"Using examples ranging from Monty Python to Monty Hall, *The Skeptics' Guide to the Universe* offers the first ever page-turner that teaches you how to think clearly."

—Paul A. Offit, MD, author of *Bad Advice: Or Why Celebrities, Politicians, and Activists Aren't Your Best Source of Health Information*

"If everyone in the world were to read this book, we might just arrest humankind's depressing slide into truthlessness. Someone should put *The Skeptics' Guide* on the vaccination schedule."

—Tim Minchin, musician/comedian

"If there's one thing we all need in these confusing and stressful times, it is clear thinking and accurate appraisals of the information flooding our senses. Thankfully, this book gives to the reader precisely the tools needed to bring this about. *The Skeptics' Guide to the Universe* is an essential resource for a lifetime of critical thinking and analysis."

—Michael Whelan, award-winning artist and author of *The Art of Michael Whelan* and *Beyond Science Fiction*

"Our lack of critical thinking skills and embarrassing scientific illiteracy are among the most critical issues of our time. We are drowning in a sea of myths, lies, deceptions, fakes, and superstitions. We are inundated and surrounded by pseudoscience and illogic. We have lost our way. The timing couldn't be better for the publication of a brilliant new book, *The Skeptics' Guide to the Universe*. It's a friendly, comprehensive, clear, and direct guide to these pressing issues and guess what…it's a hell of a lot of fun to read."

—Dean Edell, MD, host of the *Dr. Dean Edell Show* and author of *Eat, Drink & Be Merry*

The SKEPTICS' GUIDE to the UNIVERSE

How to Know What's Really Real in a World Increasingly Full of Fake

DR. STEVEN NOVELLA

with **BOB NOVELLA, CARA SANTA MARIA, JAY NOVELLA, AND EVAN BERNSTEIN**

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At the other end of the spectrum is poor Neal Adams. He desperately wants to be taken seriously as a scientist, but he has done none of the actual work. He has nothing except wacky ideas based on his own superficial observations, and he blithely suggests a cascading transformation of virtually all of modern science to accommodate his wild notions.

Somewhere in the middle is Daryl Bem and his ESP research. He is following standard scientific protocol, to an extent, but is overwhelmed by his own biases. In the end he's created a great example of pseudoscience, with all the trapping of science but failing to rigorously prove his main hypothesis.

23. Skeptics' Guide Entry: Denialism

Section: Science and Pseudoscience
See also: Pseudoscience

Denialism or science denial refers to the motivated denial of accepted science using a series of invalid strategies.

> I deny nothing, but doubt everything. —Lord Byron

Denialism is a real thing, by which I mean that denialism is a definable intellectual strategy with consistent features that tend to cluster together. Denialism begins with the desire to deny an accepted scientific or historical fact, and therefore, like all pseudosciences, works backward from the desired conclusion.

In fact denialism is a subset of pseudoscience, one that tries to cloak itself in the language of skepticism while eschewing the actual process of scientific skepticism. Denialism exists on a spectrum with skepticism, without a clear demarcation between the two (similar to science and pseudoscience). People tend to use themselves for calibration—anyone more skeptical than you is a denier, and anyone less skeptical than you is a true believer.

At this point, science denial has become common in our society and may be more impactful than the promotion of pseudoscientific beliefs that are not true. There are ideological movements that deny the scientific consensus of anthropogenic global climate change, the modern

synthesis of evolutionary theory, the germ theory of disease, that the brain causes consciousness, the existence of mental illness, that HIV causes AIDS, and the safety and effectiveness of vaccines.

There are even those who deny the existence of denialism itself, arguing that this is just a rhetorical device to shut down criticism of mainstream ideas. They miss the fact that denialism relies upon a set of invalid logical strategies—it's defined by these features, not the belief itself.

As you will see, many of the strategies used by deniers are insidious because they are extreme versions of reasonable positions. Some of their underlying principles are sound. It's their specific application that's the problem.

What follows is a list of some of the most prevalent denialist strategies.

Manufacture and Exaggerate Doubt

Doubt is key to skepticism and science. The absence of doubt is gullibility. This feature, most of all, is what makes denialism pseudoskepticism. The problem with the denialist approach is that doubt is not used as a tool of honest questioning but rather for undermining a belief one doesn't like.

This strategy can also be called "just asking questions" or "JAQing off." You can often tell the difference between science and denialism because, when true scientists ask a question, they want an answer and will give due consideration to any possibilities. Deniers, on the other hand, will ask the same undermining questions over and over, long after they have been definitively answered. The questions—used to cast doubt—are all they are interested in, not the process of discovery they're meant to inspire.

Of course, there is always doubt in science. Science is never 100 percent certain about anything, because science is not about certainty. It's not even really about proving things, but rather *dis*proving them. Science is also not directly about truth, but rather about building testable models that predict how the universe behaves.

Scientific theories become progressively more accepted as they survive serious attempts at proving them wrong. Such acceptance is provisional, however, as the next experiment or observation could potentially falsify any theory. Theories are favored when they have useful explanatory power and are consistent with other accepted theories as we slowly build one coherent model about how the universe works.

Scientific literacy means not only understanding what the best current scientific explanation of a phenomenon is, but also how sure we are that the current answer is correct, and how complete an answer it is (what does it leave unexplained?). Some theories are controversial, others simply unknown, while still others are fairly robust. At the extreme end of the spectrum are those theories that are, as Stephen Jay Gould noted, "confirmed to such a degree that it would be perverse to withhold provisional assent."

Deniers exaggerate our current level of doubt about a scientific theory and minimize what is known. They perversely withhold even their provisional assent. Often they take this strategy to the extreme of denying that we can know anything—they deny scientific knowledge itself.

As part of this strategy, they will likely appeal to the fact that scientific knowledge has changed over time. If scientists were wrong in the past, they can be wrong now. Of course, no one denies that current scientific knowledge is provisional—that misses the point entirely. They are essentially making a false analogy between a prior belief that wasn't well established and one that is currently very robust, even rock-solid.

Always Ask for More Evidence than Exists or Can Exist

Perhaps the core logical fallacy of the denier is moving the goalposts, a technique described in chapter 10: They ask for evidence, and when that evidence is provided, they demand still more evidence. Nothing will ever satisfy them.

This is very different from how science normally operates. After preliminary research clarifies the questions being asked and how the evidence relates to current theories, scientists supporting competing

theories will often put their nickel down—they'll state exactly what evidence will refute their theory, refute competing theories, or will change their mind about which theory is superior. When the evidence comes in, scientists will actually change their mind. Of course, individuals don't always change their mind with the evidence, but enough do to shift the consensus to the theory supported by the evidence.

Deniers rarely do this. When their questions are answered or their demands for evidence met, they simply slide over to another question. Nothing will convince them because they've already decided on the answer.

For example, evolution deniers are fond of pointing out gaps in the fossil record or our knowledge of which species evolved from which ancestors. They take a snapshot of our current scientific knowledge and argue that the existence of gaps in that knowledge calls into question the more fundamental conclusions about what is happening. Because we cannot prove, for example, what group birds evolved from, evolution itself is questioned (the previously mentioned "god of the gaps" strategy).

Scientific theories, however, are better judged by how useful they are than what they can currently explain. What evolution deniers should be asking is not what evolution can explain right now, but how has it fared over the years? Specifically, if evolutionary theory is useful and correct, those gaps should be shrinking over time. How they change over time is more telling than how big they are at any one moment in time.

Anyone even casually familiar with evolutionary biology knows the answer to this question: Those gaps have been steadily decreasing. The gaps between humans and our closest ape relative, birds and dinosaurs, whales and terrestrial animals, fish and tetrapods, and many others have been filled in nicely in the last century.

Evolution deniers pointed to all these gaps in the past, and when they were filled in, they never acknowledged that fact. They just focused on another gap. One of their favorite gaps now is the one between bats and other mammals. When that one gets filled they'll move on to something else.

All this goalpost moving can be tiring, however, so some deniers

use a simpler strategy—they simply ask for more evidence than can possibly exist.

Sticking with evolution as an example, they will ask for one fossil that proves evolution. This, of course, is impossible, because evolution is a complex process. There are similar calls from HIV deniers to point to one paper that proves the human immunodeficiency virus is the sole cause of the acquired immune deficiency syndrome. These claims require dozens, even hundreds, of individual studies added together.

Anti-vaccinationists who deny the safety and effectiveness of vaccines commonly ask for a randomized vaccinated-versus-unvaccinated study. While this may seem reasonable at first, they know such a study will never be done. They are essentially requiring a study that randomizes children to receive no vaccines at all. It's unethical: Vaccines are already part of the standard of care because they have proven benefits. In a clinical trial you cannot randomize subjects to not receive standard treatment.

They set the bar this high so they can deny the value of all other evidence that shows vaccines are safe. There are vaccinated-versus-unvaccinated studies, just not randomized, and there are many other types of studies showing the safety of vaccines.

This strategy also uses special pleading. If a study shows that there is no association between the timing of vaccines and the incidence of autism or any other outcome, they'll say that the effect is delayed or is from the vaccines the mother received while pregnant. If there's no dose response, that's because maximal negative effects are reached at tiny doses. If an ingredient is removed, then trace amounts are sufficient to have the negative effect, or some other ingredient is to blame. No evidence will ever be enough.

Use Semantics to Deny Categories of Evidence

As part of the strategy to deny evidence for the scientific theory they wish to dismiss, deniers will often play word games to exclude entire categories of evidence. For example, evolution deniers have argued

that anything that happened in the past is beyond the reach of science. Science is about experiments, and you cannot run an experiment on evolution, therefore evolution is not even science.

This is an artificially narrow definition of science, however. Science is about using empirical evidence to test hypotheses. The past leaves traces of itself behind—evidence. We can ask falsifiable questions about what happened in the past, including evolution. Obviously, fossils are left behind, but so are the genes and other features of living things.

Those who deny the existence of mental illness play similar semantic games. They narrowly define illness as pathological disease, meaning that there has to be something objectively abnormal about cells, tissues, or organs. This description does apply to some diseases, but not all: There are disorders that are defined by the way some organ or system is functioning, but in the absence of clear pathology. Migraine headaches, for example, are a clear disorder without any diagnosable pathology.

There are many brain disorders, because brain function depends upon more than just the health of brain cells. Healthy brain cells may still be organized and networked in such a way that their function is disordered. The brain is the organ of mood, thoughts, and behavior. Disordered brain function may therefore lead to a mood disorder or thought disorder. We call such entities mental illness.

Mental illness deniers (such as Scientologists, who are against the psychiatric profession) don't speak meaningfully about the relationship between brain function and symptoms of mental disorders, but rather use semantics to deny that such things even exist.

Interpret Disagreements About Details As If They Call the Deeper Consensus into Question

To understand this feature of denialism you have to first understand something about science itself. As science progresses it tends to dig deeper into finer and finer details about how nature works, and

hopefully achieves a more fundamental understanding. It's important to think of scientific knowledge as acting on different levels, with some levels being deeper than others.

For example, it was known since antiquity that certain traits can be passed down from parents to children. It's obvious that children look like their parents. It was thought, however, that the biological mechanism for inheritance was a pattern, a little homunculus curled up inside each sperm that was the template for the child.

Mendel and others discovered that some traits seem to be inherited discretely. When you cross a yellow pea with a green pea, you get some pattern of yellow and green peas, not mixed yellow-green peas. This trait didn't blend.

Not all traits work that way, but it showed that some are transferred as discrete units, or genes. At that point, we hadn't identified the molecule that carried this information. Some scientists thought it would be proteins, but it was eventually demonstrated convincingly that the molecule of inheritance is DNA.

That DNA carries genes and heritable information is now so well established that it can be considered a scientific fact. Yet there remained a great deal we didn't know about DNA and genes. We later discovered the genetic code, how that code is translated into proteins, and how DNA function is regulated. We still have many more details to learn about DNA.

But—and here is the critical part—nothing we currently don't know about DNA or will learn in the future can possibly change the basic fact that DNA is the primary molecule of inheritance. Scientists arguing about the details of gene regulation or stating how much we don't know about the evolution of the genetic code doesn't call into question this fundamental fact.

That, however, is exactly what many denialists argue. That is, in fact, the favorite strategy of neuroscience denialism, specifically the denial that consciousness is essentially the functioning of the brain.

Dualists—or those who think that the brain doesn't explain consciousness—point to what we currently don't know about how the

brain produces consciousness, which shouldn't reduce our confidence in the conclusion that the brain does indeed cause consciousness.

The same is true for evolution. That life is the result of common descent through an evolutionary process has been demonstrated beyond any reasonable scientific doubt. There is no competing theory that can come even close to accounting for the evidence we have, or that has been as successful in predicting what we will find when we explore biology. Evolution is a slam dunk. But, of course, there is always complexity and argument in the details: What, exactly, evolved from what? What is the pace and tempo of evolution? Have we accounted for all the forces at work?

These are all interesting questions, but none of them call into question the fact that evolution occurred.

Deny and Distort the Consensus

Magnifying disagreements among scientists is easy, because such disagreements are always present. This strategy can take two basic forms. The first is to magnify the implication of the disagreement, as I described above. The second is to present a small minority dissent as if it's a mainstream controversy.

You can almost always find some scientists somewhere to disagree with even the most solid scientific consensus. I've argued that this is a good thing. Complacency can lead to stagnation in science, and it's always good to have someone shaking the tree. But such dissent needs to be put into context. Sometimes it's a genuine controversy and the science can go either way. Other times the science is solid and the dissent is insignificant.

Recent political controversies over anthropogenic global warming (AGW) have brought the consensus argument to center stage. Defenders of AGW argue that there is a strong scientific consensus that the globe is warming due to human activity. A 2013 survey of the published scientific literature, for example, described its method and findings as follows:

> We analyze the evolution of the scientific consensus on anthropogenic global warming (AGW) in the peer-reviewed scientific literature, examining 11 944 climate abstracts from 1991–2011 matching the topics 'global climate change' or 'global warming.' We find that 66.4% of abstracts expressed no position on AGW, 32.6% endorsed AGW, 0.7% rejected AGW and 0.3% were uncertain about the cause of global warming. Among abstracts expressing a position on AGW, 97.1% endorsed the consensus position that humans are causing global warming.

This was the source for the famous "97 percent" consensus figure that is widely quoted (although it doesn't refer to 97 percent of climate scientists but rather 97 percent of published studies that either explicitly or implicitly expressed an opinion about AGW). This is in line with other research on the question. Another way to establish a scientific consensus is for scientific organizations to review the evidence and then make a determination. The 2013 Intergovernmental Panel on Climate Change report, for example, concluded with 95 percent confidence that AGW is real.

There is also a very strong consensus that currently available genetically modified organisms are safe for human consumption. More than twenty international scientific organizations have reviewed the research and independently come to this conclusion. For example, in 2013 the American Association for the Advancement of Science concluded that "the science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe."

Turning to evolution, 98 percent of the world's scientists in biological fields agree with the consensus that life is the result of organic evolution.

Deniers will not only deny that a consensus exists, they'll often deny that a scientific consensus is meaningful. They try to portray referring to a robust scientific consensus as an "argument from authority" logical fallacy. This, of course, is not the case. That fallacy is the result of inappropriately relying upon an individual as if they

were a sufficient authority or relying upon the opinion of those without appropriate expertise (such as celebrities). It can also be a fallacy if it's used to deflect valid criticism or evidence.

For a nonexpert to cite a legitimate consensus of experts, however, isn't a fallacy. In fact, substituting your own nonexpert opinion in place of a robust consensus of recognized experts is the dubious approach.

Appeal to Conspiracy, Question the Motives of Scientists

It is easy to portray someone's motives as sinister. There's always some way to weave a tale about how scientists are biased or corrupt. Such claims can be manufactured out of whole cloth as needed.

While bias and corruption certainly exist, that doesn't mean it is reasonable to assume that any science with which you disagree can be casually dismissed as entirely the result of such corruption. But that's exactly what deniers do.

Deniers of global warming would, for instance, have you believe that climate scientists throughout the world decided to manufacture an elaborate hoax in order to increase their funding. To support their allegations, they engineered "Climategate" by trolling through thousands of hacked e-mails until they found some statements that could be taken out of context.

Anti-GMO (genetically modified organism) activists have employed the same strategy. Just read the comments to any article on GMO and see how long it takes for anyone defending the science of GMO to be labeled a Monsanto shill. US Right to Know (an anti-GMO group funded by the organic lobby) has used Freedom of Information Act (FOIA) requests to demand the e-mails of public scientists. They then scour these e-mails looking for anything that can be made to seem sinister. Any connection to industry, no matter how innocent or appropriate, is spun into a narrative of nefarious corporate shilling.

And, of course, evolutionary biologists just hate God.

At the reasonable end of the spectrum is the sensible requirement

for full disclosure of potential conflicts of interest, so readers can judge for themselves the integrity of the source. This can easily slide into a witch hunt, however, with even the thinnest and most tenuous connection used to argue that a scientist is actually a paid insider and should be completely discounted.

Appeal to Academic/Intellectual Freedom

Personal freedom is highly valued in US culture (and elsewhere), so the appeal to personal freedom is especially effective, which explains its popularity as an argument. Laws meant to shield charlatans from being held responsible for the proper standard of care in medicine are sold as "health care freedom" laws. Creationist attempts to undermine the teaching of evolution are framed as "academic freedom." Anti-vaccinationists, of course, are constantly advocating for the parent's right to choose.

What all such movements miss, however, is that science, academia, and professions have standards. Maintaining standards isn't anti-freedom, but it is easy to misrepresent it as such and to portray all attempts at promoting high standards as "elitism."

Universities, for example, are under no obligation to allow any crank to teach nonsense in their name. They do, however, have a responsibility to their students to teach only academically valid material.

Argument from Consequences

Accepting a particular science may be inconvenient for a specific political or religious ideology, and pointing out this inconvenience in order to deny the science is also extremely common. Creationists argue that accepting evolution will undermine belief in God and even result in moral decay. Global warming deniers argue that accepting the "alarmist" claims about climate change will result in a government takeover of private industry. I characterize this strategy as

an argument-from-final-consequences logical fallacy—evolution is wrong because if it were true society would suffer. This feature also often provides a clue as to the true motivation of the denial. The science is secondary: It's the moral hazard they're truly concerned about.

This is an inherently flawed strategy. If you truly wish to advocate for a particular moral or ethical position, the worst thing you can do is tie that position to a false scientific conclusion. Doing so allows opponents to attack your moral position by attacking the pseudoscience to which you have anchored it. You are far better off acknowledging legitimate science and advocating for your moral position on moral grounds. If you ideologically favor free markets, don't deny global warming, rather offer free-market solutions.

Some researchers have labeled this phenomenon "solution aversion" in the case of global warming: Reject the science because you don't like the proposed solutions. Again, it's a better strategy to focus on the solutions rather than deny the science.

It should be clear by now that I and my SGU colleagues are all strong advocates of science. It is clear from history that science is the most powerful tool we have for understanding the world and improving our position in it. But science requires courage—the courage to face reality and accept its findings, even if they upset us or are disruptive to our comfortable ideology.

Denialism seeks to deprive us of the power of science by attacking those findings the deniers lack the intellectual courage to evaluate honestly. But denialism does not refer to specific people as much as it does to a behavior, one we need to be vigilant against—in ourselves most of all.

24. Skeptics' Guide Entry: *P*-Hacking and Other Research Foibles

Section: Science and Pseudoscience
See also: Pseudoscience

There are multiple ways to bias the outcome of seemingly rigorous scientific studies. It is critical to be able to assess the reliability of research to know if its claims should be taken seriously.

> The nature of science is not that of a steady, linear progression toward the Truth, but rather a tortuous road, often characterized by dead ends and U-turns, and yet ultimately inching toward a better, if tentative, understanding of the natural world. —Massimo Pigliucci

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I was watching my daughter Julia play Rock'em Sock'em Robots with my four-year-old nephew (Jay's son, Dylan). On one round, Dylan's robot knocked Julia's bot's head off, and he declared that he had won. On the next round, Julia struck first, and Dylan's robot dutifully popped his head. Again, Dylan declared that he had won. In response to Julia's questioning he explained that on that round the robot that lost its head was the winner.

We all remember this from our first ventures into group play—young children will sometimes try to change the rules after they see the results. We laugh now because their feeble attempts at rigging