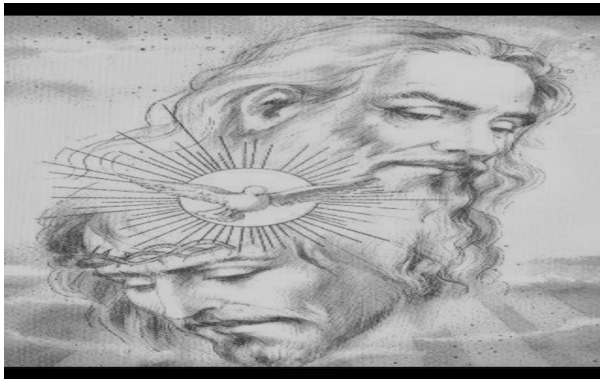


mechanics and with facts established by experiment." Bernard d'Espagnat, Winner of the Templeton Prize.

Well, where do I stand? Looking at the history of science, one can see failed theories, theoretical entities disproved by experiment--phlogiston by Count Rumford's cannon-boring experiments, the ether by the Michelson-Morley experiment. Possibly theory is converging to the truth--the Higgs boson confirmed by the CMS experiments--but that convergence is an article of faith. Faith in science as a partial mirror of reality is one component of my faith that the world God created would be an orderly and intelligible world, not the "dappled world" of Nancy Cartwright, with one set of scientific laws here and another there--Bach, not Cage. I also believe with Fr. Jaki that science is limited in what it can explain: it can not explain itself, it can not answer the "why" questions (rather than the "how" questions), it can not explain our minds, our love, or our religious faith. So am I a Science agnostic? Probably not, but it is a catchy title.

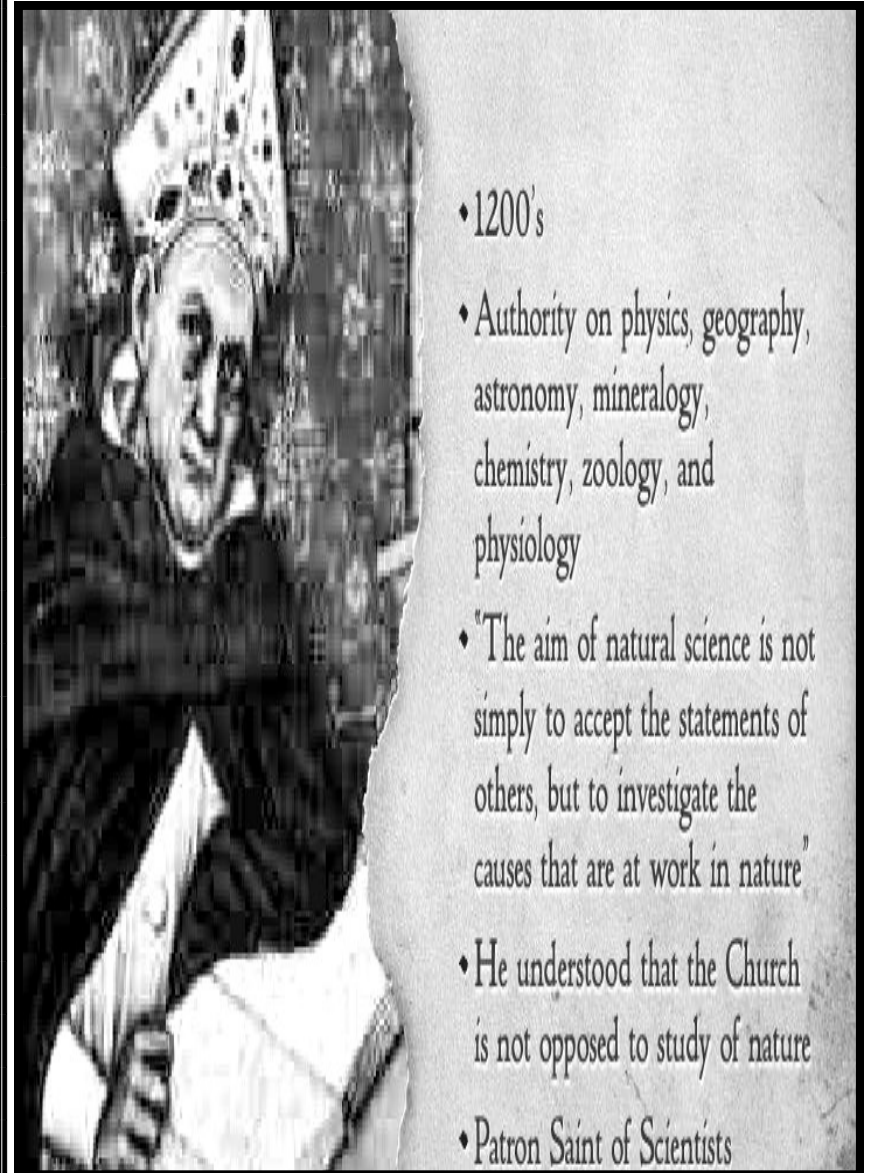
Ed. Note:

Cow Tipping" is actually not a real activity, despite the widespread image of drunken youths pushing a poor bovine over on its side, but, as with "science agnostic", it makes a catchy title.



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Catholic Physics - Reflections of a Catholic Scientist - Part 27 Tipping the Sacred Cow of Science-- Confessions of a Science Agnostic



- ♦ 1200's
- ♦ Authority on physics, geography, astronomy, mineralogy, chemistry, zoology, and physiology
- ♦ "The aim of natural science is not simply to accept the statements of others, but to investigate the causes that are at work in nature"
- ♦ He understood that the Church is not opposed to study of nature
- ♦ Patron Saint of Scientists

Tipping the Sacred Cow of Science-- Confessions of a Science Agnostic



Alice and the White Queen

Definition of "agnostic" (Oxford):
"having a doubtful or noncommittal attitude toward something"
"Behind the tireless efforts of the investigator there lurks a stronger, more mysterious drive: it is existence and reality that one wishes to comprehend." Albert Einstein, *Essays in Science*.

"In support of realism there seem to be only those 'reasons of the heart' which, as Pascal says, reason does not know. Indeed, I have often felt that belief in realism involves a profound leap of faith, not at all dissimilar from the faith that

animates deep religious convictions." Arthur Fine, *The Shaky Game--Einstein, Realism and the Quantum Theory*.

"The fundamental laws of physics do not describe true facts about reality. Rendered as descriptions of facts, they are false; amended to be true, they lose their explanatory force." Nancy Cartwright, *How the Laws of Physics Lie*

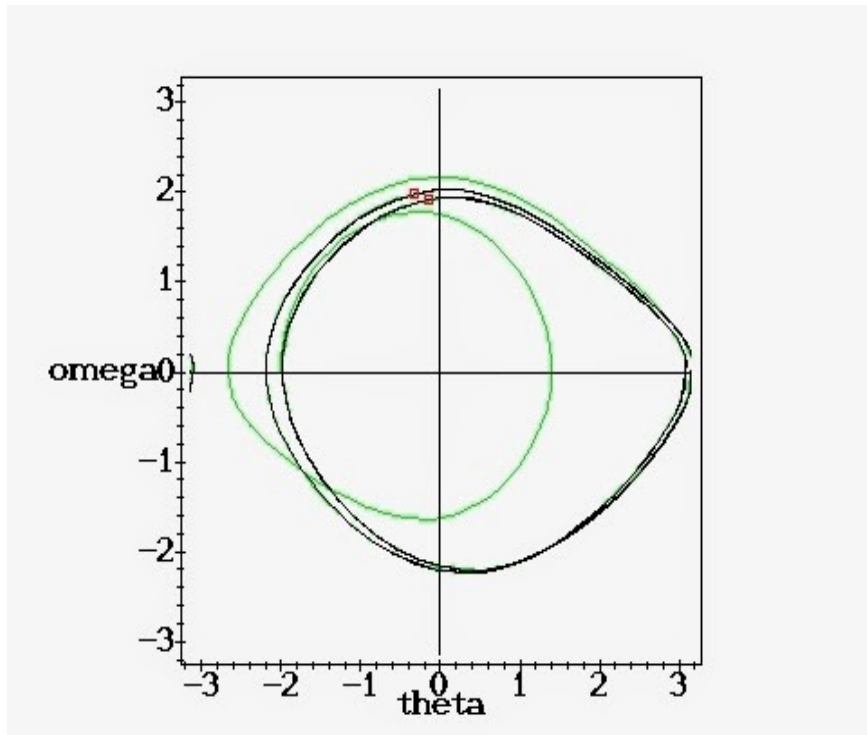
"When you are a Bear of Very Little Brain, and you Think of Things, you find sometimes that a Thing which seemed very Thingish inside you is quite different when it gets out into the open and has other people looking at it." A.A. Milne, *Winnie-the-Pooh*

The point is that the original phenomenological relation educed by Galileo progresses to a much more complicated and sophisticated account of chaotic motion as the description becomes more realistic, but at each stage when simplifying factors are removed the physics is accounted for theoretically and can be verified empirically. Indeed there is a undergraduate physics laboratory dealing with this phenomenon. This progression from simple to complicated is, I maintain, a general situation in science and does not negate the validity of the theoretical foundation. When theory can not give a simple description (as in quantum mechanical computations of electronic energy levels for very large molecules), it is because the calculations are too complicated, not because the theory is wrong.

And when the calculations become too complicated, then simplified models--e.g. the random walk model for molecular diffusion, Lewis dot models for chemical bonds--are appropriate. But these are only models--simulacra as Cartwright would have it--not real.

The empiricist philosophers--Cartwright, van Fraassen, Fine--have much to say about quantum mechanics and its reality, but that's a subject that requires a post, nay a chapter, by itself. There are at least 17 different interpretations of quantum mechanics and to my knowledge only the Local Realistic (with hidden variables) has been falsified by experimental tests of Bell's Theorem. I'll just say that even scientist/philosophers who believe that science is a mirror of the real world are confounded by the puzzling, non-intuitive aspects of quantum mechanics--the delayed choice experiment, the Conway-Kochen Freewill Theorem. "No one understands quantum mechanics." Richard Feynman, Nobel Prize Winner for work in quantum electrodynamics;"The doctrine that the world is made up of objects whose existence is independent of human consciousness turns out to be in conflict with quantum

Here is where I jump into the pool, considering first Nancy Cartwright's comparison of phenomenological versus theoretical laws. One of the first such phenomenological laws was Galileo's discovery of the periodicity of pendulums. Galileo timed the period of pendulum swings using his own pulse and found that the period, the repetition time of the swing, was independent of the mass of the pendulum bob. In first year physics courses the simple pendulum (idealized as a point mass at the end of a massless rod undergoing undamped small swings) is treated as a simple harmonic oscillator. In advanced physics classes the more realistic example of a physical pendulum is treated as a problem in rotational dynamics (still with undamped small swings) for harmonic oscillation. Going still further to large amplitude, damped motion chaos theory rears its terrible head and the motion follows many paths, showing Lorenz attractors and bifurcation diagrams.



Physical Pendulum--Attractor with Bifurcation from
The Chaotic Physical Pendulum

"It is only shallow people who do not judge by appearances. The true mystery of the world is the visible, not the invisible." Oscar Wilde, *The Picture of Dorian Gray* (as quoted by Bas van Fraassen in *The Scientific Image*)

"Science will tell us what things are real but will refuse to say what is reality." Professor Henry Margenau, *The Nature of Physical Reality*

"To answer the question 'To be or not to be?' we cannot turn to a science textbook." Fr. Stanley Jaki, *The Limits of a Limitless Science*.

When I was much younger (almost 70 years ago) I regarded what my professors in college and graduate school said as holy writ. When Julian Schwinger strode into class (usually a half-hour or more late--we'd make book on the delay time) and in beautifully articulated sentences told us about projection operators, Lagrangian formulations, S-matrices, we sat as disciples, not necessarily understanding, but faithfully recording the gospel of quantum mechanics. It was only until after I retired that I began to inquire into the philosophic foundations of science and learned that although quantum mechanics worked, it was a house built on epistemological and ontological sand.

Given this change of belief, why this post? I'd like to see those who justify science/Science as an all-compassing worldview, justify their faith and refute the arguments given by the "anti-realist" philosophers--those who deny the fundamental reality of scientific theories/laws/entities and claim that science is validated only empirically, by the truth or falsity of the predictions derived from scientific theories. For these "anti-realists" there are no scientific laws, and the reality of theoretical entities--quarks, gluons, etc--is problematic.

Scientific theories do not, according to them, mirror reality, veiled or unveiled. Am I an anti-realist? Not entirely, or perhaps I'm not sure--that is to say, maybe I'm a Science (uppercase S) agnostic.

Now, I might have done with any further remarks and just used the quotations at the beginning, which summarize the various points of view on whether science connects to a "real" world. But the argument needs fleshing out, so let's discuss three works dealing with this question: Nancy Cartwright's *How the Laws of Physics Lie*, Bas van Fraassen's *The Scientific Image*, Fr. Stanley Jaki's *The Limits of a Limitless Science*.

Nancy Cartwright does not believe that fundamental, theoretical scientific equations are true (e.g. Maxwell's equations, the Schrodinger equation), although she does believe that theoretical entities are real (e.g. the electron, quarks), and that phenomenological equations (those empirically rather than theoretically derived), such as Poiseuille's Law of viscous flow, are true. Her reason for disbelief, supported by a number of examples, is generally stated in the quote above. The equations have to be amended, supplemented, supplied with empirical fudge factors, or require conflicting mathematical prescriptions in order to describe real situations. I won't go over all the examples (Snell's Law of refraction, Crooke's radiometer, quantum damping, the BCS theory of superconductivity) but only say they are well chosen and show that she knows mathematical physics. However, in an example I'll give below I'll try to show that these criticisms do not invalidate science as it is practiced.

Bas van Fraassen believes that a scientific theory can be judged to be true if it is empirically verified, and only by that test. Here I agree with him. He does not believe that theory corresponds to the real world, discoverable by science--that would be a metaphysical assumption, a truly bad thing for the empiricist philosopher. With this judgment, I might disagree. Van Fraassen also argues that theory can not be evaluated as a best explanation for phenomena. (The ether is one example of an incorrect but plausible explanation for that in which

electromagnetic waves vibrate.) The function of theory is "to save the phenomena", i.e. to give a concise description of real phenomena that is empirically verified.

Like van Fraassen, Fr. Stanley Jaki considers only those scientific theories that are empirically validated to be true, but he adds a further restriction: science concerns itself only with that which can be quantified, i.e. measured numerically:" "...wherever reality offers aspects with no quantitative properties to be measured, science is not applicable." (*The Limits of a Limitless Science*). Many would consider this requirement too restrictive; large areas of chemistry, biology, geology and other disciplines that are generally considered science would be out of the pale. I concur with Fr. Jaki's requirement in the following sense: it removes from the scientific domain disciplines that would like the prestige of a scientific cloak, but which do not require empirically verifiable, reproducible, quantifiable tests of hypotheses. I'm not sure whether Fr. Jaki is a scientific realist (it seems to be implied in the quote above), but as a follower of Pierre Duhem, it seems that he would require a metaphysical foundation for science:

"Now these two questions — Does there exist a material reality distinct from sensible appearances? and What is the nature of reality? — do not have their source in experimental method, ... Therefore, if the aim of physical theories is to explain experimental laws, theoretical physics is not an autonomous science; it is subordinate to metaphysics Pierre Duhem, *The Aim and Structure of Physical Theory*