The Nature of Truth

Search for Scientific Method

Evolution: assertion, hypothesis, theory, law, or fact?

Is there an Intelligent Designer?

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Abstract

This paper is a debate about **epistemology** and the philosophy of science. We attempt to clarify the nature of scientific truth. The concept of **falsification** as a method that demarcates science from non-science was introduced by Karl Popper in 1934, and in spite of its being the linchpin of scientific thought, falsification is not widely articulated or appreciated. The difference between verification and falsification of the theory of evolution provides a convenient platform for understanding the nature of science. Evolution will probably always remain falsifiable, and therefore, will never truly become a fact. Theories rarely become facts and even scientific laws sometimes are falsifiable. Changes in theories occur by what Thomas Kuhn called a **paradigm shift.** Falsification does not define what is a valuable or useful intellectual activity: theology might be valuable but is not falsifiable; mathematics is a system of relationships, and is not falsifiable, but historically is included among the sciences. Creationism, theism, and atheism are not falsifiable. Probability estimates in statistical analysis are neither verifiable nor falsifiable. The null hypothesis in statistics is not the same as falsification but is a hypothesis that a statistician attempts to test by using probability estimates. An alternative to evolution, **Intelligent Design** is not falsifiable, and therefore not scientific; we debate this.

CONCLUSION

Falsification is a method for demarcating science from non-science, but does not define what is valuable intellectual activity and is not the way to ultimate truth. It is important to know what science is and to be able to articulate what is not science.

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Introduction

Humanity has taken a long time to learn how to think logically and rationally. Many are still learning. Many will never learn to think scientifically. Large numbers of people do not understand the **scientific method.** Many argue vehemently over evolution and creationism. Scientific "proof" is a hotly debated subject. Those trained in the sciences often find themselves at a loss for words when confronted by religious fundamentalists. What are the differences in the definitions for assertion, hypothesis, theory, scientific law, and fact?

The idea of falsification is not widely known or appreciated, but is the linchpin of scientific thought. Karl **Popper** introduced the notion of falsification in his 1934 book *"The Logic of Scientific Discovery"*. Popper insisted that the right test for a scientific theory is falsification, by which he meant that the test should seek some circumstance for which the theory or hypothesis does not hold. If no such case can be found, then the theory is not falsified, but is tenable until such time as new facts are discovered which would force revision of the theory.

My son Daniel, a mathematician *, and I have debated this subject and I believe that our dialogue is not only entertaining, but also is instructive. We are uncertain about theological matters because we are trained in empiricism and tend to reject the non-empirical. This essay, or

debate, is an exercise in the nature of truth, or knowledge, and is what a philosopher might call epistemology. The debate centers on evolution because our whole world-view is shaped by Darwinism and by the opposition to it and because our methods of thinking about evolution shape how we think about other important issues, affect our ideologies, our theological perspectives, and even our social interactions.

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My friend Craig Jones who holds a Ph.D. in economics critiqued this paper, and I have included him in the debate just as if the three of us were discussing the subject at one time.

In the section on Intelligent Design, I thank the following for joining the debate: my daughter Rebecca Jaxon, a psychologist, her husband, Greg Jaxon, a computer scientist, my grandson, Paul Grayson, a Ph D candidate in molecular physics, and Bruce Green, a retired airline pilot.

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THE DEBATE

Falsification

Craig:

Popper insisted that the test of truth of a theory is falsification. What about Popper's hypothesis itself? Is there a circumstance for which falsification does not hold? Is Popper's idea only an assertion and its acceptance simply a matter of faith?

Richard:

I would call falsification more than an assertion or a hypothesis; it is an axiom, a postulate, a self-evident principle that is accepted without proof as the basis for argument. Popper called falsification a **method**. He states: "According to my proposal, what characterizes the empirical method is its manner of exposing to falsification, in every conceivable way, the system to be tested. Its aim is not to save the lives of untenable systems but, on the contrary, to select the one which is by comparison the fittest, by exposing them all to the fiercest struggle for survival."

In the light of Popper's "struggle for survival" description, it seems that the scientific method is therefore a Darwinian-like statement of the evolution of ideas. In other words, the theory that survives argumentation is the right one.

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Evolution

In regard to Darwin's theory of evolution: If life began more than once and used nonDNA each

time except the first time and then each form evolved into multiple species, you would find DNA and non-DNA based forms. Evolution from a common ancestor would therefore be proven false because all life would not be related. We would conclude that life began more than once and began with a different biochemical mechanism.

However, biologists have found that all life on Earth apparently is either DNA or RNA based and uses the same fundamental biochemistry. All life forms are related to one another biochemically. Therefore the idea that all life has come from common ancestors by way of evolution is supported or verified.

Therefore, since there is no possibility that any species have arisen independently, evolution is not falsifiable. If evolution is not falsifiable it is not a scientific theory but an assertion.

Daniel:

I propose a scenario under which evolution would be falsified. That scenario is where we observe that all different species have different fundamental biochemical mechanisms at work internally. Since the theory of evolution predicts that at least some species should be related to each other, under my falsifiable scenario we would no longer believe evolution.

You propose a different scenario in which the species of the world are divided into several (X) different camps, and each camp shares a unique biochemical mechanism. Presumably X is a relatively small number, so that each camp has many species in it. This scenario doesn't necessarily falsify evolution, because you've provided the species with related species.

But my original scenario still would have falsified evolution since all species would be different biochemically, and thus unrelated, so evolution is falsifiable. I don't need to consider your proposed scenario at all.

Richard:

Daniel, you have presented a test of evolution that has verified the theory of evolution but has not falsified it.
Karl Popper states "I shall certainly admit a system as empirical or scientific only if it is capable of being tested by experience. These considerations suggest that not the verifiability but the falsifiability of a system is to be taken as a criterion of demarcation. In other words: I shall not require of a scientific system that it shall be capable of being singled out, once and for all, in a positive sense; but I shall require that its logical form be such that it can be singled out, by means of empirical tests, in a negative sense: it must be possible for an empirical scientific system to be refuted by experience."

He further states "we must expose the system to falsification in every conceivable way."

I claim that you have simply presented me with a single test for evolution that the theory has passed so far. We both know in advance that the DNA test has verified the theory. But verification is not the same as falsification and if there is no further test that would falsify the theory, then the theory is nonfalsifiable and not a scientific theory.

Daniel:

This is the crucial point. We did the experiment over the last decades and got the result, and the theory wasn't falsified by the experiment, as it turned out. But if the result had been different (as I sketched) it would have been falsified!

My thesis is that in 1950 the theory was falsifiable, and then the indicated experiment was done, and it wasn't falsified. I don't address the issue of whether the theory is falsifiable today.

So now you have to consider the following question: over history, as experiments which could falsify a theory are performed, and results come out not falsifying the theory, is it necessary to keep inventing further experiments which have not yet been done, but could conceivably falsify the theory? Or, can we stop at some point?

Richard:

Let's start over with a description of evolution theory. We say that life began one or more times from the primordial ooze by biochemical chance and through the process of mutation, natural selection, recombination, the founder effect, genetic drift, punctuated equilibrium and possibly other as yet undiscovered mechanisms, produced all known forms of life and that all these forms today are DNA based. There is, it seems to me, a metaphysical assumption underlying both the creationist's view and the Darwinian view. The Darwinian concept states that a blind watchmaker called natural selection, which is without purpose except to survive, does the work of evolution. The Creationist seems to say that the watchmaker is God. The type of creationist who believes in limited evolution says that God directs natural selection and has purpose.

There seems to be no way to test either metaphysical assumption or to falsify either one, and therefore either one might be valid.

The theory of evolution otherwise has been repeatedly verified, including the thesis that all forms of life use common biochemical mechanisms. Since both the Darwinian and the Creationist constructions seem to be nonfalsifiable, neither view is scientific, both are basically metaphysical, and both are equally valid and a matter of faith. Either view is rational and neither view is more irrational than the other. Since neither is falsifiable, there seems to be no rational method for choosing one over the other.

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Creationists

Daniel:

Actually, both theories were falsifiable in 1950, for we might have gone on to discover that evolution didn't occur at all.

But I object to you calling this latest theory a creationist construction. Creationists reject evolution, don't they? They don't say that God directs evolution.

It seems that you have discovered how to make a creationist theory from a scientific one. Simply add the phrase "and it is all directed by God" to the theory. Then the predictions of the theory remain the same, and the added phrase cannot be tested independently. The new theory can be tested the same way that the original (scientific) theory can be tested. One might try this with

gravity. Assert a new theory of gravitation that says that there is an attractive force between two objects proportional to the mass of either, inversely proportional to the square of the distance between them, and that the force is instilled by the presence of God.

This theory certainly seems to be in accordance with experiment because the added phrase changes no predictions of the theory. The error comes in not letting me separate the added phrase from the rest of the theory. Popper's whole point is that the added phrase, by itself, is not scientific, for it is not falsifiable.

Richard:

Your assumption that creationists "don't say that God directs evolution" is incorrect. Some Creationists actually do believe in evolution. For example, a brief search via Google.com for "**scientific theist evolution" produced** 26,000 citations. Here is a relevant quotation from one of them:

Theistic evolution takes the Darwinian picture of the biological world and baptizes it, identifying this picture with the way God created life. When boiled down to its scientific content, however, theistic evolution is no different from atheistic evolution, treating only undirected natural processes in the origin and development of life.

Theistic evolution places theism and evolution in an odd tension. If God purposely created life through Darwinian means, then God's purpose was ostensibly to conceal his purpose in creation. Within theistic evolution, God is a master of stealth who constantly eluded our best efforts to detect him empirically. Yes, the theistic evolutionist believes that the universe is designed. Yet insofar as there is design in the universe, it is design we recognize strictly through the eyes of faith. Accordingly the physical world in itself provides no evidence that life is designed.
http://www.arn.org/

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Metaphysics

Craig:

The phrase *Intelligent Design* is metaphysical. This is defined as the branch of philosophy that deals with the nature of ultimate reality and implies that the subject matter is beyond the physical or beyond physics.

Daniel:

Your ruse in appending the watchmaker to the scientific story of evolution was intended to deceive me into thinking that God's presence is an alternative to something already in the theory, rather than an unfalsifiable appendage.

Craig:

My point exactly! You cannot test metaphysical propositions because they are assertions and do not fit the criteria for science.

Richard:

For the time being I agree with you not to use the blind watchmaker analogy. We are trying to discover the truth of the theory of evolution. We have assumed that the only way to falsify it was to discover that species used different biochemistry.

(Actually, I am trying to discover in general how to determine truth from error.)

Daniel:

I haven't assumed that was the ONLY way, just that it was ONE way.

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Spontaneous Generation

Richard:

It occurs to me that the basic way to falsify evolution is to demonstrate spontaneous generation of life in the laboratory in a replicable experiment. This would disprove the tenet that all life comes from other life of the same kind. Since we know that the spontaneous generation experiment has always failed, we are left with a nonfalsifiable statement of evolution that no longer qualifies as a theory but as a fact.

Craig:
Suppose life began many different times but only with the DNA biochemistry. Then suppose you could produce spontaneous generation of life in a laboratory and it turned out to be DNA-based. This would not disprove evolution at all. That newly generated life could then given the right conditions, evolve like previous forms of spontaneously generated life forms that evolved. So therefore, the spontaneous generation of life could not falsify evolution.

Daniel:

I would prefer not to call it nonfalsifiable now. But after a theory has survived many attempts to falsify it, it must necessarily become harder to find new experiments, not yet done, which might falsify it. But I think I could still do it.

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The Law of Evolution?

Richard:

Like the laws of thermodynamics it can be called the law of evolution rather than the theory of evolution. So the answer to your question about what to do with a theory after it can no longer be falsified is that it must become fact or scientific law. So from a philosophical or logical reference I have been attacking evolution and have found that it must be true. I still worry, however, about Stephen Jay Gould's statement that he can think of many other ways to falsify evolution. If so, what are other ways?

Daniel:

Popper's point is that it never becomes "fact", just a heavily verified theory. So don't say things like "it must be true".

Daniel:

Here's a good experiment for the future. Find a planet physically like earth, but without life. Deposit 100 species of plants and animals there in such a way that they survive initially. Return after one billion years to see how many species there are. If the same 100 species are there, that would tend to call evolution into doubt.

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Theory of Intelligent Design

Richard:

 Well, let's see. We start with a large ball of molten rock, say 7,900 miles in diameter and 3,000 degrees hot, then wait a while, say 4.5 billion years, and we get a DNA code with some 24,500 genes that takes 100 phone books to write down, and the code repetitively replicates 6 billion people, or elephants or Dinosaurs or some 100 million other species of plants and animals. God, how did he pull off this sleight of hand? What a planet! What a trick!

Therefore, considering what I see of the universe, I think my thesis on the nature of truth is incomplete without a discussion of Intelligent Design theory, popularized so well by biochemist Michael Behe in "Darwin's Black Box". Let us start a debate on intelligent design with a quote from my favorite genius, Albert Einstein:

"I believe in **Spinoza's God** who reveals himself in the *orderly harmony* of what exists, not in a God who concerns himself with fates and actions of human beings." (Upon being asked if he believed in God by Rabbi Herbert Goldstein of the Institutional Synagogue, New York, April 24, 1921, /Einstein: The Life and Times/, Ronald W. Clark, Page 502.)

Therefore, my question is, did Einstein and Spinoza believe in an Intelligent Designer?

Bruce:

Spinoza's God was the sum total of all intelligence in the universe, as I guess he hadn't yet thought of multiple universes. His argument notes that an ant has intelligence, a colony of ants

has more, the ant colony and the surrounding environment has still more, as does the island, continent, planet, universe, etc. In his mind, the combined total of all intelligence must be God. This would seem to be a rather diverse creature to hang whiskers on, or to sit at the right hand of. So, Einstein's reference would seem to be of little comfort to those who would pose a God, or Gods of anything other than worship of the infinite. The opinion of Einstein, or any other being, would seem beside the point, as finite contemplating infinite always comes out zero.

The argument from design is circular, and consequently meaningless. The argument presupposes a magic creator that was not him (or her or it) self-created. It was agreed on when the question was posed that evidence of design and therefore creation would stop and all further thinking cease at the destination of "God." If the universe had a "creator," the "creator," being even more complicated, must also have a creator. Etc. ....to infinity.

Richard:

The argument from design is not really circular. The argument hinges on the mousetrap analogy in that there are biochemical systems such as vision and the amoebae's flagella in which if one component is lacking, function is lost entirely, and therefore evolution cannot occur. (Re: Michael Behe.) See the details of the 50 proteins that make the flagellum work as a nano-motor.

Dr. Michael Behe

Bruce:

I had always thought the argument circular, as it took mankind to invent or create God, who created man, etc. I think that all systems would be something else, by definition, if any one component is changed. Evolution is a common occurrence, as in the case of antibiotic resistant strains of bacteria, DDT resistant insects and many others.

Once we have biological entities as they now exist, evolution is obvious. They are designed to adapt. The real question here is how did it start? God is obviously more complicated than an amoeba's flagellum. God therefore must have a designer. This designer must be more even more complicated than the first god and must have an even more complicated designer, - - - -ad infinitum.

I might pose another question. Can there ever be a scientific proof of anything (gods in this case) that cannot be seen, heard, studied, influenced, described, and has no measurable physical influence on anything we know.

If there were a proof, we wouldn't need faith, as we would have knowledge. Science requires knowledge. Faith requires faith, which I understand is highly esteemed in even formal religious circles.

Greg:

A "God who reveals" has a Will. One who has a "himself" is a Personality. One whose

revelation takes the form of "what exists" either Creates if "his" creation seems "orderly and harmonic", we'd call it "intelligent design".

So yes, I'm afraid even Einstein, when cornered, caved in and made a statement with no scientific basis whatsoever to please his listener(s). But since he clearly doesn't want any of this hogwash to get in the way of how he lives and works, he further claims that an omnipotent being whose Mind conceives and creates everything for revelatory purposes is not concerned with his personal morals or intellectual integrity.

Isn't it amazing how forceful some memes can be! This quote just indicates that Einstein had trouble thinking straight on this subject, and caved in to rhetoric that would please and disarm his interrogator.

Einstein was a physicist, not a biologist. This quote seems to be about morals and spirituality, not about evolutionary biology. Wouldn't it be more relevant to ask whether G.W.Bush believes in Armageddon as detailed in the Bible, and whether he thinks the U.S. appears as a character in that allegorical tale?

Richard:

 Thanks for the forceful reply. In regard to Einstein's occupation, if Spinoza's Pantheism is the correct model, would not any intellectual be eligible to discover or perceive the possibility of a designer for all that exists? Maybe we can please the Fates up there with our verbal algebra and hold off Armageddon

It occurs to me that we both have just committed a venial sin; you for using the rhetorical ruse of argumentum ad hominem wherein you imagined Einstein's motivations, and I for enjoying the poetry of your rhetoric. As happens so often in debates, we forget to be scientists and we descend to the depths of our emotional midbrains where our animal ancestors lie awaiting to maim and kill the enemy. So we need to be penitent and to discuss the real issue as to whether there is evidence of an intelligent designer in the universe. I thought you would enjoy the Catholic verbiage here, that is, if it doesn't give you a seizure.

I looked up your word "meme" and found that we should explain it in context. Grant compares memes to viruses of information which spread through the culture:

Unlike a virus, which is encoded in DNA molecules, a meme is nothing more than a pattern of information, one that happens to have evolved a form which induces people to repeat that pattern. Typical memes include individual slogans, ideas, catch-phrases, melodies, icons, inventions, and fashions. It may sound a bit sinister, this idea that people are hosts for mind-altering strings of symbols, but in fact this is what human culture is all about.

http://pespmc1.vub.ac.be/MEMIN.html

Greg:

Bruce's points were well taken, though. The "First Mover" arguments all lead to infinite recursion. Even if Behe's "Irreducible Complexity" claims held water (and they do not), they

don't necessarily lead to a God-like designer. Replacing a presumed gap by an infinite recursion isn't much of an advance, especially since it sabotages the scientist's access to Truth. And when that biological system is analyzed, Mr. Behe just has to survey the frontier of science until he finds the next Gap in which to grow a Godhead. Perhaps Behe doesn't really like being human.

Rebecca:

Dad, your first question was ad hominem. You asked whether Einstein believed in a supreme being. You didn't ask what the arguments for or against it are. So, the question should be, what is the evidence for a supreme being (or intelligent designer, or creator, or whatever you want to call "God" in the context of this debate)? Why should anyone believe in it?

Richard:

My question about Spinoza and Einstein sounds ad hominem but actually is a device to elicit the underlying logic for their assertions. Thus your re-statement: "So, the question should be, what is the evidence for a supreme being (or intelligent designer, or creator, or whatever you want to call "God" in the context of this debate)? Why should anyone believe in it?" is a cogent question. Meanwhile, I am inspired by the fact that the greatest intellect of the 20th century said what he said and by the nagging thought that logic impelled him to conclude there is a Designer, if that is what he meant?

Rebecca:

I think that what Einstein says he believed or didn't believe is not relevant to a truly scientific debate about intelligent design. Otherwise you will just have a debate about which of the proponents of each side are the smartest, or most scientifically minded, or most likely to be right.

Paul:

My impression has always been that Einstein thought the way to see what God was thinking was to look at the fundamental laws of physics instead of, for example, biology. But then I haven't read almost anything of what he wrote. Maybe it's time to do some reading...all of his papers are going online:

Richard:

The following seems to rebut the Intelligent Design theory: Paul, since you are in molecular physics, please comment on the following article.

 "Symbiotic/endosymbiotic/exogenous models: *These argue some version of the idea that the cilium evolved from a symbiotic spirochete that attached to a primitive eukaryote or archaebacterium."*

"The only real point in favor of the symbiotic hypothesis is that there apparently actually are eukaryotes that use symbiotic spirochetes as their motility organelles (only inside termite guts, though, as far as I know). While this is a flabbergasting example of co-option and the creativity and flexibility of biological systems, none of the proposed homologies that have been reported

between cilia and spirochetes (e.g. Bermudes et al. 1987; Barth et al. 1991) have stood up to further scrutiny (e.g. Bermudes et al. 1994, Munson et al. 1993). The homology of tubulin to the bacterial replication/cytoskeletal protein FtsZ (see "Some web references on FtsZ-tubulin", below) would seem to clinch the case against Margulis, as FtsZ is apparently found native in archaebacteria (e.g. see Faguy and Doolittle, 1998), providing an endogenous ancestor to tubulin (as opposed to Margulis' hypothesis, that an archaebacterium acquired tubulin from a symbiotic spirochete -- see Margulis et al., 2000 for the latest version).

 http://meta.wikipedia.org/wiki/Evolution_of_the_Flagellum

Paul:

The article has a nice description of the various simpler things that the bacterial flagellum could have evolved from, so yes, it does beat the intelligent design argument.

The real interesting thing to think about is what the first living thing might have been. Was it very simple runaway chemical reactions that gradually evolved into cellular life or did it involve the very unlikely random creation of a fairly complicated system that could replicate? We have no way of knowing how long it takes a planet on average to accidentally develop life because we only have one data point, and it's very biased.

 Richard:

The debate is this: **Is Intelligent Design a scientific theory?** Dr. Michael Behe reduces his argument to a mousetrap. He states that if you have a mousetrap with one less component, it is no longer a mousetrap and therefore cannot by incremental steps of natural selection, ever become one. This is an irreducibly complex system which cannot have evolved. A mousetrap that cannot trap mice because one part is missing is not a mousetrap and therefore, cannot become one by evolutionary stages unless intelligence intervenes. There must be a Designer to make the system into something that CAN evolve. The bacterial or amoeba's flagellum is the analog which he thought was irreducible. However, if a spirochete can somehow become a flagellum, does that not falsify his statement about irreducibility? In other words, the flagellum is NOT irreducible. Irreducibility has been falsified. And if irreducibility is falsifiable even in one case, does that not make Intelligent Design into a scientific theory as demanded by Karl Popper? The debate is then about Behe's statement: Intelligent design is a scientific theory. This argument has vast political-cultural importance, for if Intelligent Design is a scientific theory, it can be taught in school science classes as an alternative to evolution. Falsifiability is a method of TESTING a statement by all possible means. Verification is not a test of the truth of a statement and does not make a statement scientific. You cannot falsify God, so God is not a scientific theory. Irreducible complexity might be evidence of God. If irreducible complexity can be falsified,   it is a scientific statement and the possibility of a Designer must be considered. The debate is vastly important, for if we agree that Intelligent Design is a scientific concept by virtue of its attribute of falsifiability, we must admit the idea to science classes.

Rebecca:

  The theory of intelligent design is not scientific because it cannot be tested. It is not based on empirical data. It does not change as new data comes in. All that the I.D. people do to support their own theory is try to disprove the "opposing" theory. That's not scientific.

Greg:

Behe's Theory of Irreducibility /is/ a scientific theory. It is logically sound so far as it goes. I am not so sure that it is capable of actually making falsifiable claims. Let's step through the flagellum example: Behe thinks a while and when he's done he makes the claim that "You can't get from here to there using the paved roads of evolutionary biology". Some time later, another researcher finds spirochete DNA in the flagellum DNA producing similar essential structure, and concludes "This signature substructure got from here to there somehow!". Would Behe then admit that this was evidence of common ancestry? If so where did he go wrong? He says he has the map of all paved roads. Somehow smugglers used the unpaved roads (at higher costs that he failed to consider in his first analysis). Is his Theory falsified? or did he just flub the calculations? [If he has such good maps of evolutionary pathways, I wish he'd publish them and save us all the work of figuring out how life evolved!]

The only way to know if a counter example amounts to falsification is to examine how Behe does his thinking. Reapply his Theory, in light of the new evidence, and decide whether the formula is wrong or if he just used bad input data. My guess is that when you finally whittle it down to the right formulas it will be indistinguishable from evolution and will "predict" as does evolution, that you can get pretty much anywhere in the design space given enough time and sufficient energy input. If he can ALWAYS claim that the input data wasn't sufficient, then his theory is not falsifiable.

The mousetrap example illustrates why his characterization of evolution is wrong. Mousetraps are evolved objects, and they occur naturally quite independent of human intelligence. Mice occasionally die of traumatic crushing when they dine in some inappropriate venue. It takes a selective pressure to refine those circumstances to the point where crushing becomes inevitable and frequent.

Who is it Behe claims "designed" the mousetrap you can buy today for a few pennies? If set down in a room full of mice, he or she could not make a commercial mousetrap for a few pennies. They'd need forged spring steel, tin fittings, milled pine base, etc. The commercially available mousetrap evolved. It did this in far more complex surroundings than itself. Granted, some of the steps in that evolution were larger than others. But which ones are qualitatively different enough to be called "design" steps vs. successful mutation steps?

Mousetraps result partly from artificial selection - which is why they have those ink markings on the wood instead of nothing -and partly from natural selection - some catch mice better or cost less. But notice that if mousetraps were /really/ designed by humans, mice would be extinct by now. The traps would kill the babies before they can reproduce, for example.

Mousetraps exist to produce a steady stream of income for their manufacturers. They are a parasitic species that lives on the mouse/human interface. If you took away the humans or the mice, mousetraps would become extinct. Does that make them irreducible, or just adaptive?

Paul:

My understanding of Engineering indicates that irreducible complexity also rules out intelligent design. Intelligent designers build things one step at a time, testing as they go.

Greg has a very good point about irreducible complexity. Look at the St Louis arch and you will think that it could never have been built step-by-step, because if you remove any piece it would fall apart. But actually it was - the scaffolding was removed later. Similarly, even if a flagellum or something is irreducibly complex, it might have arisen from something more complex! So we have just falsified your "theory of irreducible complexity".

 Richard:

Isn't that the point? If the theory that there is such a thing as irreducible complexity is falsifiable, the statement that there is such a thing is scientific and is subject to further testing. This means that if you find something irreducible, there must have been a Designer. Right?

Paul:

No. Greg has disproved the statement "Irreducible things can't be built step by step," with some simple logic - they could have been constructed from MORE complicated things. So that statement is no longer worth considering. We already falsified irreducible complexity by arguing that a complicated system could evolve from a more complicated one. Why don't you address that point?

Richard:

I'm still awaiting a non-rhetorical, non-satirical, logically rigorous, publishable opinion of more than a few words on whether irreducible complexity is falsifiable. If I say all swans are white, that is falsifiable, because I might find a black one. If Behe says there is a set of biochemical systems which are irreducible, I think that it is falsifiable if it is possible to find one or all to be reducible. Then Intelligent Design becomes scientific and you can prove Intelligent Design. Darwin himself wrote that if only one system is found that could not have evolved incrementally from previous systems, then evolution would be disproved utterly. There are several hundred millions of people out there awaiting your considered and rigorous reply as to what reasons you have for declaring the answer in favor of falsifiability, for that would, of course, mean that Creationism is correct, evolution is wrong, God exists, and you have provided the reasons.

Paul:

I'm not sure which theory you want to be falsifiable. But we have proven one theory wrong already: "Evolution can't result in irreducible systems."

This theory is false because they can evolve from more complicated systems. Therefore, the whole argument about irreducibility is a waste of time. Please comment on this argument!

Richard:

OK. The mousetrap CAN evolve from something MORE complex, like a scaffold. This leads to infinite recursion, because then you have a possible NEXT irreducible system, the scaffold. Who designed the scaffold? Was it possibly irreducibly complex? How do you know? The same test of falsifiability would apply to the second and third and fourth scaffolds. Falsifiability is only the ABILITY to show falsehood upon testing. When the test shows failure of the hypothesis, we can say it has THEN been falsified.

Rebecca:

But even "irreducible complexity" as a concept, is just an attempt to disprove evolution. There is no proof of a "designer". They refuse to even define the "designer", though we all know that their agenda is to prove the god of the bible. How scientific is a theory about something you refuse to define?

Paul:

No. The logic is very simple. It could have evolved from something more complex, which in turn evolved from something simpler. The number of possible paths like this is so many that it's impossible to speculate about them, and I have no responsibility to prove that a particular path works, since my only goal was to demolish the original "irreducible complexity" argument.

You are too hung up on falsifiability. The theory "everything will turn blue tomorrow" is a completely falsifiable statement, but there is nothing scientific about it. Also "all Martians have two heads", "the next U.S. president will be a woman," etc. As a scientist, why should I be interested in such ridiculous things? Science has to be based on evidence. In the present discussion, the evidence has to do with flagella being irreducibly complex. I have shown you that it is no problem, because they could have evolved from something more complicated, which in turn evolved from something simpler. Unless you have some specific evidence about that evolutionary path, you are just speculating wildly! "All Martians have two heads" is falsifiable but unscientific.

Richard:

Ridiculous is not a sound criterion. For example: A photon can go through two slits at the same time and the speed of light has a limit are both ridiculous statements. And everybody knows about the ether that obviously was there but isn't.

Greg:

This brings us to the special case of axiomatic truth. In Richard's reading of Popper "A or Not A" is not falsifiable. But depending on the A it might be undecidable, or it could be ill-defined, or self-referential. I think Paul brings up the right criteria for "science": it has to be a claim

about reality, and there ought to be a non-empty subset of reality for which it appears to hold true.

I.D. does not confine itself to empirical reality. Or at least I
haven't read an I.D. author who knows how to test the I.Q. of
the Designer. I guess if there's just One His IQ would
statistically be 100 ;-)

Richard:

Popper did not accept axiomatic truths, known as *a priori* assumptions, and neither do I. All statements must be tested, not for verification, but for falsification. The statement that there are irreducible biochemical and molecular systems appears to be falsifiable because, hypothetically, you could find such systems in nature. The debate is not really how these systems got that way. The debate is about whether there ARE such systems. I don't know if there are, but I aver that there are tests for the statement. If there are falsifiable tests, then the statement is a scientific one, not metaphysical, or ridiculous. I realize you all think this argument is disguised Creationism, but I don't see it that way. I perceived this to be a rigorous exercise in epistemology.

It's too bad *argumentum by incredulity* is not a good argument because everything is so amazing, like DNA. Such an argument is like finding a watch in the forest and saying it must have evolved because I believe in evolution. Is a watch falsifiable?

Dan:

It's very unlike finding a watch in the forest and saying it must have
evolved, because there seems to be no mechanism for it evolving, mainly
because auto-reproduction of watches doesn't occur.

Richard:

On the contrary, it is obvious that self replicating, repairing, and evolving machines are even now being researched:

"The Center for Self-Organizing and Intelligent Systems (CSOIS) is a multi-disciplinary
        research group at Utah State University (USU) that focuses on the
design, development, and implementation of intelligent, autonomous mechatronic
systems.

"CSOIS research advances the state-of-the-art in the theory, development, and
application of systems that need advanced automation, autonomous operation or
behavior, and intelligent decision-making and learning to achieve their objectives. Core
CSOIS expertise areas are: control system engineering, including algorithms (intelligent
control), actuators and sensors, and hardware and software implementations; artificial
intelligence, including planning, optimization, and decision-making; embedded systems
engineering, including real-time programming; electronics design and implementation;

and mechanical engineering, including machine design and implementation; and system integration "

SO THE WATCH COULD HAVE EVOLVED.

I have just given you a description of a company that currently is researching artificial intelligence and robotics. Now, you find a beautiful accurate watch in the forest along your path. How would you know the watch did not replicate? You say that replication is obviously necessary for the evolution of the watch. Suppose I invented a self organizing replicating watch and after 101 years it suddenly replicated itself. Or suppose it improves itself only once every 101 years. You observed it only 100 years. You say it cannot replicate, therefore it had a designer and did not evolve. You maintain that evolution can occur only by mutation and natural selection.

You are guilty of the problem of induction and are using verifiability as your criterion because you only watched the watch 100 years.

Suppose THE WATCH HAD A DESIGNER WHO DESIGNED IT TO REPLICATE OR EVEN TO STOP REPLICATING

The lesson is that the source of the hypothesis and the criterion of replicability are not tests of truth. The question remains.

Did this watch evolve or was it created de novo. Or both; did a designer cause it to evolve. It's an amazing discovery, this watch. What is the test for how it came to be in the forest? We have always said there had to be a designer because every watch we have ever seen was designed by a watchmaker. That's might be a falsifiable statement. That was like saying all swans are white because we never saw a black swan. Maybe there is no true test for the watch even though we KNOW it was designed. We have faith because of a hundred years of seeing watches that all watches are artificial. But here is a watch that might be self organizing watch I myself designed.

Next question: Is the watch falsifiable. Still NO? Amazing conclusion. Maybe it is falsifiable if we find the genius who designed self organization and gives you the manual on how to do it. But maybe he is a liar.

Isn't this AMAZING? YOU CAN'T EVEN TELL ME IF SOMEBODY DESIGNED THIS WATCH.

One Uncaused Event, None, or Many?

IMAGINE A NANOTECHNOLOGY MACHINE far beyond the state of the art: a microminiaturized rotary motor and propeller system that drives a tiny vessel through liquid. The engine and drive mechanism are composed of 40 parts, including a rotor, stator, drive shaft, bushings, universal joint, and flexible propeller. The engine is powered by a flow of ions, can rotate at up to 100,000 rpm ... and can reverse direction in a quarter of a rotation. The system comes with an automatic feedback control mechanism. The engine itself is about

1/100,000th of an inch wide -- far smaller than can be seen by the human eye. Most of us would be pleasantly surprised to learn that some genius had designed such an engineering triumph. What might come as a greater surprise is that there is a dominant faction in the scientific community that is prepared to defend, at all costs, the assertion that this marvelous device could not possibly have been designed, must have been produced blindly by unintelligent material forces, and only gives the appearance -- we said appearance! -- of being designed. As you may have guessed, these astonishingly complex, tiny, and efficient engines exist. Millions of them exist inside you, in fact. They are true rotary motors that drive the "bacterial flagellum," a whip-like propulsion device for certain bacteria, including the famous E. coli that lives in your digestive system." (Peterson D., "The Little Engine That Could...Undo Darwinism," The American Spectator," 8 May 2005).

Richard:

In light of the complexity of the interior of any cell so ably described in the journal above, do you think that the hypothesis of irreducible biochemical complexity, that is, intelligent design of some kind, is a possibly valid alternative to the hypothesis of mindless self-organization controlled only by mindless selection and mutation?

Paul:

The bacterial flagellum? If you see a fundamental problem with that, it's just due to a lack of imagination. There are lots of channels in the cell that are used to export and import different things, there are caused a cell to export proteins that stuck together, forming a hair, and it found that it was useful to have hairs to protect itself or to allow itself to better stick to things. Then maybe some unrelated energy-consuming pumps in the cell found that they worked more efficiently if they associated themselves together into a ring, and they happened to do that around the hair attachment point. Then, a mutation caused the motors to start directly turning the hair...

It's easy to make up scenarios like this one. By the way "irreducible complexity" is a ridiculous concept because evolution does not require things to always go up the complexity scale. The flagellum could have evolved from something with *more* parts. It's not a hypothesis, just some scenario for how it could have happened. I find it more probable because it's based on logical events instead of assuming that someone just made it like that.

Richard:

And I claim that the probability that the flagellum shows
intelligent design. These are both assumptions.

Richard:

If there is a God, is it Spinoza's God (Pantheism): Pantheism (Greek: ('pan') =
all and ('theos') = God) literally means "God is All" and "All is God". It is the

view that everything is of an all-encompassing immanent God; or that the
universe, or nature, and God are equivalent. More detailed definitions tend to
emphasize the idea that natural law, existence, and the universe (the sum total
of all that is, was, and shall be) is represented or personified in the theological
principle of 'God'

Richard:

Does that mean you have no ideas about the nature or attributes of this something you have a
name for? For example, do you not hold the view that the creator, the prime mover, the
uncaused cause, the uncaused event, is infinite, eternal, omnipresent, omniscient, and/or
omnipotent? These attributes are of logical as they follow from the premises and from the
evidence of the Big Bang itself. Is there not an actual fact you can see, the residual background
radiation plainly visible in between TV channels? Is that not an observable fact that physicists
claim proves there was a beginning of matter, energy, space, and time?

Paul:

You can always have the alternative hypothesis that somebody just built
everything, or that nothing really exists, that it's all a dream. But it's more fun
for us to try to reason about nature based on what we see, using logic and
mathematics instead of fantasy.

Richard:

Assume that you do not consider irreducible complexity to be a valid hypothesis. You believe in
God but not Spinoza's/Einstein's Pantheism/Deism, you say. Does it follow that God is
OUTSIDE his creation and not in or part or all of his creation?

Does that mean you have no ideas about the nature or attributes of this something you have a
name for? For example, do you not hold the view that the creator, the prime mover, the
uncaused cause, the uncaused event, is infinite, eternal, omnipresent, omniscient, and/or
omnipotent? These attributes are of logical as they follow from the premises and from the
evidence of the Big Bang itself. Is there not an actual fact you can see, the residual background
radiation plainly visible in between TV channels? Is that not an observable fact that physicists
claim proves there was a beginning of matter, energy, space, and time?

Greg:

IMAGINE an argument in which you claim that some premise leads to a
conclusion which suits you, but leads to the opposite conclusion when it doesn't:
The argument is composed of just three parts, any existing object on the frontier
of science, a miraculously omnipotent designer and a gullible listener. Since the
frontier of science is, by definition known either not at all, or to but a few

listeners, it follows that the gullible listener is baffled as to the sequence of material causes that might have produced the cited phenomenon. The argument then concludes that the omnipotent designer produces it.

In his rejoinder, your interlocutor marvels at the intricacy and power of this omnipotent designer, which he also does not quite understand? Following your line of reasoning, he claims that this even more stunning phenomenon could not have arisen blindly from material causes, and so it too must be the product of an omnipotent designer. "AH NO", you say, "That is not the proper conclusion; there is NO infinite regress of intelligent designers."

Seeing that he is not permitted to employ the logic you first taught him, the gullible listener infers a class ladder of religious consciousness in which he occupies the lowest wrung, while those who baffle him must have reached higher planes of consciousness where it is safe to appear inconsistent and still feel smugly faithful.

Richard:

Greg has enunciated an important notion: "You say that is not the proper conclusion; there is NO infinite regress of intelligent designers." I don't recall taking any position on an infinite regress of intelligent designers inasmuch as that idea is debated repeatedly in the best intellectual circles as an alternative to a single Big Bang. It is also considered that there could be an infinite regress of unintelligent causes. I once heard Dirac surmise that there might have been 17 Big Crunches. However, the total absence of empirical evidence for anything before the Big Bang does not support this fancy. We are left with an uncaused event.

Richard:

Intellectually the notion of an infinite regress of intelligent designers is elegant and appealing. However, an infinite regress of non intelligent causes is equally elegant and appealing, namely the bubble multiverse thesis, wherein our Big Bang was simply a bubble from another universe. So that gives us these possibilities:

1   One intelligent designer

2   One non intelligent designer

3   An infinite regress of intelligent designers.

1.   An infinite regress of non intelligent designers.

That now makes 4 possibilities for the existence of everything. Does anyone see any reason to choose one or the other? Does that exhaust the possibilities?

I like the notion that Prime Mover might not necessarily mean Intelligent or Prime Designer.

Probably the non intelligent designer would be synonymous with non intelligent prime mover. Now we are beginning to think out of the box. It occurs to me that a hundred years from now we might look back on this dialog as from the Dark Ages. An example is the following wild accumulations of frontier thoughts:

http://www.web-books.com/GoodPost/Articles/SeeGod.htm

Which includes string theory, multiple dimensions, gravitons, branes, dark matter and dark energy.

The author thinks we could see God with gravitons, for example. Well, that certainly is an insane idea, but considering how vast is our current ignorance, perhaps we need some more insane ideas lie this.

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Intelligent Design Mathematics

A question for debate:

Arithmetic is irreducibly complex. (Eliminate 3 and it falls apart). Therefore it had an intelligent designer. Yes or no?

(From Steven E. Landsburg: *The Big Questions.)*

Daniel:

I like Landsberg's argument. He's right about the irreducible complexity of the arithmetic of the integers. But his point (as I vaguely recall) is that arithmetic has no designer, so anyone who claims that something irreducibly complex necessarily has a designer is wrong. Do I remember correctly?

It might have something to do with the fact that we have no choice about which theorems are provable. I know I don't "design" my theorems: if I try to prove something that's false, I'll never succeed in finding a proof, because there isn't one.

Richard:

Let's see: he claims arithmetic existed before people and is irreducibly complex but did not have an intelligent designer. Therefore, even though a life form is irreducibly complex, it does not prove there was a designer because there is at least one other thing that is irreducibly complex and was not designed and that is arithmetic.

There is something wrong with his argument. I think arithmetic did not exist before people. It was invented by people.

If you invent a theorem, you designed it. It was not there before. He's comparing a life form with a thought. Oranges and apples.

I am suspicious he is in error because his reason is an analogy. I have an axiom; analogies are not proof. Therefore he has not destroyed intelligent design theory as he claims.

He says "If arithmetic couldn't have been any different, it can't have been designed." And "If you accept that the laws of arithmetic are dictated by logic, then even God can't change them."

I think that in logic, this statement is what's called the "straw man". Meaning you set up a false premise to knock it down.

Daniel:

No, I think you only call an issue a straw man if it's irrelevant to the topic under discussion. See

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

A straw man is a fallacy in which an irrelevant topic is presented in order to divert attention from the original issue. The basic idea is to "win" an argument by leading attention away from the argument and to another topic.

Presenting and refuting a weakened form of an opponent's arguments can be
a part of a valid argument. For example, one can argue that the opposing position
implies that at least one other statement—being presumably easier to refute than
the original position—must be true. If one refutes this weaker proposition, the
refutation is valid and does not fit the above definition of a "straw man" argument.

The two statements you point to actually are relevant.

Richard:

OK. A more rigorous statement:

Landsberg paraphrased: "The irreducible complexity of a life form is analogous to the
irreducible complexity of arithmetic and therefore rules out an intelligent designer of
life forms."

Definition of analogy: A form of logical inference or an instance of it, based on the
assumption that if two things are known to be alike in some respects, then they must be alike in
other respects.

Comment: The first statement is an analogy. Analogies are not dispositive facts of
similarity. Therefore the statement is not a cogent refutation of the argument for
intelligent design by irreducible complexity in life forms.

DRG: I think your paraphrasing of what Landsburg says probably changes the
meaning of what he said to make it unintelligible. And putting quotation marks
around a paraphrasing could be unintentionally misleading, because quotation
marks imply quotation. And you call that "rigorous" (?).

If you're going to argue against what Landsburg says, you should quote him
accurately, especially since I don't have the book in front of me.

So, umm, what did he actually say that you think is wrong?

Okay, he says that. Then...?

Richard:

OK back to my opening statement:

He says "If arithmetic couldn't have been any different, it can't have been designed." And "If you accept that the laws of arithmetic are dictated by logic, then even God can't change them."

My position is that arithmetic does not exist de novo. Mankind thinks and invents numbers from whence come relationships called arithmetic. Arithmetic HAS an intelligent designer and it is US.

Therefore it is wrong to say, as Landsberg did, that the pre-existence of an irreducibly complex structure (arithmetic) destroys the concept of an Intelligent Designer for the world.

The reason is that his premise claims that arithmetic pre-exists the world. Arithmetic does not pre-exist anymore than the idea of a wheel. Before the first wheel there was no wheel anymore than before the first arithmetical equation. It is apparent that mankind invented the thought of numerical relationships called mathematics. So

Mankind is the Intelligent Designer of Math, and the Intelligent Designer of the world might yet exist.

Daniel:

You say that "He thinks that arithmetic was there first". Do you have a direct quotation from the book to convince me that he thinks that? The one you provided below seems unrelated.

In any case, *you* might be introducing a straw man. Is the issue of *when* arithmetic was in existence relevant to whether it was *designed*?

(I'm having a bit of difficulty thinking of the number 3031102 as something that is here now in 2009 but wasn't around 100,000 years ago, because I don't see any relationship between numbers in mathematics and the passage of time in the physical universe, other than the arrival of people who could ponder the subject.)

Richard:

> Here is Landsberg's dogma in his own words: ***"I'm not just saying that the laws of arithmetic are eternal and immutable; I'm saying more than that. Eternal means for all time, but mathematics exists outside of time. Even if there were no time, there would still be mathematics."***

This almost sounds like Socrates, who thought that each soul knows everything at birth but forgets. Neither Socrates nor Landsberg has any evidence to assert this idea.

Daniel:

It's hard for me to argue against that without having the book at hand. I'll ignore Socrates, because he seems to be a straw man. Tomorrow I will see if I still have my draft copy of Landsburg's book on the shelf, or I will buy one for my kindle-app.   I will search the sentences on the pages before the one you quote for sentences that could be called evidence for that idea.

Save me some time and do the search for me!

Meanwhile, I will tell you my evidence for the idea. Here is the proof that 2+2 equals 4. Start with the definitions: 4 is 3+1, 3 is 2+1, 2 is 1+1. Then write 2+2 = 2+1+1 = 3+1 = 4. Conclude that 2+2 = 4. There. Now I look at the proof. I consider that 2+2=4 is provable, and 2+2=5 is not. The concept of time isn't involved, as far as I can see. Now you look at the proof and tell me if you can discern the involvement of time somehow.

Richard:

The quote is in chapter 1."On What There Is" about page 2-3 in "The Big Questions", (Kindle locations 226-33).

I am sure you can prove anything you wish. However, isn't he saying that you only ***discover*** theorems that already exist? How could a theorem exist if nobody ever thought of it? Where would it exist? That seems to be pure Greek mythology.

Daniel:

Do you admit that the theorem "2+2=4" exists? If so, tell me where it exists. If not, then you are denying existence for theorems both before and after people think of them.

Richard:

Right! I deny theorems exist before the thought of them. The idea of anything does not exist before the idea exists. That would be a tautology. The idea for a computer chip never existed 2,000 years ago, or at least we have no record of it, although we can surely say that the idea of a computer chip did not exist in the Dinosaur age.

You are about to conclude that you have before you an infinite number of pigeonholes, each filled with a theorem, and all you must do is look into each pigeonhole forever.

If so, how did they get there?

It must be the Intelligent Designer.

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Facts

Richard:

We must talk about facts for a moment. There are such things as facts. The earth is (roughly) round, the earth circles the sun (or more accurately they circle a common point in space), the moon orbits the earth, night and day are caused by the earth's rotation, the seasons are caused by the inclination of the earth's axis, and I could go on ad infinitum with facts that are no longer hypotheses. Do you now agree that theories can become facts?

Daniel:

Yes, and it happens when the scientists involved agree to dub the theory a fact.

Richard:

"Dubbing a theory as fact by the scientists" might be a little too simplified. Thomas S. Kuhn wrote (*The Structure of Scientific Revolutions*) how changes in theories occur. He called this the "paradigm shift". Anyway, I like the phrase Paradigm shift; it has elegance. For example, I think we will see a paradigm shift in psychology and psychiatry to the newer concept of evolutionary psychology.

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Objections to Evolution

Stephen Jay Gould said that evolution, for example, is now a fact, and the mechanisms and details about evolution are the theories. Now that I have said that evolution must be true, I have reread the book <u>Darwin On Trial</u> by Phillip Johnson. I would like you to answer his objections to Darwinism:

1. The hypothesis that natural selection has the degree of creative power required by Darwinist theory remains unsupported by empirical evidence.

Daniel:

The theory has been supported by the empirical evidence, i.e., it has not been falsified yet. *2. The common ancestors and transitional links are still only theoretical entities, conspicuously absent from the fossil record.*

Daniel:

Their absence from the fossil record may be conspicuous, but that doesn't cause any problems for the theory. The fossil record is incomplete.

Richard:

Absence of proof is not proof of absence. Furthermore, Gould states there are plenty of transitional forms, so it looks as if there is a debate that we non-paleontologists are not qualified to join.

3. Science knows of no natural mechanism capable of accomplishing the enormous changes in form and function required to complete the Darwinist scenario.

Daniel:

Science does know a mechanism; it is natural selection of variations and mutations.

4. The real mystery of evolution is how the marvelous molecular structures could have evolved in the first place and how could a simple cell change into a complex plant or animal.

Daniel:

Some details of the process will never be known, but this doesn't mean the theory is false.

5. Darwinism is an empirical doctrine but as for how complex organisms came into existence in the first place, it is pure philosophy.

Richard:

What is science?

"Systematized knowledge in any field, but applied usually to the organization of objectively verifiable sense experience. The pursuit of knowledge in this context is known as pure science to distinguish it from applied science that is the search for practical uses of scientific knowledge, and from technology, through which applications are realized." (Microsoft Encarta)

The encyclopedia Encarta also states that the scientific method is a "Term denoting the principles that guide scientific research and experimentation, and also the philosophic bases of those principles. Whereas philosophy in general is concerned with the why as well as the how of things, science occupies itself with the latter question only, but in a scrupulously rigorous manner. The era of modern science is generally considered to have begun with the Renaissance, but the rudiments of the scientific approach to knowledge can be observed throughout human history."

6. *The falsifiability criterion does not necessarily differentiate natural science from other valuable forms of intellectual activity.*

Daniel:

I don't understand this objection. For example, mathematics is a valuable form of intellectual activity but is not an empirical science; it is the logic of relationships.

Richard:

In addition, I might argue that theology is a non-falsifiable intellectual activity, but does this mean that theology is not of value? We might debate that one forever, I think.

7. *Common ancestry is a hypothesis, not a fact.*

Daniel:

Hardly anything in science is a fact.

Richard:

Some argue that you cannot even prove that you or anything else exists. The strength of the scientific method is its flexibility. As Popper pointed out, verification is not proof, but only if the hypothesis passes the test of failure to find a falsification can the thesis, or what he called the "statement", be sustained.

8. *The universal genetic code does imply an element of commonality which means only that it is unlikely that life evolved by chance on many different occasions. Relationships may have come from some process altogether beyond the ken of our science. As a hypothesis it deserves our most respectful attention, which, in Popper's terms, means that we should test it rigorously.*

Daniel:

It's his responsibility to produce a theory outlining this mysterious process of his, so the theory can be tested. Simply asserting that there might be another process is not good enough.

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Theories

Richard:

Upon reflection, perhaps I should withdraw my conclusion that evolution is a fact and revert to the word "theory". Furthermore, so far as I can tell, universal laws such as those of thermodynamics, are falsifiable, making me think that there is no semantic difference between law and theory. For example, the laws of gravity seem to have been modified by Einstein. High-energy physicists and cosmologists have new and obscure theories about gravity, so it appears to be a theory, not a law or a set of eternal laws.

This debate is becoming more involved because now we are confronted with trying to define our basic ideas about theories, hypotheses, empiricism, falsification, scientific laws, facts, and truth. We could give up the dialogue out of pure exhaustion by claiming that all is but wind and semantics, but you and I know that this is not merely an exercise in verbiage, it is a discussion about the most important ideas to our species: where did we come from? Why are we here? How can we prove our answers?

I have found two tests involving falsification that Charles Darwin himself described in "Origin of Species", even though the concept had not been invented, or at least codified, until 1934 by

Popper:

1   *"Though Nature grants long periods of time for the work of natural selection, she does not grant an indefinite period . . ."* In other words, Darwin himself seems to agree that if there would be found insufficient geological time for natural selection to act, evolution would be proven false.
2   *"If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down. But I can find no such case."*

According to Phillip E. Johnson in "Darwin on Trial", there are many structures such as hemoglobin and mammalian hair which could not have been produced by natural selection. This is a provocative assertion and I think that for us non-biologists, all we can do is confess ignorance on the subject and await some expert to present us with a study of each challenged organ or structure.

I now would like to address Johnson's objection number six above wherein he states that the falsifiability criterion does not necessarily differentiate natural science from other valuable forms of intellectual activity.

Apparently Johnson thinks there are other valuable forms of thought. If we hold that

metaphysics and theology are inadequate forms   of knowledge and not to be trusted, then we are, by definition, logical positivists, or empiricists. What are other forms of intellectual activity worth our consideration? Is only that which is falsifiable the only criterion of value for intellectual activity?

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Mathematics

Daniel:

As a professor of theoretical mathematics, I must affirm that math is a valuable intellectual activity. My problem, however, is that I find math in no sense falsifiable. In other words, two plus two equals four is not open to question.

Craig:

Mathematics is 100% deduction. It is a tautological system and therefore discussion of its falsifiability is not relevant. Tautology means redundancy or reiteration.

Richard:

In other words, when you say 2 and 2 is 4, you are simply repeating what you know in different words, and thus the answer in a way is redundant.

If mathematics is not a science and is not falsifiable, the world must have turned upside down, because I thought that math was a science. Historically, the Pythagorean scholars distinguished only four sciences: arithmetic, geometry, music, and astronomy.

Now, however, in studying the subject, I find that math is not an empirical science but is called a science anyway: "During the 19th century scientists finally recognized that pure mathematics differs from the other sciences in that it is a logic of relations and does not depend for its structure on the laws of nature. Its applicability in the elaboration of scientific theories, however, has resulted in its continued classification among the sciences." (Microsoft Encarta)

Daniel, I challenged you once that there must be certain axioms in mathematics and that if there are axioms, or premises, and you could find one premise that was not true, then math is like other empirical sciences. You claim there are at least four premises in your work. What are they?

Daniel:

Mathematics is what you get when you insist on absolute certainty for your conclusions.

The premises underlying mathematics are technical and ad hoc, so are not worth discussing here. The main embarrassment we suffer from them is the inability to prove the premises are not self-contradictory.

Craig:

Does this mean you think we can't handle it**?** Maybe you're right!

Richard:

Daniel, when you said that "premises underlying mathematics are technical and ad hoc, so are not worth discussing. The main embarrassment we suffer from them

is the inability to prove the premises are not self-contradictory". Were you referring to Godel's proof? He proved that within any rigidly logical mathematical system there are propositions or questions that cannot be proved or disproved on the basis of the axioms within that system and that, therefore, it is uncertain that the basic axioms of arithmetic will not give rise to contradictions. Now will you discuss this with me?

Daniel:

Yes, that's what I meant.

I suppose we could discuss it, but if you've already found a reference to Goedel's proof, then you have found a discussion of it, perhaps and we don't need to explore it further.
Richard:

Well, let's talk anyway. What is the significance of Godel's (Goedel's) Proof? The reference said that his proof shook mathematics and still does. Does it mean that you can never prove that a straight line is the shortest distance between two points, for example?

Daniel:

No, we can prove things like that. So it has no significance at all for the day to day practice of mathematics.

Richard:

Does Godel have any meaning for the lay person?

Daniel:

One consequence is that there are simple sounding mathematical statements which can neither be proved nor disproved. Another consequence is that we might find some day that our axioms on which we base all our arguments might be self-contradictory, and we would have to find a new set of axioms. No one expects this to happen, though.

Richard:

Does it mean that space could be bounded?

Daniel:

That's a question about the real world, and doesn't fall within the realm of questions one can answer using mathematics.

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Theorems and Proofs

Richard:

Was his a proof or a theorem or a theory? Why do they call it a proof?

Daniel:

He stated and proved a theorem. The theorem shows how to construct a mathematical statement that can not be proved nor disproved from the axioms, provided the axioms are sufficiently powerful to allow the discussion of arithmetic. The statement he constructed in mathematical form says "There is no proof of me." Now if there were a proof of it, that would contradict the assertion made by the statement, and if there were a disproof of it, that would also be a contradiction. The tricky part is phrasing the statement as a statement about numbers.

Richard:
Are there any other forms of intellectual activity other than science and mathematics of value?

Daniel:

Yes, for example, this discussion.

Richard:

The answer to that statement seems to be that we are involved in the philosophy of science. I would arbitrarily conclude that to discuss how to do science is part of science and really is science and therefore not a separate intellectual activity. We are simply talking about how to do science, or in other words to think about science. We have applied terms such as logic, epistemology, philosophy, science, scientific method, and metaphysics to this discussion. How do you see our debate now?

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Philosophy

Daniel:

As part of the philosophy of science.

Richard:

Then it appears that there are at least four valuable forms of intellectual activity: philosophy of science, science itself, mathematics, and statistics.

What is philosophy?

1. Inquiry into the nature of things based on logical reasoning rather than empirical methods.
2. The critique and analysis of fundamental beliefs as they come to be conceptualized and formulated. (American Heritage Dictionary.)

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Statistics

Craig:

Why statistics? It is a part of math.

 Richard:

Is statistics a branch of mathematics? Daniel, is there a branch of it in your math department?

Daniel:

Statistics is not really a branch, but lots of it is mathematical. It often is contained in math departments, but at the University of Illinois the statisticians broke off and formed their own department about 8 years ago. But furthermore, I object to attempts to classify the "valuable" forms of intellectual activity. What are the criteria for deciding value?

Richard:

I am attempting to do this in order to exclude useless efforts at intellectual activity such as superstition and astrology. I would suppose that value is relative and subjective.

Daniel:

And that's exactly what Popper was trying to do when he formulated this notion of falsifiability. It seems to do a good job of distinguishing scientific theories from non-scientific theories, and that's what appeals to me.

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Non-scientific Theories

Richard:

Ah! A new term: non-scientific theories. I don't know if I have heard anyone use that phrase

before, but now if we introduce the phrase into the discussion, we at least have a definition. The

defining difference between scientific and non-   scientific theories seems to be falsifiability.

However, there are other criteria for science: It is guided by natural law; It has to be explanatory

by reference to natural law; It is testable against the empirical world; Its conclusions are

tentative, i.e. are not necessarily the final word; and It is falsifiable. (From McLean v. Arkansas

Board of Education Decision and Judgment,
Jan 5, 1982.) Let's see if you can name four more non-scientific theories.

Daniel:

Creationism, theism, and atheism. These are not falsifiable and therefore are non-scientific theories.

Craig:

My position is that non-scientific statements might or might not be true, but the Popper criterion is <u>not</u> useful in assessing the validity of metaphysical statements.

The scientific/non-scientific dichotomy you have created is unfortunate because it puts mathematics into the non-scientific class. Better to stick with falsifiable and non-falsifiable.

Richard:

Craig, that sounds reasonable. We get hung up on our arbitrary vocabulary sometimes. But think of the paradigm shift you are requesting. You are asking about 5 billion people to change their definitions of science.

I suppose that synonyms for "non-scientific theory" might be assertion, revelation, or faith. It is tempting to say that any statement that is not falsifiable, is not worth believing. (Except for math?) One could become a total non-believer in every statement that is non-scientific. In practice, however, I suspect that what we actually do in life is more complicated. I think what happens is a wager, much as Blaise Pascal would have espoused; I bet that the airliner will not crash and therefore I board it. I bet that vitamins are good for me and I take them. I bet that God might exist and therefore I continue to think and talk about Him. This wagering is really a statistical exercise; what I state is a probability that theism or atheism is true, that vitamins are probably good for me, and the odds are the airplane will not crash. I don't know all of these things in advance, but I hope I have weighed the evidence properly.

Popper, himself, had a great deal to say about probability in *The Logic of Scientific Discovery*. He said *"Probability estimates are not falsifiable. Neither, of course, are they verifiable, and this for the same reasons as hold for other hypotheses, seeing that no experimental results, however numerous and favorable, can ever finally establish that the relative frequency of `heads' is 1/2, and will always be 1/2."*

Daniel:

Actually, there is something I don't know about statistics. If we want to deduce a probability that a drug is effective from the results of trials, how do we do it? I can't think of a way.

Craig:

You don't deduce. You use **induction,** not deduction. Induction is when you draw a conclusion from a number of facts. **Deduction** is when your conclusions come from premises.

Daniel:

It's true that you can't falsify a prediction of the probability of something by performing many trials. For example, when you toss a coin and get 100 heads in a row, it doesn't necessarily mean that the coin is unfair. In fact, occasionally 100 heads in a row WILL occur.

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Null Hypothesis

Richard:

I believe that the way you test a drug statistically is by use of the "null hypothesis". Apparently what you do is to assume that there is no difference between the experimental and the control group before the test, then see if there is a difference. That sounds suspiciously like falsification, doesn't it?

Daniel:

Consider this phrase from the article you sent me: "When the probability model for the mechanism generating the observed data is known, hypotheses about the model can be tested."

I don't understand what he was really referring to but it might be this: I wonder whether much can ever be known about the mechanism generating drug test trials, and whether we are hiding something embarrassing about statistical tests of effectiveness of drugs. Suppose all patients in the world are like fair coins: they get well with a probability of 50%, and drugs don't affect the outcome. Could any test falsify this? Then suppose we do drug trials with specific drugs. Some drugs will appear to do better than others by random chance, and those will be the drugs approved. If we test enough drugs, occasionally one will come along that appears to be remarkably effective in the trial. I don't think the world is like that, but I don't know how to prove it isn't. So I do not believe that the null hypothesis is the same as falsification.

Richard:

Why isn't the null hypothesis the same as falsification? I don't understand your position. Here is a quote from the Encyclopedia Britannica Online defining the hypothesis "The null hypothesis in statistical INFERENCE is a statement against which a statistical procedure seeks to establish evidence. In scientific work a researcher often hopes to establish that an effect is present or that a difference between two treatments exists.

"For example, a new drug may be tested to determine if it is more effective than the old one. A statistician could approach this problem by hypothesizing that no difference exists--this would be a null hypothesis--and then assessing the evidence against this hypothesis provided by the data. If the evidence, often found by sampling, proves to be improbable (to whatever degree has been specified), then the null hypothesis will be rejected, and an alternative, more probable

hypothesis will be sought."

Daniel:

The null hypothesis is something that a statistician tries to falsify. Falsification is the act of falsifying something. So these two things could never be the same thing, because they aren't the same type of thing.

Richard:

Ah. That clarifies the question. The null hypothesis is the theory to be tested by looking for whatever demonstrates it to be probably false. Therefore falsification is what you use against the null hypothesis. Drug testing also takes into account the placebo effect which means that placebos actually work and also replicability, which means that if only one trial is done we don't believe it.

Daniel:

It is useful to think of tossing a coin, and keep in mind that it might not be a fair coin.

You want to know the probability that this particular coin comes up heads. Suppose you toss it 100 times and it comes up heads 48 times. What do you conclude? Do you conclude that the probability is 48%? No, that would be premature, since the true probability might be 50%, and since you might have strong reasons for suspecting the coin is fair (it looks symmetric, you can't detect any evidence of loading, etc.)

So, surprisingly, in statistics you always have two things. You have the probability you think might be true, 50% in the case above --that's the "null hypothesis". And you have the "experimental results", 48% of 100 trials in the case above. Now what do you say about those two things? How do you compare them?

You could compute the probability of getting those experimental results in the presence of the null hypothesis. In the example at hand, that probability is 7.35%, so the experimental results are not outlandish, and we wouldn't venture to guess that we've proved the coin is unfair.

Alternatively, getting 30 heads from 100 tosses of a fair coin happens only 0.0023% of the time, and the rarity of that outcome might convince us that the coin is unfair. But it wouldn't *prove* the coin is unfair, because we could and do occasionally get such a skewed result from a fair coin.

With a new drug, the correct working (null) hypothesis is that the drug is useless, and you want to see whether the experimental results lead you to doubt that, which is turn would lead you to believe the drug is useful.

Notice that we aren't assuming the null hypothesis to be true --instead, we run experiments to see whether we should doubt the null hypothesis. Only after

running those experiments do we announce our results.

Concerning your example about the two researchers, you are *right* that the researchers can't both be right. But the two null hypotheses are just two initial guesses. Don't forget about the experiments the two researchers will do. One of them is going to get experimental results that cause him to doubt his working hypothesis. It might turn out that they *both* end up doubting their working hypotheses, and so they are both wrong!

What does a scientist do after the null hypothesis is vanquished? It's sort of like what we would do after getting 30 heads from 100 tosses of a coin. We make a new working hypothesis. Should we guess that the coin is unfairly loaded so that it has a 30% probability of giving heads? Maybe. But further experiments, based on millions of trials, may convince us to reject that hypothesis and change it to 29% or to 31%.

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Probability

Daniel:

10 trials is the same as one big trial ten times the size. Even if 10,000 patients are cured by drug X, and 10,000 are killed by drug B, it might be just dumb luck.

Craig:

But the probability that it is dumb luck in one trial is much less than in the case of 10 trials. Indeed, statistical confidence tests are attempts to estimate and quantify this dumb luck.

Richard:

Regarding testing drugs or anything with a probability answer: When the DNA chemist states that the probability that the defendant's DNA could have been some other person is 1 in 5 billion on 12 different samples of blood tested in 3 different laboratories, is this not proof that the defendant's blood is being tested? Or are you going to reiterate that it could be dumb luck, ignoring the possibility of tampering or contamination for the time being?

Daniel:

No, that's a completely different situation. We know the random processes that put genes into our bodies, but we don't know the random process that puts drugs needing to be tested into our hands. Let's make a simple example. Suppose each patient is cured with a 50% chance, and no drugs have any effect. Then if each trial has 10 patients in it, we expect 5 patients on average to be cured. A trial in which all 10 patients are cured may lead us to believe that the drug is effective. Could a trial with all 10 patients are cured occur very often? It is easy to compute the probability: one chance in 1024. So if we conduct 1024 trials of 1024 useless drugs, we expect one of the trials to show all 10 patients being cured. It would be silly to pronounce that one random drug effective. Now change the situation just slightly. Suppose we conduct one trial instead of 1024, and all 10 patients are cured? Do we announce the drug effective?

Richard:

When are we confident of anything?

If someone says he is confident, I think you should immediately start to worry a lot. For example, this statement scares me to death:

"By Times Staff Writer Published
December 25, 2003

Is it safe to eat my Christmas roast?

USDA officials say they are confident all U.S. beef is safe despite this incident
of presumed mad cow disease. In addition, whole cuts of beef -steaks, chops,
roasts - are generally safe to eat because mad cow disease is not known to affect
the cattle's muscle meat."

The word confident is used by public relations people and others who do not want to be held accountable for their predictions. It is a statement of probability which can be anything from 1 to 99 percent probable, but the number is always hidden from view or is unknown even to the author. The word "generally" is obviously even more threatening a probability of death and destruction and if used in connection, say , with a statement of the safety of your parachute, should persuade you not to jump out of the airplane.

Like, I am confident that generally your parachute might work, and if it doesn't, bring it back for another.

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Rationalism vs. Empiricism

Richard:

No we don't pronounce the drug effective yet. That's why we demand replicability. You must repeat the trial one or more times, preferably in more than one place by different people to rule out dumb luck and tampering. Then you use the double blind technique to rule out the placebo effect. Now I would like to address the question of how we are to name our philosophical propensities: are you and I rationalists or empiricists? Or can we be both? I quote:

"Empiricism: In philosophy, doctrine that affirms that all knowledge is based on experience, and denies the possibility of spontaneous ideas or a priori thought."

"Rationalists asserted that the mind was capable of recognizing reality by means of reason, a faculty that existed independent of experience."

"Empiricism, also known as logical positivism, like agnosticism, rejects both atheism and theism and maintains that metaphysical statements are meaningless." (Microsoft Encarta)

Craig:

I guess that's me!

Daniel:

I won't classify myself. I would hate to say something like "I am an empiricist" because I am sure I don't understand the definition of empiricist, and there are probably connotations to the word that I don't know about. So I won't.

Richard:

It is interesting to say you choose not to classify yourself. Does that mean you don't know whether you are an

a.) empiricist or a

b.) rationalist or that you are

c.) both

d.) or it depends on the issue?

Here is an encyclopedia entry on empiricism to help you decide:

Empiricism: In philosophy, doctrine that affirms that all knowledge is based on experience, and denies the possibility of spontaneous ideas or a priori thought.

Rationalists asserted that the mind was capable of recognizing reality by means of reason, a faculty that existed independent of experience. Empiricism, also known as logical positivism, like agnosticism, rejects both atheism and theism and maintains that metaphysical statements are meaningless.

Empiricists claim that knowledge can be based only on information gained from the senses. Such information, the rationalists contend, is always open to question. They point to mathematics and logic as realms where unquestionable truths can be discovered by the use of reason alone. Baruch SPINOZA, perhaps the supreme rationalist of Western philosophy, presented his philosophical views in geometrical form and deduced theorems about the world based on axioms that he held to be rational truths. (Microsoft Encarta)

Now, what do you have to say?

Daniel:

I'm certainly not an empiricist, because I don't reject theism, and I think mathematics is not all based on experience, even though much of it is motivated by experience (such as geometry).
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To Truth?

Richard:

If you thought you knew the way to truth, you would either be asserting it as a given, that is, as a premise, or you would have to prove your method of determining truth empirically by the scientific method.

Therefore, the only way to truth, that is, to the nature of reality, is empirical. Personally, I think I am an empiricist and I suspect you are also. Admit now, that you know. Tell the world. What is the way to truth?

Daniel:

I don't know the way to truth, too bad.

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Glossary

Agnosticism

Doctrine that the existence of God and other spiritual beings is neither certain nor impossible. (Microsoft Encarta)

Axiom

A self-evident principle or one that is accepted as true without proof as the basis for argument; a postulate. An assumption. (Microsoft Encarta)

Deductive Logic

Both classical and modern logic are systems of deductive logic. In a sense, the premises of a valid argument contain the conclusion, and the truth of the conclusion follows from the truth of the premises with certainty. Systems of inductive logic are such that the premises are evidence

for the conclusion, but the truth of the conclusion follows from the truth of the evidence only with a certain probability. (Microsoft Encarta)

Deduction

In logic, the form of reasoning by which specific conclusions are inferred from certain accepted general principles, or premises. The opposite of deduction is induction, the form of reasoning by which general principles are drawn from specific cases and particular facts. (Microsoft Encarta)

Empiricism

In philosophy, doctrine that affirms that all knowledge is based on experience, and denies the possibility of spontaneous ideas or a priori thought. Rationalists asserted that the mind was capable of recognizing reality by means of reason, a faculty that existed independent of experience. Empiricism, also known as logical positivism, like agnosticism, rejects both atheism and theism and maintains that metaphysical statements are meaningless.

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Epistemology

Epistemology is the branch of **philosophy** that studies knowledge. It attempts to answer the basic question: what distinguishes true (adequate) **knowledge** from false (inadequate) knowledge? Practically, this questions translates into issues of scientific methodology: how can one develop theories or models that are better than competing theories? It also forms one of the pillars of the new sciences of cognition, which developed from the information processing approach to psychology, and from artificial intelligence, as an attempt to develop computer

programs that mimic a human's capacity to use knowledge in an intelligent way.
(http://pespmc1.vub.ac.be/EPISTEMI.html)

Falsification; a Method

It is easy to obtain confirmations, or verifications, for nearly every theory — if we look for confirmations.

Confirmations should count only if they are the result of risky predictions; that is to say, if, unenlightened by the theory in question, we should have expected an event which was incompatible with the theory — an event which would have refuted the theory.

Every "good" scientific theory is a prohibition: it forbids certain things to happen. The more a theory forbids, the better it is.

A theory which is not refutable by any conceivable event is non-scientific. Irrefutability is not a virtue of a theory (as people often think) but a vice.

Every genuine test of a theory is an attempt to falsify it, or to refute it. Testability is

falsifiability; but there are degrees of testability: some theories are more testable, more exposed to refutation, than others; they take, as it were, greater risks.

Confirming evidence should not count except when it is the result of a genuine test of the theory; and this means that it can be presented as a serious but unsuccessful attempt to falsify the theory. (I now speak in such cases of "corroborating evidence.")

Some genuinely testable theories, when found to be false, are still upheld by their admirers — for example by introducing ad hoc some auxiliary assumption, or by reinterpreting the theory ad hoc in such a way that it escapes refutation. Such a procedure is always possible, but it rescues the theory from refutation only at the price of destroying, or at least lowering, its scientific status. (I later described such a rescuing operation as a "conventionalist twist" or a "conventionalist stratagem.")

One can sum up all this by saying that the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability.

http://www.stephenjaygould.org/ctrl/popper_falsification.html   (Karl Popper, 1963)

Hypothesis

Socrates resolved to consider primarily not "facts" but the "statements" or "propositions" that one makes about "facts." His method would be to start with whatever seemed the most satisfactory A hypothesis," or postulate, about a given subject and then consider the consequences that follow from it. So far as these consequences proved to be true and consistent, the hypothesis might be regarded as provisionally confirmed. But one should not confuse inquiry into the consequences of the hypothesis with proof of its truth. The question of truth could be

settled only by deducing the initial hypothesis as a consequence from some more ultimate, accepted hypothesis. (Online 1995 Encyclopaedia Britannica, Inc.)

Inductive reasoning

When a person uses a number of established facts to draw a general conclusion, he uses inductive reasoning. This is the kind of logic normally used in the sciences. For example, a scientist may gather all the facts he can about a certain disease from observation and experiment. Then he draws his inductive conclusion, perhaps that a certain microbe causes the disease. An inductive argument, however, is never final: It is always open to the possibility of being falsified. For instance, the observation of swans over the centuries has led to the conclusion that all swans are white. The discovery of one black swan would falsify this theory, but it would still be true that most swans are white. Inductive reasoning is always subject to revision if new facts are discovered. It is by this process of induction and falsification that progress is made in the sciences. (America Online; Compton's Encyclopedia)

Induction

In logic, process of reasoning from the particular to the general as opposed to the inverse process of deduction. The basis of induction is the assumption that if something is true in a number of

observed instances, it is also true in similar, but unobserved, instances. The probability of accuracy depends on the number of instances observed. One of the simplest types of induction is involved in the interpretation of opinion polls, in which the answers given by a small percentage of the total population are projected for the entire country.
Inductive reasoning was developed by various philosophers from Francis Bacon to David Hume, John Stuart Mill, and Charles Sanders Pierce.

"Induction (logic)," Microsoft (R) Encarta. Copyright (c) 1993 Microsoft Corporation. Copyright (c) 1993 Funk & Wagnall's Corporation

Intelligent Design

In summary, intelligent design is "a predesigned complex of elements in interaction, these interactions being of an ordered (non-random) nature, that potentiates new behavior(s) or function(s), all brought about by an agency beyond the natural order."
      (http://www.asa3.org/archive/asa/199612/0001.html)

Meme

Unlike a virus, which is encoded in DNA molecules, a meme is nothing more than a pattern of information, one that happens to have evolved a form which induces people to repeat that pattern. Typical memes include individual slogans, ideas, catch-phrases, melodies, icons, inventions, and fashions. It may sound a bit sinister, this idea that people are hosts for mind-altering strings of symbols, but in fact this is what human culture is all about.

Metaphysics

Branch of philosophy concerned with the nature of ultimate reality.

Null Hypothesis

The null hypothesis in statistical INFERENCE is a statement against which a statistical procedure seeks to establish evidence (see STATISTICS). In scientific work a researcher often hopes to establish that an effect is present or that a difference between two treatments exists.

For example, a new drug may be tested to determine if it is more effective than the old one. A statistician could approach this problem by hypothesizing that no difference exists--this would be a null hypothesis--and then assessing the evidence against this hypothesis provided by the data. If the evidence, often found by sampling, proves to be improbable (to whatever degree has been specified), then the null hypothesis will be rejected, and an alternative, more probable hypothesis will be sought. DAVID S. MOORE

Bibliography: Bauer, P., et al., eds., Mathematical Statistics and Probability: Statistical Inference and Methods: vol. B (1987).

Paradigm Shift

As the philosopher Thomas Kuhn has pointed out, science does not always advance in the gradual and stately fashion commonly attributed to it. Major breakthroughs often come from a leap forward that is at least in part intuitive and may fly in the face of conventional wisdom and widely accepted evidence while strict requirements for verification and proof are temporarily relaxed. Revolutions thus often become widely accepted before the verdict from rigorous analysis of evidence is completely in. Such was certainly the case with the geologic revolution, which also confirms Kuhn's view that a new paradigm is unlikely to supersede an existing one until there is little choice but to acknowledge that the conventional theory has failed. Thus, while Wegener did not manage to persuade the world, the successor theory was readily embraced 40 years later, even though it remained open to much of the same criticism that had caused the downfall of continental drift. What is the state of the new paradigm? Is it likely to suffer sooner rather than later the same fate that inevitably awaits all scientific theories? Among the formally educated, if not among the general population, traditional science was transformed by the new heliocentric, mechanistic, and mathematical conceptions of Copernicus, Harvey, and complete an overthrow of the earlier model. Aristotle's authority gave way very slowly, and only the first of the great scientists mentioned above did his work in the period under consideration. Still, the Renaissance made some important contributions toward the process of **paradigm shift**, as the 20th-century historian of science **Thomas Kuhn** called major innovations in science.

In his first book, The Copernican Revolution (1957), Kuhn studied the development of the heliocentric theory of the solar system during the Renaissance. In his landmark second book, The Structure of Scientific Revolutions, he argued that scientific research and thought are defined by "**paradigm**s," or conceptual world-views, that consist of formal theories, classic experiments, and trusted methods. Scientists typically accept a prevailing **paradigm** and try to extend its scope by refining theories, explaining puzzling data, and establishing more precise measures of standards and phenomena. Eventually, however, their efforts may generate insoluble theoretical problems or experimental anomalies that expose a **paradigm**'s inadequacies or contradict it altogether. This accumulation of difficulties triggers a crisis that can only be

resolved by an intellectual revolution that replaces an old **paradigm** with a new one. The overthrow of Ptolemaic cosmology by Copernican heliocentrism, and the displacement of Newtonian mechanics by quantum physics and general relativity, are both examples of major **paradigm** shifts.

(Encyclopedia Britannica Online)

Philosophy

1. Inquiry into the nature of things based on logical reasoning rather than empirical methods. **2.** The critique and analysis of fundamental beliefs as they come to be conceptualized and formulated. (American Heritage Dictionary)

Popper

Karl Popper (born 1902). Originator of the theory of falsifiability, Karl Popper is best known for his rejection of the inductive method of reasoning in the empirical sciences. In inductive logic a statement of supposed fact a hypothesis is proven true if repeated observations substantiate it. In opposing this viewpoint, Popper insisted that hypotheses must be testable, and that the right test for a scientific hypothesis is to look for some circumstance for which it does not hold. If no such circumstance can be found then the hypothesis is true.

Karl Raimund Popper was born in Vienna, Austria, on July 28, 1902. He attended the University of Vienna, receiving his Ph.D. there in 1928. He taught in secondary schools in Vienna for a time, and then in 1937 he moved to New Zealand, where he taught philosophy at Canterbury University College until 1945. From 1945 until his retirement in 1969, he headed the department of philosophy, logic, and scientific method at the London School of Economics in England. He also lectured widely both in Great Britain and in the United States.

Popper's publications include a number of periodical articles and several books. In his first book, 'The Logic of Scientific Discovery', published in 1934, he presents his thoughts regarding falsifiability and inductive logic and outlines his method of distinguishing between sciences and pseudosciences. The theoretical constructs rejected by Popper as pseudosciences because they failed to pass his test of falsifiability include such fields of study as astrology, Freudian psychoanalysis, metaphysics, and Marxism.

Popper's later works include "The Open Society and Its Enemies" (1945) and "The Poverty of Historicism" (1957). In both of these books he opposes historical determinism, the view held by Plato, Hegel, and Marx that history develops in accordance with inexorable natural laws. His three volume Postscript to the Logic of Scientific Discovery, (1981) expands on the ideas presented in his first book. Popper was knighted in 1965. (America Online; Compton's encyclopedia)

Positivism

System of Philosophy based on experience and empirical knowledge of natural phenomena, in which metaphysics and theology are regarded as inadequate and imperfect systems of knowledge. (Microsoft Encarta)

Rationalism

Rationalism is a theory that contends that the most fundamental knowledge is based on reason and that truth is found by rational analysis of ideas independent of empirical data, emotive attitudes, or authoritative pronouncements. Rationalist beliefs, essentially philosophical, have significantly influenced science and religion as well.

Science

Systematized knowledge in any field, but applied usually to the organization of objectively verifiable sense experience. The pursuit of knowledge in this context is known as pure science to distinguish it from applied science which is the search for practical uses of scientific knowledge, and from technology, through which applications are realized. (Microsoft Encarta)

Scientific Method

Term denoting the principles that guide scientific research and experimentation, and also the philosophic bases of those principles. Whereas philosophy in general is concerned with the why as well as the how of things, science occupies itself with the latter question only, but in a scrupulously rigorous manner. The era of modern science is generally considered to have begun with the Renaissance, but the rudiments of the scientific approach to knowledge can be observed throughout human history.

Definitions of scientific method use such concepts as objectivity of approach to and acceptability of the results of scientific study. Objectivity indicates the attempt to observe things as they are, without falsifying observations to accord with some preconceived world view. Acceptability is judged in terms of the degree to which observations and experimentations can be reproduced. Scientific method also involves the interplay of inductive reasoning (reasoning from specific observations and experiments to more general hypotheses and theories) and deductive reasoning (reasoning from theories to account for specific experimental results). By such reasoning processes, science attempts to develop the broad laws such as Isaac Newton's law of gravitation that become part of our understanding of the natural world.

Science has tremendous scope, however, and its many separate disciplines can differ greatly in terms of subject matter and the possible ways of studying that subject matter. No single path to discovery exists in science, and no one clearcut description can be given that accounts for all the ways in which scientific truth is pursued. One of the early writers on scientific method, the English philosopher and statesman Francis Bacon, wrote in the early 17th century that a tabulation of a sufficiently large number of observations of nature would lead to theories accounting for those operations the method of inductive reasoning. At about the same time, however, the French mathematician and philosopher Rene Descartes was attempting to account for observed phenomena on the basis of what he called clear and distinct ideas the method of deductive reasoning.

A closer approach to the method commonly used by physical scientists today was that followed by Galileo in his study of falling bodies. Observing that heavy objects fall with increasing speed, he formulated the hypothesis that the speed attained is directly proportional to the distance traversed. Being unable to test this directly, he deduced from his hypothesis the conclusion that objects falling unequal distances require the same amount of elapsed time. This was a false conclusion, and hence, logically, the first hypothesis was false. Therefore Galileo framed a new

hypothesis: that the speed attained is directly proportional to the time elapsed, not the distance traversed. From this he was able to infer that the distance traversed by a falling object is proportional to the square of the time elapsed, and this hypothesis he was able to verify experimentally by rolling balls down an inclined plane.

Such agreement of a conclusion with an actual observation does not itself prove the correctness of the hypothesis from which the conclusion is derived. It simply renders the premise that much more plausible. The ultimate test of the validity of a scientific hypothesis is its consistency with the totality of other aspects of the scientific framework. This inner consistency constitutes the basis for the concept of causality in science, according to which every effect is assumed to be linked with a cause.

Scientists, like other human beings, may individually be swayed by some prevailing worldview to look for certain experimental results rather than others, or to intuit some broad theory that they then seek to prove. The scientific community as a whole, however, judges the work of its members by the objectivity and rigor with which that work has been conducted; in this way the scientific method prevails.

"Scientific Method," Microsoft (R) Encarta. Copyright (c) 1993 Microsoft Corporation. Copyright (c) 1993 Funk & Wagnall's Corporation

Spinoza [Benedict (Baruch) Spinoza (1632- 1677)]

In Part One of the Ethics, "Concerning God," after presenting a short list of definitions and axioms, Spinoza deduces 36 propositions which explain the nature of God. The most important of these is Proposition 14, which expresses Spinoza's pantheism: "Besides God, no substance can be granted or conceived." The term **"pantheism"** (literally all-God) means that God is identical to the universe as a whole. For example my car, my house, and even I myself are all parts of God. Other Western philosophers before Spinoza advocated pantheism, including Xenophanes, Parmenides, Plotinus, and Meister Eckhardt. However, the vast majority of Western philosophers and theologians strongly rejected this view in favor of a transcendent concept of God which holds that God is distinct from his creation. Indeed, some theologians maintained that God has the attribute of separateness thus being completely separate from the rest of the universe, including the physical world and humans. Spinoza's argument for pantheism in Proposition 14 is as follows:

Proposition 5. There cannot exist in the universe two or more substances having the same nature or attribute. Proposition 11: God (defined as a substance consisting of infinite attributes, of which each expresses eternal and infinite essentiality) necessarily exists. Therefore, Proposition 14: Besides God, no substance can be granted or conceived. The intuition behind Spinoza's argument above can be expressed simply. Two separate substances cannot share the same attributes (P 5). God has every actual and possible attribute (P 11). Thus, no other substance can exist. To illustrate Spinoza's point, imagine an infinitely long list of qualities such as "consciousness" and "three-dimensionality." For Spinoza, each attribute on this list can be assigned to only one substance or thing. So, substance 1 might exclusively have the attribute of "consciousness," and substance 2 might exclusively have the attribute of "three- dimensionality."

However, God has already been assigned all attributes on the list, and no attributes are left to assign to other substances. Since a substance can't exist if it doesn't have any attributes, then God is the only substance which exists.

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