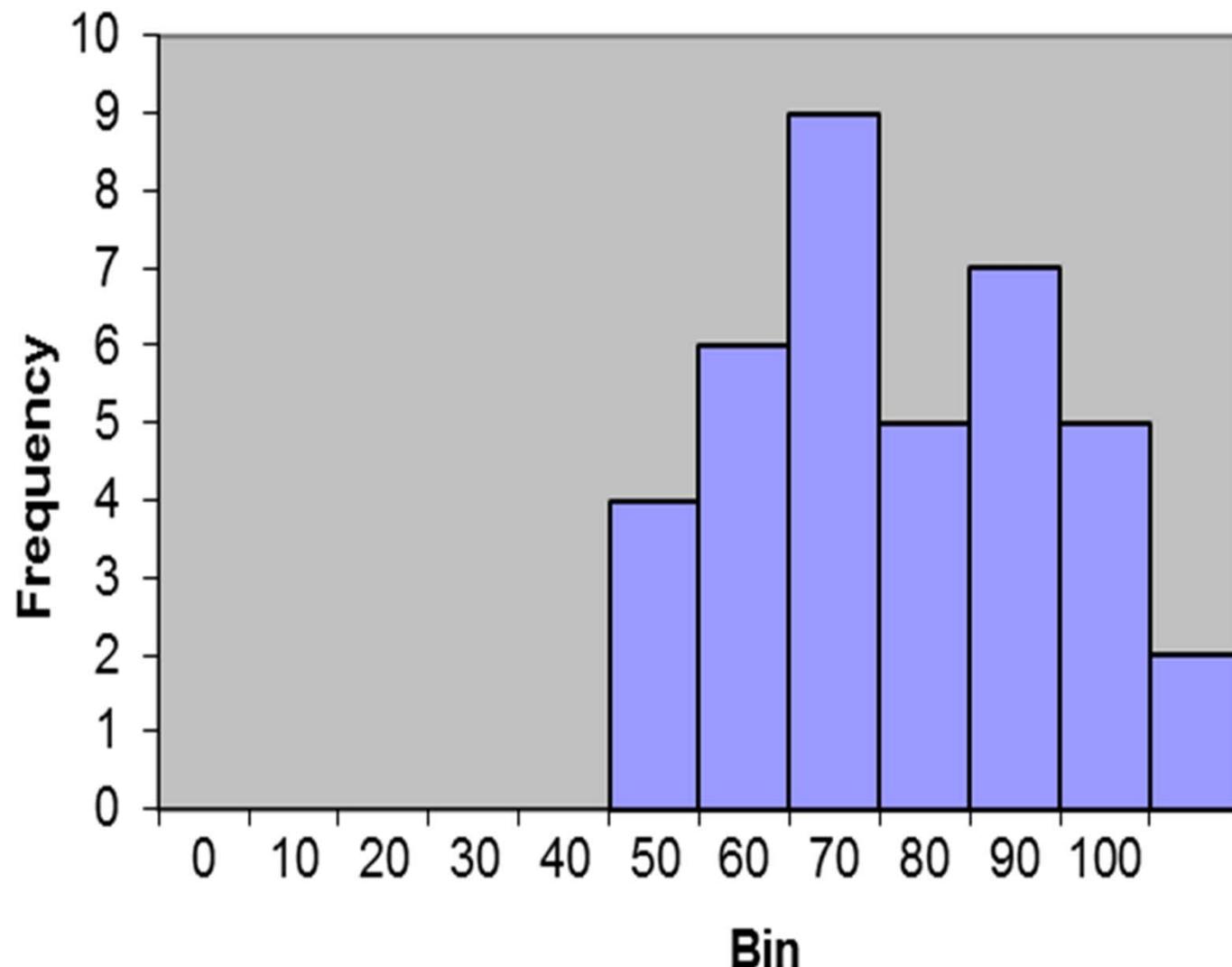
TODAY:

8. light was shed on something previously dark
 9. individual you aided in past returned the favor
 - 10.you were offered a contract or agreement
-

SUBTOTAL

3 TOTAL

Spring 2013 Intro. Astro. - TRAITS



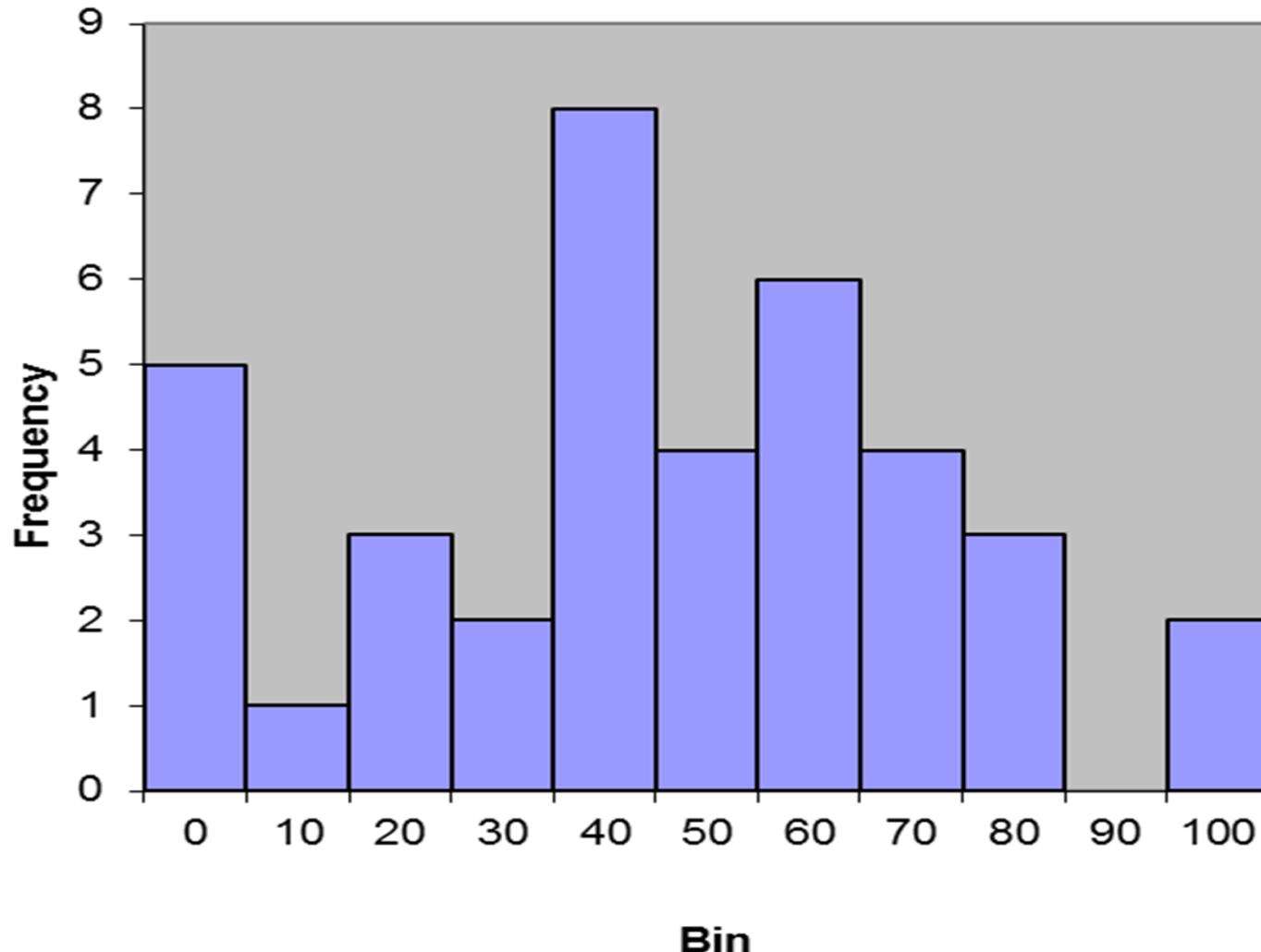
TRAITS	ALL
Bin	Frequency
0	0
10	0
20	0
30	0
40	4
50	6
60	9
70	5
80	7
90	5
100	2
More	0
N	38
AVE %	63.9
STDEV %	16.9
STDVM %	2.7
EVENTS	ALL

HYPOTHESES – TRAITS SURVEY

Why do 2/3 of you say Astrology described your personality reasonably well?

1. Astrology is “right” on
2. The descriptions were rather general and easy to agree with

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Bin	Frequency
0	5
10	1
20	3
30	2
40	8
50	4
60	6
70	4
80	3
90	0
100	2
More	0

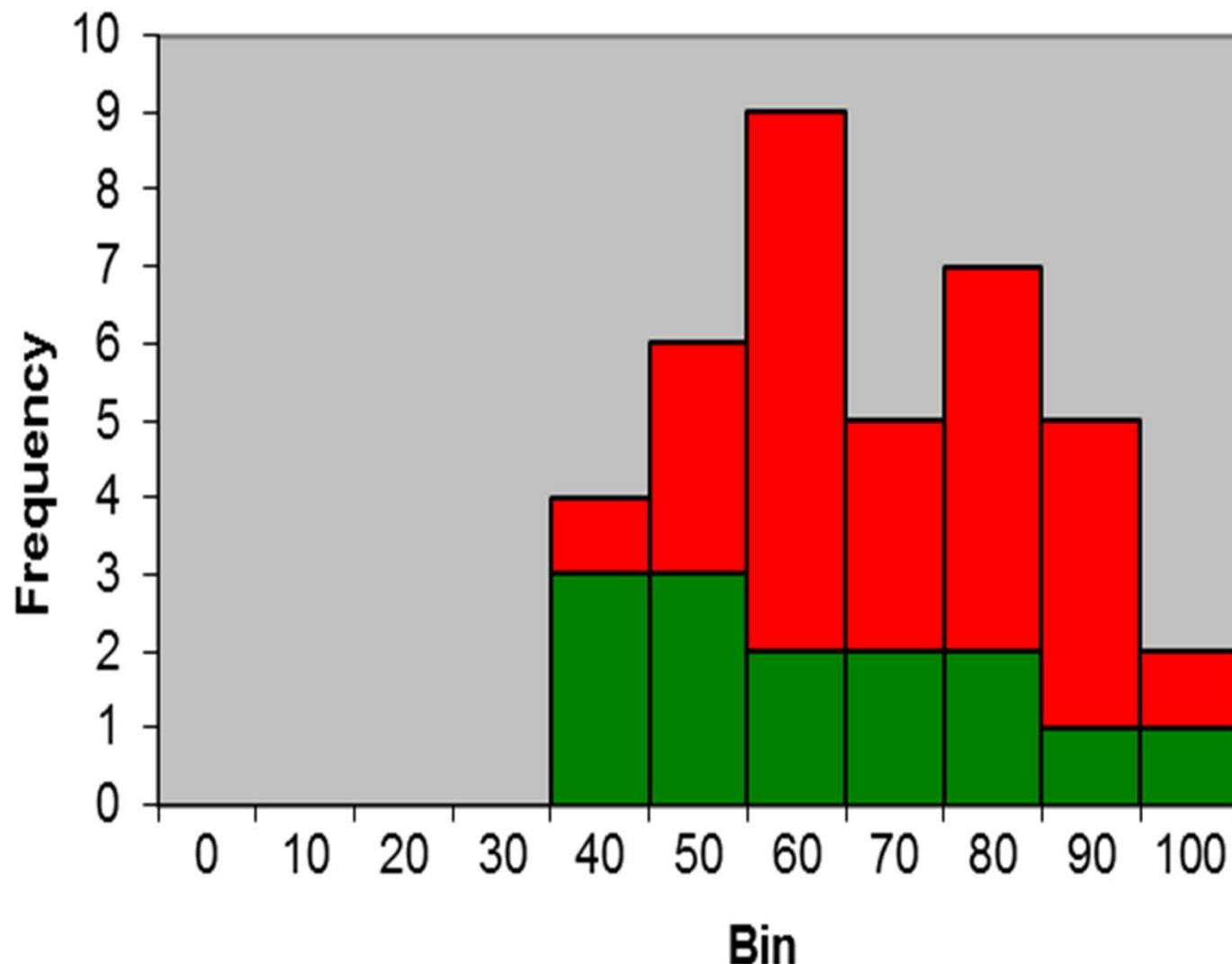
N	38.0
AVE %	41.6
STDEV %	26.2

HYPOTHESES – EVENTS SURVEY

Why do so few of you think Astrology accurately predicted what happened?

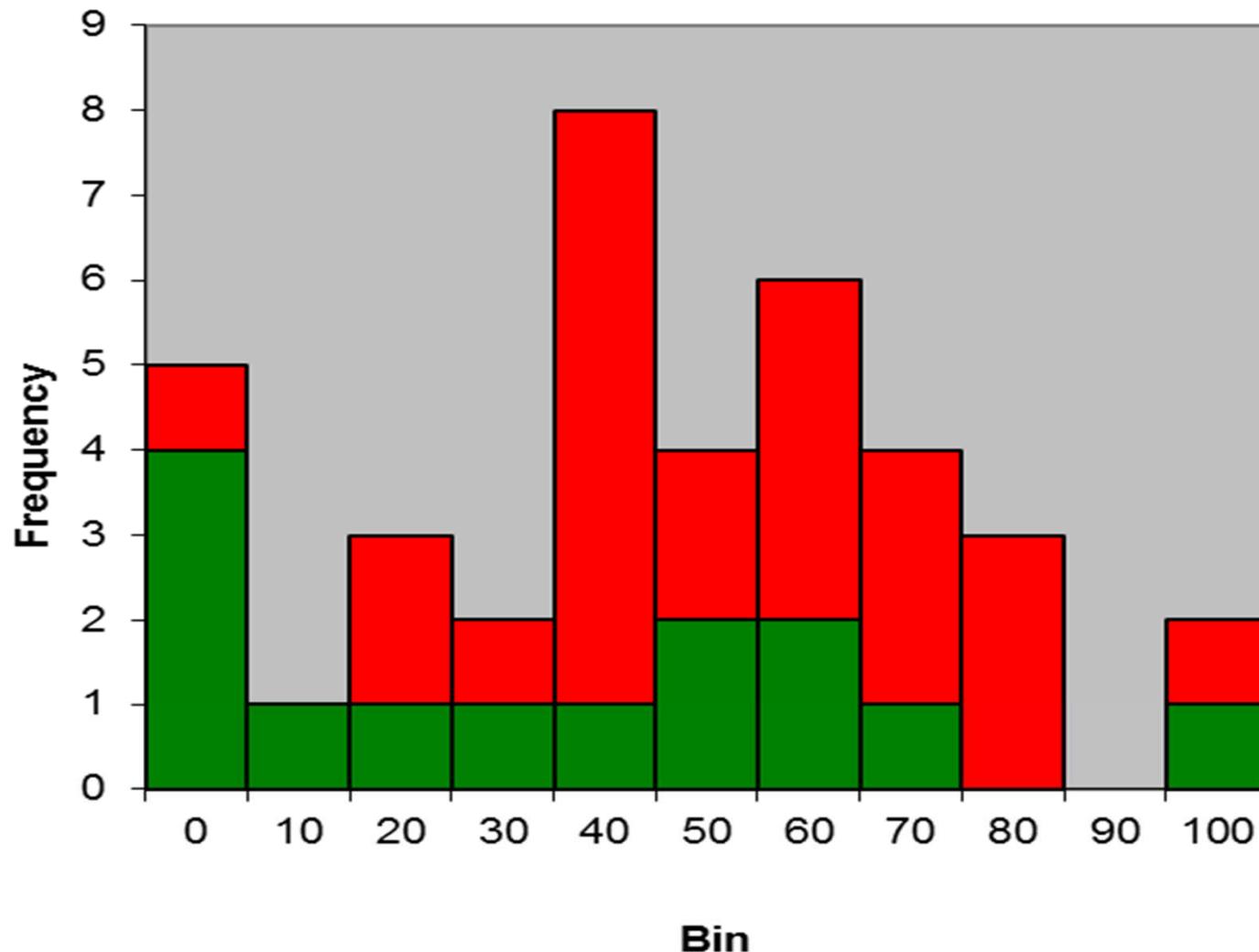
1. The questions were more specific and harder to agree with
2. Not much room for “in between” agreement
3. Multiple parts mean “disagree” if even one part fails

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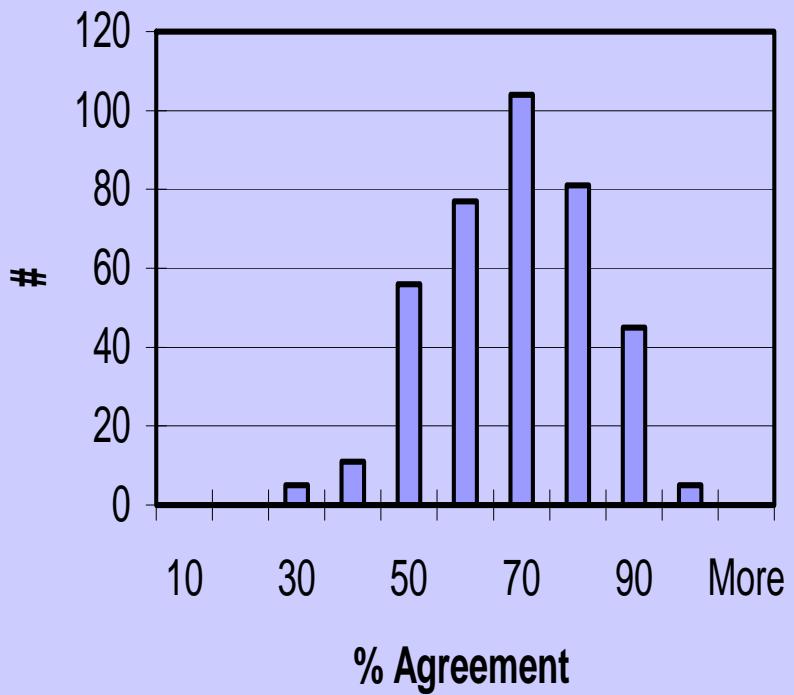
TRAITS	Correct	Incorrect
Bin	Frequency	Frequency
0	0	0
10	0	0
20	0	0
30	0	0
40	3	1
50	3	3
60	2	7
70	2	3
80	2	5
90	1	4
100	1	1
More	0	0
N	14	24
AVE %	71.7	66.5
STDEV %	9.8	15.5
STDVM %	2.6	3.2

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EVENTS	Correct	Incorrect
Bin	Frequency	Frequency
0	4	1
10	1	0
20	1	2
30	1	1
40	1	7
50	2	2
60	2	4
70	1	3
80	0	3
90	0	0
100	1	1
More	0	0
N	14	24
AVE %	49.3	47.4
STDEV %	27.0	22.8
STDVM %	7.2	4.7

TRAITS, Unmatching Surveys

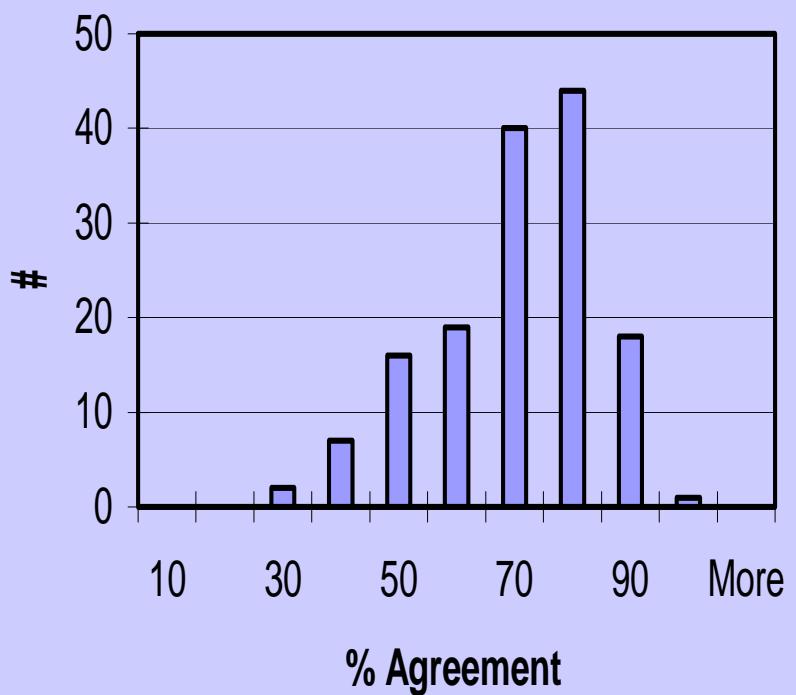


TRAITS

N= 384
AVE% = 63.9
STDEV% = 14.1

0.7

TRAITS, Matching Surveys

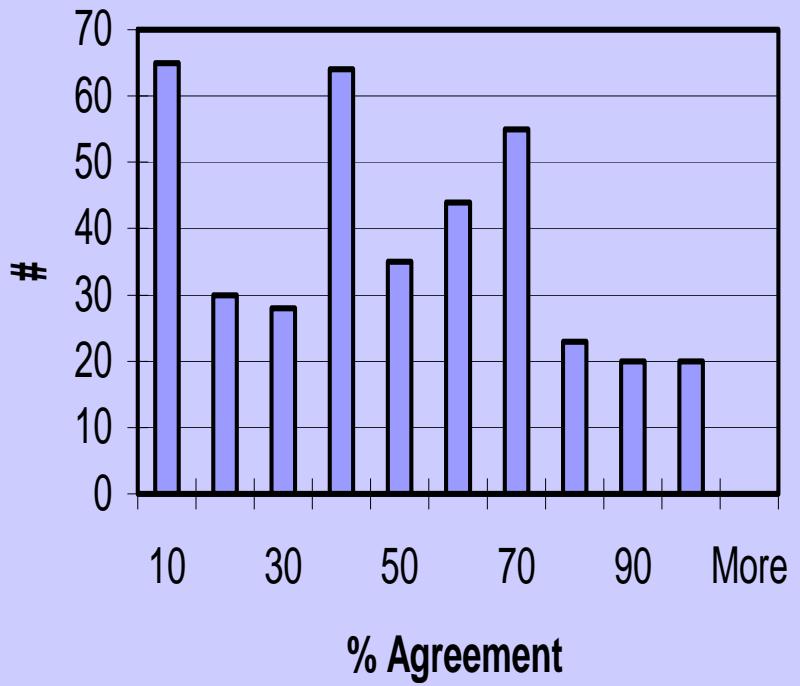


TRAITS

N= 147
AVE% = 65.7
STDEV% = 14.1

1.2

EVENTS, Unmatching Surveys

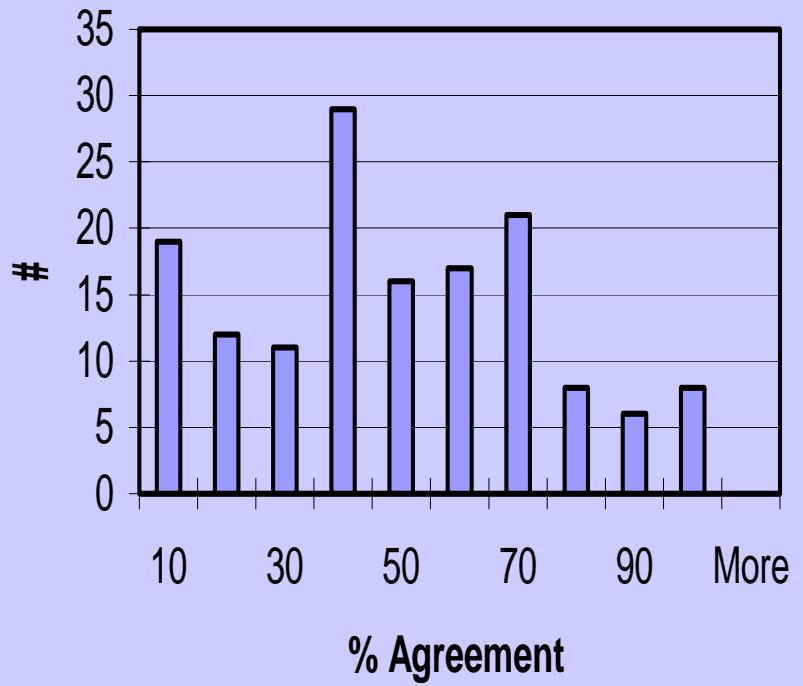


EVENTS

N= 384
AVE% = 44.2
STDEV% = 28.1

1.4

EVENTS, Matching Surveys



EVENTS

N= 147
AVE% = 44.8
STDEV% = 26.5

2.2

So, is astrology valid?

What do you think now?