

Astronomy 330:

Extraterrestrial Life

TR 11:00-12:20
Astronomy 134



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Office Hours:
by appointment or email

This class (Lecture 3):
Pseudoscience
Smackdown
Next Class:
Cosmology?

<http://eeeyore.astro.illinois.edu/classes/astro330h/spring15/>

<https://learn.illinois.edu/course/view.php?id=10593>

She Blinded Me with Science: Thomas Dolby

ASTR 330: Extraterrestrial Life



More Astro Highlights
PseudoScience vs. Science



Note: Presentation Synopsis due Feb 8th

In the News



Flyby of 2004 BL86

Measured by radar

has a small moon

325 meters (1,066 feet) in diameter

3 times Earth-Moon distance

next KNOWN large asteroid | Earth-Moon distance in 2027



ASTR 330: HW #1 Result



Drake Equation



Frank Drake

Drake Equation Results:

Min: 10^{-14}

Max: 10^{13}

Average: 10^{12}

Median: 120

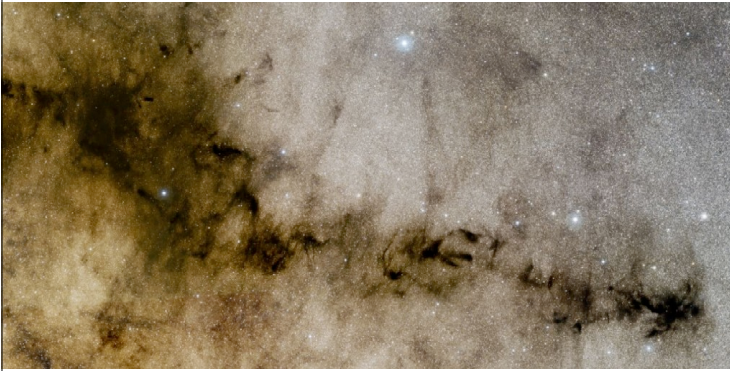


$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

of advanced civilizations we can contact in our Galaxy today Star formation rate Fraction of stars with planets # of Earthlike planets per system Fraction on which life arises Fraction that evolve intelligence Fraction that communicate Lifetime of advanced civilizations

stars/yr systems/star planets/system life/planet intel./life comm./intel. yrs/comm.

What is in *Empty* Space?



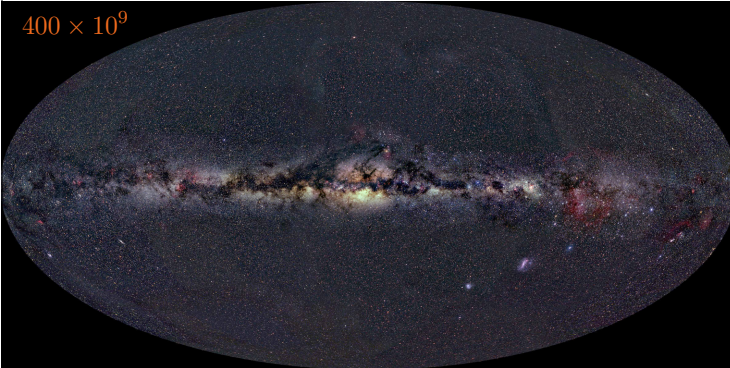
Gas + Dust

5

Milky Way Recipe



400×10^9



Stars + Gas + Dust + *Stuff*

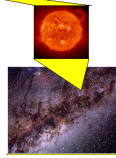
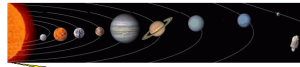
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One of



We are: 8

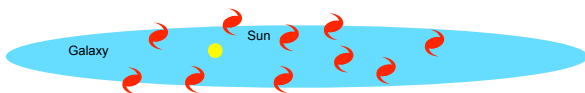
- 1 planet out of ~~X~~ in our solar system.
- 1 stellar system of 100s of billions of stars in our Milky Way galaxy
- What's next? This took until the 1920s to know.



Weird Spiral Nebulae



- Dim, diffuse, “interstellar” nebulae with spiral structure were seen in the 17th century.
- Some disagreement on what they were.

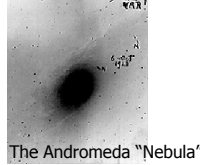


Two views: 1. A galaxy is a spiral “island universe” and the other spiral nebulae are the same and far, far away” 2. “Milky Way is all there is in the Universe, and the spiral nebulae are nearby.”

Edwin Hubble, PI



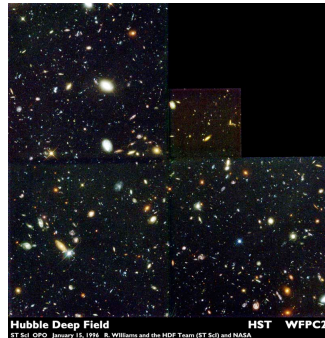
- In 1923, Hubble resolved M31, the Andromeda “Nebula”, into stars
- M31 must be far away!
- Estimated 1 million light-years (modern estimate is 2.5 million light years)
- Andromeda is an “island universe” like our own Galaxy.



Galaxies: “Ecosystems” of the Universe



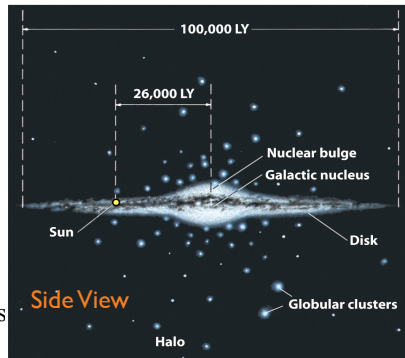
- Galaxies “fill” universe.
- Typical separation **3 million light years!**
- Most distant galaxies are billions of light years away
- Range in size from large (Milky Way-like) to small “Dwarf”
 - 1 billion to 100’s of billions of stars
 - About 300 sextillion (3×10^{23}) stars in the observable Universe!!



The Milky Way



- Globular clusters– oldest stars
- Galactic nucleus– dense collection of stars (center of Galaxy)
- Nuclear bulge– mostly old stars, but very densely packed
- Spiral arms and the disk– mostly young stars and lots of dust
- Note position of the Sun, just over half way out.



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Galaxy Song



Monty Python's The Meaning of Life (1983)

Just remember that you're standing on a planet that's evolving
And revolving at nine hundred miles an hour,
That's orbiting at nineteen miles a second, so it's reckoned,
A sun that is the source of all our power.
The sun and you and me and all the stars that we can see
Are moving at a million miles a day
In an outer spiral arm, at forty thousand miles an hour,
Of the galaxy we call the 'Milky Way'.
Our galaxy itself contains a hundred billion stars.
It's a hundred thousand light years side to side.
It bulges in the middle, sixteen thousand light years thick,
But out by us, it's just three thousand light years wide.
We're thirty thousand light years from galactic central point.
We go 'round every two hundred million years,
And our galaxy is only one of millions of billions
In this amazing and expanding universe.

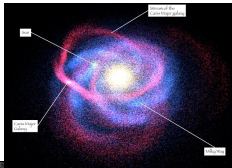
The universe itself keeps on expanding and expanding
In all of the directions it can whizz
As fast as it can go, at the speed of light, you know,
Twelve million miles a minute, and that's the fastest speed there is.
So remember, when you're feeling very small and insecure,
How amazingly unlikely is your birth,
And pray that there's intelligent life somewhere up in space,
'Cause there's bugger all down here on Earth.

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Is the Milky Way Alone?



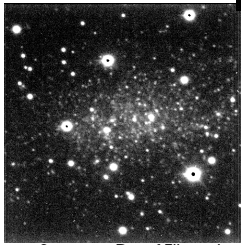
We have lots of neighbors!



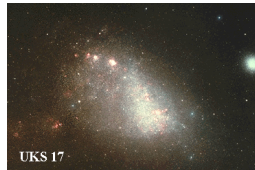
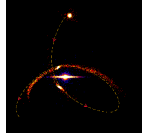
Canis Major
(42,000 ly away)



UKS 14
Large Magellanic Cloud
(180,000 ly away)



Sagittarius Dwarf Elliptical
(80,000 ly away)

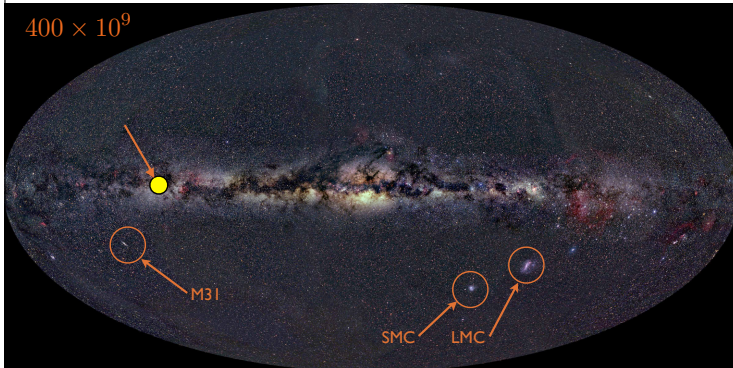


UKS 17
Small Magellanic Cloud
(250,000 ly away)

Checkin out the Hood



400×10^9



The Local Group



- Our Galaxy is in a poor, irregular cluster
- Called the **Local Group**
- Dominated by two large spirals
 - The Milky Way
 - The Andromeda Galaxy (M31)
- About 40 smaller galaxies
 - Some satellites of the big two
 - M33 (small spiral)
 - Lots of dwarfs ellipticals and irregulars



Andromeda (M31)



Triangulum (M33)



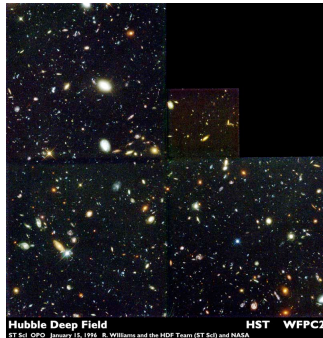
Local Group dwarf galaxies

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Galaxies: “Ecosystems” of the Universe



- Galaxies are the cosmic engines that turn gas into stars and recycles the gas the stars eject, back into stars
- In between, no star formation occurs – “nothing happens” in intergalactic space.



Hubble Deep Field HST WFPC2
ST Sc OPO January 15, 1996 R. Williams and the HDF Team (ST Sc) and NASA

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What's this All about Then?



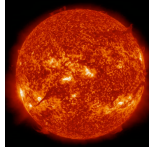
Planets

- Round
- In orbit around a star
- Have cleared their orbit



Stars

- Nuclear burning machines, usually turning hydrogen into helium
- Colors (temperatures: cold/red to hot/blue),
- Sizes (Jupiter-sized to 1000x the Sun)
- Masses (80x Jupiter to 100x the Sun)
- Ages (Just born to nearly the age of the Universe)



Galaxies

- Collection of stars, gas, and dust (huge!)
- Separated by vast distances



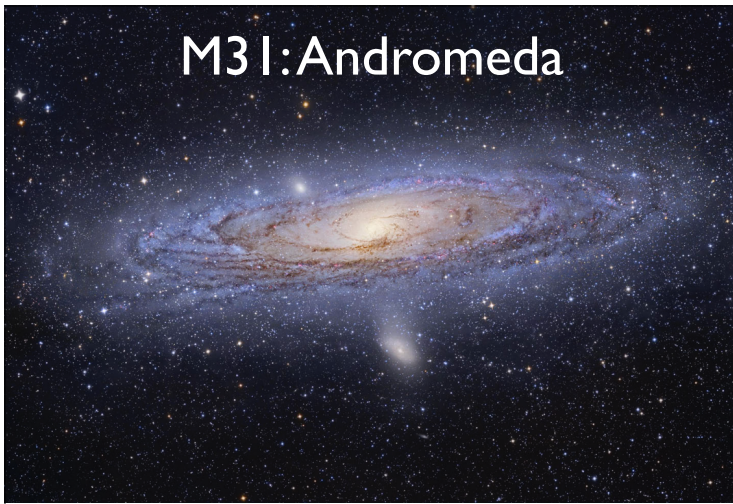
What do we see in the Hubble Deep Fields?



- a) Dark Matter
- b) Many spiral galaxies
- c) Many low luminosity stars
- d) Many galaxies with different shapes, sizes, and colors
- e) Aliens.

iClicker

M31: Andromeda



Distance = 2.5 million light years

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Sombrero Galaxy • M104



Distance = 30 million light years

Hubble
Heritage

NASA and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope ACS • STScI-PRC03-28

M51: Whirlpool



Distance = 31 million light years

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SDSS Virgo



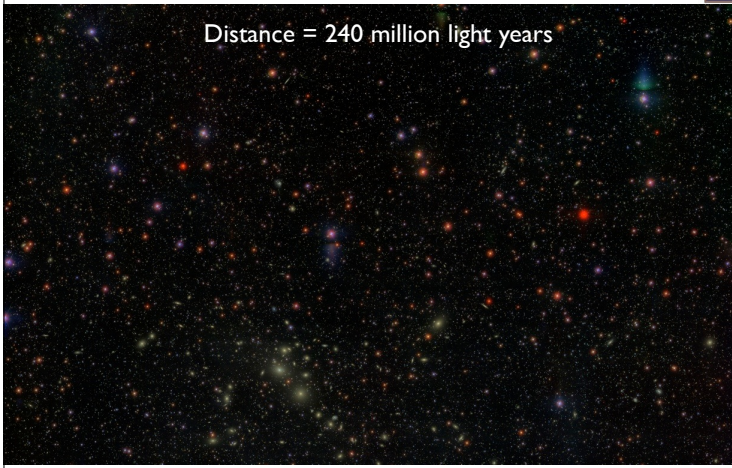
Distance = 54 million light years

22

SDSS Perseus



Distance = 240 million light years



23

SDSS Coma

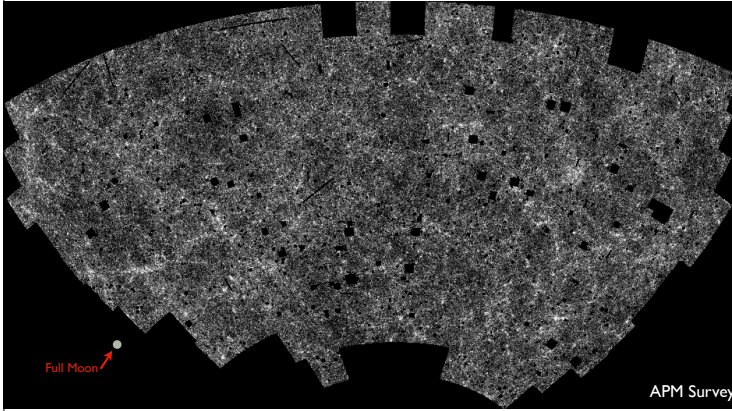


Distance = 333 million light years



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Galaxy Distribution



South Galactic Cap: $100^\circ \times 50^\circ$

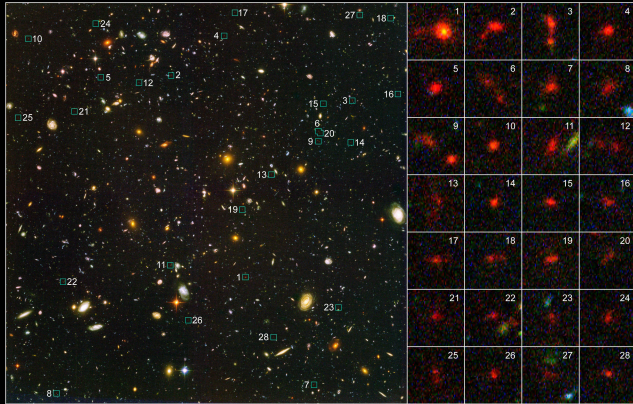
Credit: Maddox et al., Astrophysics Dept., Oxford University

The APM Galaxy Survey is a computer-generated sky survey of over 2 million galaxies and 10 million stars, covering 1.3 steradians (about 1/10 of the whole sky), in the South Galactic Cap, made by **Steve Maddox, Will Sutherland, George Efstathiou & Jon Loveday**, with follow-up by **Gavin Dalton**.

http://www-astro.physics.ox.ac.uk/~wjs/apm_survey.html

credit: Maddox et al, Astrophysics Dept, Oxford University.

A Cosmic Time Machine



Distant Galaxies in the Hubble Ultra Deep Field
Hubble Space Telescope • Advanced Camera for Surveys

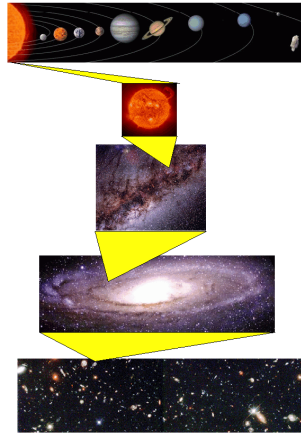
NASA, ESA, R. Bouwens and G. Illingworth (University of California, Santa Cruz)

One of



We are: 8

- 1 planet out of ~~8~~ in our solar system.
- 1 stellar system of 100s of billions of stars in our Milky Way galaxy
- 1 galaxy of the 100s of billions of galaxies in the observable Universe.



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Grouped



In a group write down, in only a few minutes, the definitions of :

1. Science
2. Pseudo-science

Smackdown



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The Scientific Method



1. Make Observation
2. Ask a **Question**
3. Suggest a Hypothesis
 - a tentative explanation
4. Make a **Prediction**
5. Test
6. What are the results?
 - confirm, reject, or modify

These should be the same no matter who conducts the test

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Science



We especially need imagination in science. It is not all mathematics, nor all logic, but is somewhat beauty and poetry.

Maria Mitchell (1818–1889)
Astronomer and first woman elected to American
Academy of Arts & Sciences

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Scientific Thinking



Natural
Human
Behavior

Experiences



Conclusions

Trial & Error → PROGRESS

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Hallmarks of Good Science



- Science seeks explanations for *observed* phenomena that rely solely on natural causes.
- Science progresses through the creation and testing of models of nature that explain the observations as simply as possible.
 - Occam's Razor

Hallmarks of Good Science



- Science seeks explanations for *observed* phenomena that rely solely on natural causes.
- Science progresses through the creation and testing of models of nature that explain the observations as simply as possible.
 - Occam's Razor
- A scientific model must make testable predictions that could force us to revise or abandon the model.

Theory - a model that survives repeated testing

Very different usage than everyday speech!



Occam's Razor



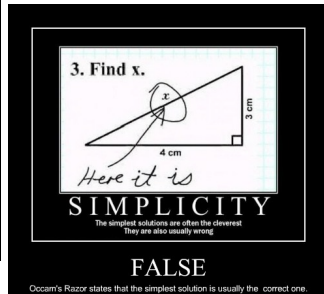
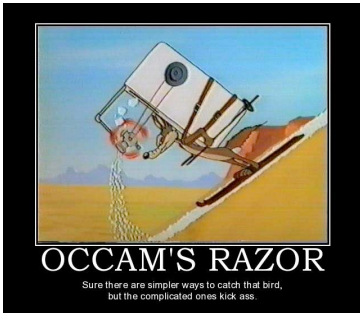
- *Pluralitas non est ponenda sine necessitate* [Latin]
- Given two equally predictive theories, choose the simpler.

Or

- *The simplest explanation is usually the best.*



Occam's Razor



Science Scams



Pseudoscience Definition:

Pseudoscience:

"Claims presented so that they appear scientific, even though they lack supporting evidence and plausibility" - Dr. Michael Shermer

Brian Brushwood

Good or Bad?



The NCCAM continues to fund and promote pseudoscience?

http://en.wikipedia.org/wiki/National_Center_for_Complementary_and_Alternative_Medicine

Other studies funded by NCCAM have included "rats stressed out by white noise" and "energy chelation."

Human Scientists



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Bad Science



Pseudoscience: masquerades as science, but does not follow the scientific rules of evidence

Not Science: establish “truths” through belief

<https://webpace.utexas.edu/cokerwr/www/index.html/distinguish.htm>

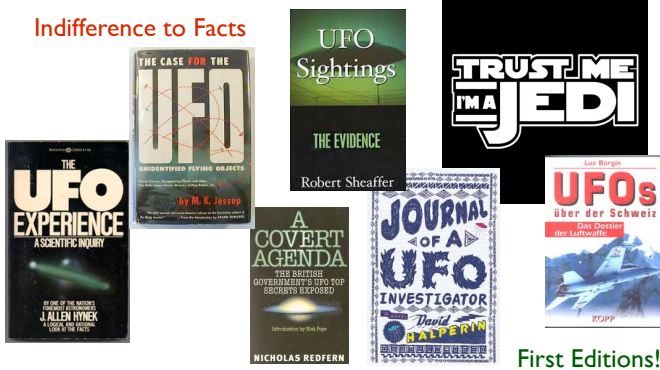
40

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Hallmarks of Pseudoscience

Indifference to Facts



First Editions!

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PSEUDOSCIENCE displays a remarkable and characteristic *indifference to fact*. Writers tend simply to make up bogus “facts”— what Norman Mailer calls “factoids”— where needed, instead of going to the trouble of consulting reliable reference works, much less investigating directly. Yet these fictitious facts are often central to the pseudoscientist’s argument and conclusions! This can also be seen in the fact that *pseudoscientists never revise*. The first edition of any pseudoscience book is almost always the last, even though the book may go through innumerable *new printings*, over decades or centuries. Even a book with obvious mistakes, errors, and misprints on every page is just reprinted as it is, over and over. Compare to college science textbooks, which usually see a new edition every few years because of the rapid accumulation of new facts, ideas, discoveries, experiments and insights in science.

<http://www.icsahome.com/elibrary/studyguides/education/astopsiencevspseudoscience>

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Hallmarks of Pseudoscience

Evidence only supports hypothesis



Militantly Antiscientific

42

PSEUDOSCIENCE begins with a hypothesis— usually one which is appealing emotionally, and spectacularly implausible— and then looks only for items which appear to support it. Conflicting evidence is ignored. Notice how often, when you are asked by a friend about what should be a question of fact if the topic were not pseudoscience, the opening phrase is, “Do you believe in ESP?” (or flying saucers, or prophecy, or Bigfoot)... not, is the evidence good, but rather, do you believe, without raising dull questions of evidence. Generally speaking, the aim of pseudoscience is to rationalize strongly held beliefs, rather than to investigate and find out what’s actually going on, or to test various possibilities. Pseudoscience specializes in jumping to “congenial conclusions,” grinding ideological axes, appealing to pre-conceived ideas and to widespread misunderstandings. Not just Creationists, but 20th Century pseudoscientists of all flavors, from J. B. Rhine and Immanuel Velikovsky to Rupert Sheldrake, have underlying their claims and assertions an anachronistic world-view that essentially rejects *all or most* of the tested, reliable findings of science as “unacceptably materialistic!” The general public tends to view pseudoscientists as “mavericks” who are working slightly beyond the “accepted” boundaries of science. In fact, nothing could be further from the truth. Pseudoscientists invariably represent a world-view which is not simply unscientific or pre-scientific, but rather militantly **antiscientific**.

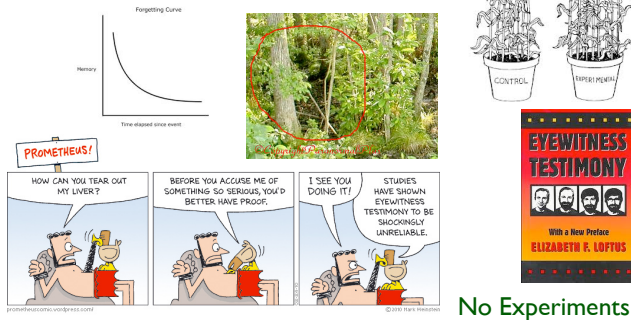
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Hallmarks of Pseudoscience

Indifference to valid evidence



No Experiments

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PSEUDOSCIENCE shows a total *indifference to criteria of valid evidence*. The emphasis is not on meaningful, controlled, repeatable scientific experiments— instead, it is on unverifiable eyewitness testimony, stories, faked footprints, blurry photos, and tall tales, hearsay, rumor, and dubious anecdotes. Genuine modern scientific literature is not cited. Real research is never done. Generally pseudoscientists never present *any valid evidence* of any kind whatsoever for their claims. One of the most bizarre recent tactics of pseudoscientists is to publish a novel, a work of fiction in which essentially everything is made up by the author— as usual in works of fiction!— but then to turn directly around and treat the completely made-up material as if it were actual, factual and researched. Recent examples of this tactic are [The Celestine Prophecy](#), by James Redfield (1994), and [The Da Vinci Code](#), by Dan Brown (2003). This is really having your cake and eating it too, because the authors, when taken to task for gross errors and mis-statements, calmly say, “Can't you read? It's fiction, not non-fiction,” and yet when **not** taken to task for equally gross errors, sneakily treat them as established facts and build upon them to generate yet more best-selling books.

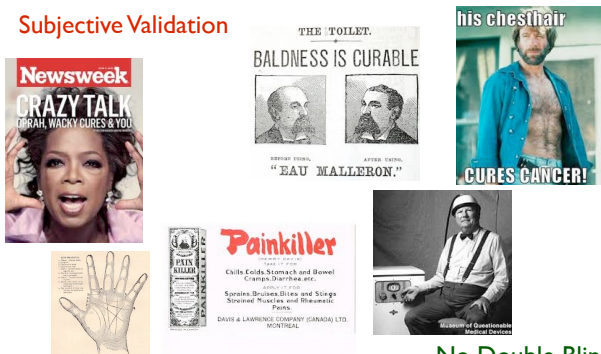
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Hallmarks of Pseudoscience

Subjective Validation



No Double Blind

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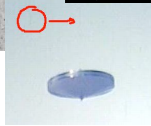
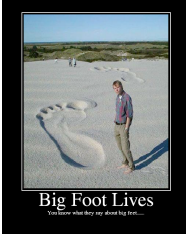
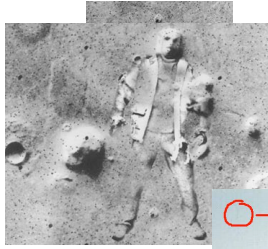
PSEUDOSCIENCE *relies heavily on subjective validation*. Joe Blow puts jello on his head and his headache goes away. To pseudoscience this means jello cures headaches. To science this means nothing, since no experiment was done. Many things were going on when Joe Blow's headache went away— the moon was full, a bird flew overhead, the window was open, Joe had on his red shirt, etc.— and his headache would have gone away eventually in any case, no matter what. Modine Flark reads her newspaper horoscope and says there must be something to astrology because the horoscope describes her perfectly. But when we read it we see it is a perfectly generally true statement that describes just about every human who has ever lived, and has nothing to do with Modine or her birth-stars. These are examples of *subjective validation*, one of the main foundations of popular support for pseudoscience. Essentially all of medical quackery (aka “alternative medicine”) relies on subjective validation entirely for its continued existence. A controlled experiment to study the effectiveness of a headache remedy, for example, would put a large number— thousands or tens of thousands— of people suffering from headaches in identical circumstances, except for the presence or absence of the remedy it is desired to test, and compare the results... which would then have some chance of being meaningful. Subjective validation renders such studies meaningless unless they follow a so-called **Double-Blind** protocol, which insures that no one involved in the study knows what the results “should be.” That is, no one in the study should know until final results have been

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Hallmarks of Pseudoscience

Avoid testing claims



No Repeatability

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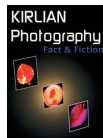
PSEUDOSCIENCE always avoids putting its claims to a meaningful test. Pseudoscientists never carry out careful, methodical, convincing experiments themselves— and they also generally ignore results of such experiments that are carried out by scientists. Pseudoscientists also never follow up. If one pseudoscientist claims to have done an experiment (e.g., the “lost” biorhythm studies of Hermann Swoboda that are an alleged basis of the modern pseudoscience of biorhythms), no other pseudoscientist ever tries to duplicate it or to check his supposed results, even (and especially) when the original results are lost or questionable! Further, where a pseudoscientist claims to have done an experiment with a remarkable result, he himself almost never repeats it to check his results and procedures. This is in extreme contrast with science, where crucial experiments are performed over and over, by scientists all over the world, with ever-increasing precision. When pseudoscientists became extremely excited by fuzzy 1980s photos of a “face on Mars,” they somehow never wanted to look at or even hear about 1990s and later photos which show the area with much sharper resolution, and do not show any “face.” Those who believed that the measurements of the Pyramid of Cheops contain secret information encoded by Gods or Space Aliens were somehow never found making any measurements themselves. Nor did it ever occur to practitioners of “therapeutic touch,” which involves ritual hand-waving to manipulate and smooth the “human energy field,” to demonstrate experimentally that such a field (completely unknown to science) actually exists. Believers in the supernatural wonders of crop circles never bother to take a clothesline and a broomstick and see how simple it is to make a circle precisely like the ones they find “inexplicable.” Those who say the UFO photos of George Adamski or Billy Meier or Ed Walters convince them

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Hallmarks of Pseudoscience

Progress is not made



No new knowledge!

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PSEUDOSCIENCE does not progress. There are fads, and a pseudoscientist may switch from one fad to another (from ghosts to ESP research, from flying saucers to psychic studies, from ESP research to looking for Bigfoot). But within a given topic there is no progress made, no new information uncovered; new theories are not forthcoming; old concepts are never modified or discarded in light of new discoveries, since there are no new discoveries for pseudoscience. The older the idea, the more respect is given it. ESP experiments started at about the same time as research into the nature of electromagnetic radiation. They're still guessing cards in the ESP labs and yet applications of electromagnetism have completely revolutionized the world, time and time again, since the 1880s. No natural phenomena or processes previously unknown to science have ever been discovered by pseudoscientists. Indeed, pseudoscientists almost invariably deal with phenomena well known to scientists, but little known to the general public— so that the public will swallow the total misrepresentations of the phenomena that the pseudoscientist wants to make. Classic examples: firewalking, Kirlian and orb photography, “psychic motors.”

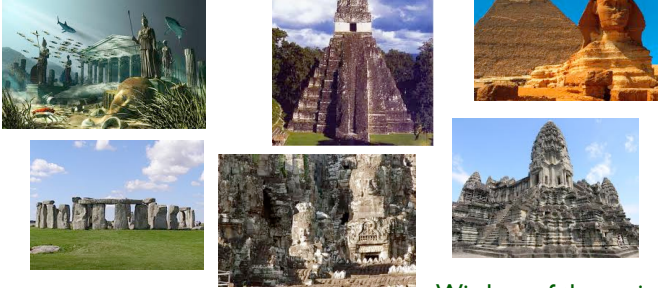
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Hallmarks of Pseudoscience

Relies on anachronistic thinking



Wisdom of the ancients

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PSEUDOSCIENCE *relies heavily on anachronistic thinking.* The older the idea, the more attractive it is to pseudoscience— it's the wisdom of the ancients!— very especially if the idea is transparently wrong and has been discarded by science for centuries. Bogus wisdom of the ancients, as in Theosophy, whose supposedly ancient sacred texts were actually inventions of Madame Helena P. Blavatsky in the late 19th Century, is just as effective as authentic holy ravings from 2000 or 3000 years ago. The *claim* of being ancient is all that is important. When Dolores Krieger invented the pseudoscience of **Therapeutic Touch**, she initially used the vocabulary of Theosophy to describe the imaginary mechanism that was the basis of the quack therapy, but a few years later she swapped traditions by switching completely to the vocabulary of traditional Chinese healing magic. One tradition is as good as any other, but there has to be a tradition!

<http://www.icsahome.com/elibrary/studyguides/education/astopsciecevspseudoscience>

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Hallmarks of Pseudoscience

Invented vocabulary



Sounds scientific

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PSEUDOSCIENCE *makes heavy use of an invented vocabulary* in which the new terms introduced do not have precise or unambiguous definitions, and most have no definitions at all. The listener is forced to interpret the statements according to his or her own preconceptions. What, for instance, is "biocosmic radiation energy?" Or a "psychotronic amplification system?" Or the "Intelligent Design Hypothesis?" Or the "Zero Point Vacuum Free Cosmic Energy Motor?" Or "craniosacral therapeutic osteopathy"? By spouting gibberish that has a vaguely "technical" sound, the pseudoscientists and crackpots believe they imitate the jargon of actual scientific and technical fields. Pseudoscientists also like to take terms from actual science, such as "energy," and drain them totally of meaning, then use them as senseless, referentless buzzwords. Quack "healers" babble a lot about **energy**, but nothing they say has anything whatsoever to do with physics or biology or with any aspect of reality.

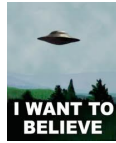
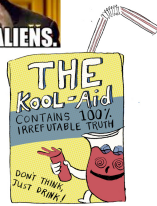
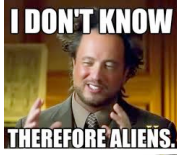
<http://www.icsahome.com/elibrary/studyguides/education/astopsciecevspseudoscience>

Doctor Truth



Hallmarks of Pseudoscience

Claim one side of legitimate scientific debate



Jury is still out ...

PSEUDOSCIENCE often pretends to be one side of a legitimate scientific controversy. That is, pseudoscientists like to pretend that “the jury is still out,” and that “further research” is needed to clarify the validity of their beliefs. This is essentially **never the case**. There is no controversy among astronomers concerning astrology— they unanimously agree it is nonsense. There is no controversy among physicists concerning Velikovsky's ideas— they are unanimously condemned as simply wrong. There is no controversy among biologists regarding “Intelligent Design”— it is dismissed as a set of religion-based beliefs empty of scientific content. There is no case known to me in which a pseudoscientist's claims have taken advantage of any genuine scientific controversy. Instead, pseudoscientists operate entirely outside science, and their claims and beliefs are not relevant to any known scientific puzzle or uncertainty. One frightening trend observed more and more strongly during the last half of the 20th Century was the incorporation of **contrarian pseudoscience** into the core beliefs of various fundamentalist religions, so that today a fundamentalist is almost certain to deny the facts of global warming, biological evolution, human origins, etc., and to affirm that basic scientific research is essentially of no value.

There is general agreement among interested observers that, over the past two decades, Americans have grown increasingly indifferent to the often-demonstrated fact of their **ignorance** of even the most basic scientific discoveries of the last four centuries, and increasingly unconcerned that US **K-12 students** generally tie for last place in knowledge of math and science, in comparisons among 70 or more nations. An actual and naked hostility to science and scholarship has been tied up seemingly inextricably with political and religious ultra-conservatism.

Doctor Truth (Summary)



Hallmarks of Pseudoscience

Use of vague, exaggerated or untestable claims

Over-reliance on confirmation rather than refutation

Lack of openness to testing by other experts

Personalization of issues

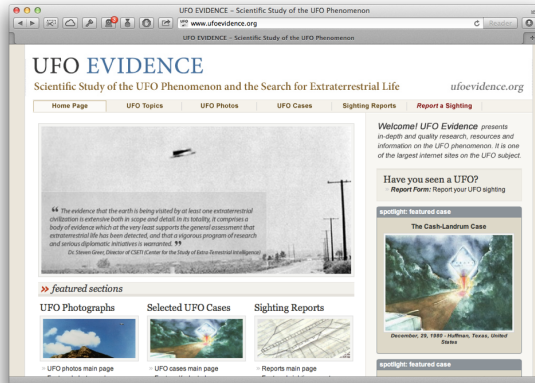
Use of misleading language

Science	Pseudoscience
Willingness to change with new evidence	Fixed ideas
Ruthless peer review	No peer review
Takes account of all new discoveries	Selects only favourable discoveries
Invites criticism	Sees criticism as conspiracy
Verifiable results	Non-repeatable results
Limits claims of usefulness	Claims of widespread usefulness
Accurate measurement	"Ball-park" measurement



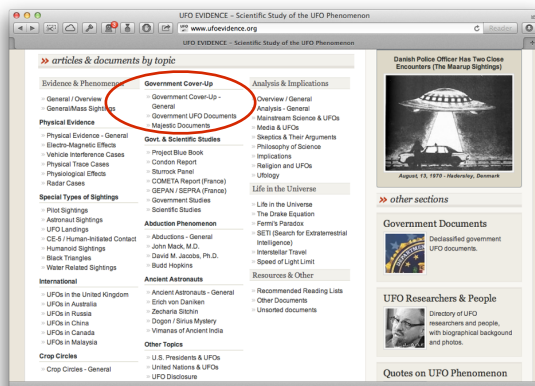
TRUTH hurts

Pseudoscience?



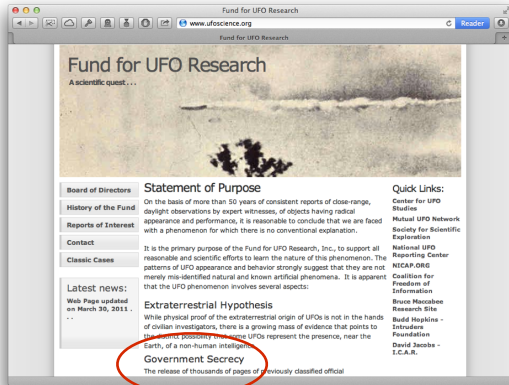
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Pseudoscience?



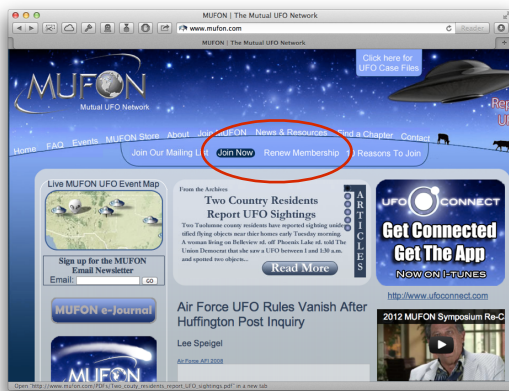
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Example



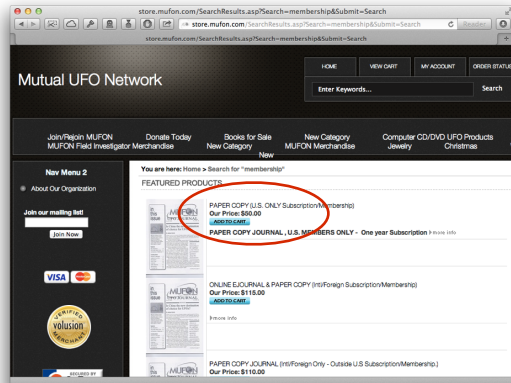
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Example



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Example



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Question



A

What item do these pseudoscience website not advertise?

- a) Peer reviewed published literature
- b) Suggestion of government cover-up
- c) Solicitation of payments
- d) Inclusion to a small group of believers
- e) Often vague or overly complicated technical descriptions

iClicker

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Next Time



Cosmology