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# Understanding Science as a System of Knowledge With Its Natural Boundaries

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## Abstract

Science and technology has played a significant role in the progress and prosperity of mankind. Therefore there is no denying celebrating science for its achievements with remarkable ability to explain a wide range of phenomena in natural world. But public pronouncements through popular science literature trying to convince people to embrace a materialistic God-less universe for which science is the only hope and only route to knowledge is not sound enough. This is because Science and its world view aren't the same as it were up to nineteenth Century. There has been a paradigm shift to replace the materialistic world view in the aftermath of the twentieth Century revolution brought about by the theory of relativity and quantum physics. This new science with its demarcated natural boundaries imposed by relativity, indeterminism and incompleteness for the logico- mathematical frame work has clearly exposed the irrelevance of any kind of dogmatism pertaining to science which questions our traditional values and Cultural practices blaming everything as superstition.

## Introduction

Every Lay person in this twenty-first Century must be at least familiar with the word 'Science' through its technological marvels in one's day-to-day life. But the same is not true as far as 'Science' as a knowledge system with its specific methodology, its scope and limitations are concerned. The purpose of this article is therefore to address this aspect in particular since it has involved our life in such a way that we have so to say blindly developed a fresh belief system in the name of science denigrating in a way, all other subtle human faculties and human factors relevant to our life.

## What Is Science

Science is essentially a knowledge system involving systematic and rationalistic study of all aspects of physical nature. It tries to explain all that exist and all that happen in this physical world with the help of natural causes without invoking any divine cause thereof. The methodology adopted in science for the study of nature involves experimental observation for gathering data; analysis of the observed data to search for some pattern or regularity in the data, and finally construction of some mathematical



framework based on mathematical logic to generate the same observed patterns or regularities. This mathematical frame work is called a theoretical formulation to explain certain aspects of nature and the pattern in the data, It generates as predictions, is called some law of nature when it matches with the experimentally observed data. Theoretical formulations can also be effectively made starting with some basic principles approved by common sense or otherwise on the basis of seer intuition. The predictions of such theoretical formulation need verification by experiment or else must be falsified by deeper mathematical logic. Infact any scientific theory or any experimental observation must go through many critical scrutinies before it becomes acceptable to the scientific community. However if any new valid experimental observation appears challenging the existing theory; then Science would accept it in open mind to modify or re-formulate the theory. More and more unexplained aspects of nature come to the fore bringing more and more such challenges and science, thus marches on its own two legs, i.e. theory and experiment in many zig-zag ways keeping academic integrity in tact without proclaiming any final words regarding the nature of reality in nature. The mathematical formulations describing the working of nature are just mere models representing the reality at certain level of its description. Therefore this very scientific exercise is rather called realism. This scientific knowledge system, which is said to have originated in the Western world during the renaissance period in Europe, has taken more than four hundred years to mature to its present level. During this period, science has marched through several phases, reluctantly making paradigm shift for its world view. It adopted a materialistic or mechanistic world view during its initial classical phase as against the prevalent animistic or organic world view. To appreciate the growth and evolution of this scientific enterprise, we must have therefore a cursory look at its history.

## History and Evolution of Science

The era of scientific revolution started noticeably in 17th century Europe, when the intellectual tradition was largely influenced by Judeo-Christian religious doctrines and ancient Greek philosophy. Church with strong royal patronage was powerful enough strictly disallowing any free thinking differing from Aristotelian philosophy. Any idea counter to the Christian doctrines would amount to blasphemy and heresy punishable under laws of the land. As late as in fourth Century BCE, Socrates, the Greek philosopher credited as the founder of western philosophy with ethical tradition was sentenced to death and was executed in 399 BCE by forced suicide through poison. Again Giordano Bruno, the Italian philosopher, mathematician and cosmologist, was publicly burned to death in 1600 CE, mainly because of his views in support of Nicolaus Copernican helio-centric model. Bruno's case is still considered as a landmark in the history of free thought and emergence of Science in western World Copernicus (1473-1543 CE), the renaissance polymath, whose model of the Universe placed Sun



rather than the earth at its Center quite against the Ptolemaic geo-centric model accepted by the then Catholic church and also Galileo Galilei (1564-1642 CE), the Italian astronomer called as the father of observational astronomy and the pioneer of scientific method; Could not escape the trial and some sort of punishment under the prevalent law. This was the social background against which scientific rationality was raising its head continuously over centuries. A torrent of new learning during the last phase of renaissance began to forcefully challenge the authority of the ancients as a result of which the long established intellectual foundation began to crack. The English man Francis Bacon, the French mathematician philosopher Rene Descartes and the Italian physicist Galileo Galilei spearheaded an international movement proclaiming a new foundation for learning that involved careful scrutiny of nature instead of analysis of ancient texts. Galileo believed that the book of nature is written in a codified language of mathematics and hence study of nature should emphasize more on the quantitative measurement leaving aside the not so relevant qualitative aspects. Galileo including Descartes assumed that those things which could be weighed, measured or counted were more true than those which could not be quantified. Bacon and Descartes used particularly strong rhetorics to carve out space for the new methods of acquiring genuine knowledge about the world; Bacon formulated the scientific methodology based mainly on empiricism with strongly worded instructions Such as,

***“Nature should be hounded on its wanderings and forced to divulge Secrets so as to be conquered for the Service of mankind.”***

Descartes believed following Galileo, a distinct split between matter and mind. Matter has nothing in Common with mind or spirit and vice versa. All the qualitative aspects like emotions, feelings etc belonging to mind are not relevant for scientific studies. The Universe is primarily built out of matter and it operates according to natural laws expressible in mathematical language. Descartes advocated further a mechanistic and materialistic Universe which can be studied part by part to gain the knowledge of the whole. This approach of reducing the whole to its various parts for study separately is called reductionism which became the standard practice of western classical Science. Both Bacon and Descartes claimed that by learning how the physical world works, mankind could become master and possessor of nature. By that humans could overcome hunger through innovations in agriculture, eliminate diseases through medical research and dramatically improve overall quality of life through technology and industry. Ultimately science would save humans from all sufferings and self-destructive tendencies. All these goals can be achieved in this world in one life, not in the afterlife. It was a very bold and prophetic vision since the new method found great success over the time. Both Bacon and Descartes elevated the use of reason and logic by denigrating other human faculties such as memory, imagination and creativity. It demoted history, poetry and humanity to second class status. Descartes rendering of the entire Universe



as a giant machine including humans left little room for art, music and other forms of human expressions. Although such rhetoric of these visionaries opened up great new vistas for intellectual inquiry, it proposed a vastly narrower range for other worthwhile human activities. A century later many of the enlightened intellectuals even claimed that science not only could enhance the quality of life, it could even promote moral improvement. Human mind would be more virtuous and contented with the preserve of all human knowledge. Many of the French philosophers even claimed that science could be a substitute for religion. Therefore during the French revolution (1789-1799 CE), numerous Catholic churches were converted to 'Temples of Reasons' where quasi-religious services for the worship of Science were held, By that time on the solid foundation so developed by the visionaries, a Super structure had been built by Galileo, Kepler, Leibnitz and Newton etc explaining various aspects of the world using abstract mathematical formulations. Laplace (1749-1827) proved the invariability of planetary mean motion (average angular velocity) in 1773, which was the first and the most important step in establishing the stability of the solar system. This was most important in physical astronomy supplementing the works of Issac Newton for proclaiming absolute determination of the classical theoretical frame work so advanced by Galileo, Kepler and Newton, etc. Laplace claimed that given the initial conditions of all the constituent bodies of the universe, the future state of the universe can be in principle predicted absolutely, for which there is no necessity of any divine presence or intervention. This claim goes by the name 'Laplacian determinism' for the world of our experience. There is a famous anecdote involving Pierre Simon Laplace, the physicist and Napoleon Bonaparte, the French royalty. Laplace presented the King five volumes of his own work after which Napoleon asked Laplace:- ***"Newton Spoke of God in his book, I have perused yours but failed to find His name even once. Why?"*** ***On this Laplace replied; "I have no need of that hypothesis"***

Thus Laplace is said to be the first Scientist to expect God from the celestial realon.

There after faith in Science grew day by day over two centuries side by side with the advancement of classical science. The most powerful expression of this belief system was found in 19th century as positivism through the philosophy of the positivist. Auguste Francois Xavier Comte (1798-1857CE). Comte is regarded as the first philosopher of Science in the modern sense of the term, who formulated the doctrine of positivism following David Hume's empiricism and scepticism. He claimed that the only valid data about nature's working is acquired through sensory perceptions. There can be no validity to anything else metaphysical or transcendental. The task of scientists is to demonstrate first of all how all phenomena including human behaviour are subject to invariable natural laws by reducing them to smallest possible parts and ultimately drawing the inference for the whole under the laws of physics. Comte envisioned the trajectory of intellectual history as the "Law of three Stages." According to this, each



branch of knowledge passes through three stages. The first stage is theological which is fictitious. The second stage is metaphysical which is abstract. In the last stage it becomes Scientific which is positive. He believed that through the continual advancement of human understanding, religion would fade away, philosophy and humanities would be transformed into naturalistic basis and all human knowledge would eventually become a product of science. Any idea outside the realm of science would be pure fantasy and superstition.

The fundamental tenets of positivism were reinvigorated and elevated to a different level by the name logical positivism by a group of scholars known collectively as "The Vienna Circle". They were a group of elite philosophers and scientists drawn from natural and social sciences, logic and mathematics, who met regularly from 1924 to 1936 at the University of Vienna, Austria. Notable amongst them were, Ernst Mach, David Hilbert, Henri Poincare, Bertrand Russel, Karl Popper, Ludwig Wittgenstein and Albert Einstein. It had the aim of making philosophy scientific with the help of modern logic. The essential scientific view of Vienna Circle about the world can be characterized by two broad features. First it is empiricist and positivist, which means right knowledge, can be gained only from experience through experimental observation and verifications. Second is logical analysis based on mathematical logic. Anything outside this frame work is considered as empty Concept. However Karl Popper was of the opinion that only a few statements in science can actually be completely verified. A single observation otherwise has the potential to invalidate a hypothesis and even an entire analytical theory. Therefore instead of experimental verification, he proposed the principle of falsifiability as the acid test for what can qualify as knowledge. Never the less positivists claimed observation as essential to the empirical approach of science for which brute facts are necessary to establish, evaluate and compare the theories. W.O. Quine further reminded that observations themselves are partly shaped by theory. Infact in the matters of how to design an experiment and what data the instruments are so designed to collect, an interpretive theoretical framework is all the more a requirement. This certainly undermines the positivists' claim that science rests entirely on facts and is the indisputable foundation for knowledge. On the other hand Science has to walk on its two legs; empirically and analytically both.

So far we have been describing the socio-scientific ethos that was created up to early twentieth century along with the formulations of scientific methodology and philosophy of science by the pioneers of renaissance enlightenment. The pioneers of this scientific revolution considered the world to be consisting of separately situated solid substantial massy concrete bodies in a stage of absolute space and absolute time, enacting various phenomena physically by natural causes. Thus they adopted a materialistic or mechanistic world view with the conviction that the world is basically



material with matter as the primary element of nature to be studied and understood. The material universe was also pictured as a machine. Such world view initially advanced by Galileo, Descartes and Newton etc achieved spectacular success in various fields of our everyday world demonstrating certainty for its predictive power. Hence reductionism and absolute determinism became the hallmark slogan of science to impress popular psych that continues to prevail even today even after many more mysteries at the microscopic realm of space, time, matter and energy have been unraveled by twentieth century science overthrowing the prevalent materialistic world view.

## Science of the Modern Era

We would like to provide here a cursory look toward s the science of the modern era at the aftermath of the new revolutions brought forward by relativity and quantum physics and thereby outline the imminent natural boundaries within which science has to operate in creating knowledge which is quite in contrary to the claims of the positivists.

Modern Science had to adopt a different world view over throwing the materialistic world view of absolute determinism. In this new world view matter has melted away to nothingness and void seems to be dynamic with bubbling un-manifest energy field out of which all possibilities of existence emerge to actualize the world we perceive. The world of our perception is no more considered to be entirely as it is by itself independent of observer. Observer has to be very much in picture for experiencing the world. Determinism vanishes in the microscopic realm bringing only probabilistic predictions due to the inherent nature of uncertainty at this Level. Thus Science at the most fundamental level does not have any word with absolute certainty. It can at best make a statistically accurate prediction. Twentieth century science has revealed that it has to operate within some boundaries laid down by nature itself. Those boundaries serving as some limitations of science as a system of knowledge can be stated as follows.

### (I) Uncertainty Principle:-

At the microscopic level; matter as well as radiation behaves simultaneously as particles and waves. They are neither particles nor waves but both at the same time. This is called the dual nature. Because of this dual nature, there exist pairs of observables for these entities like location and motion or time and energy etc,' which cannot be measured.simultaneously with absolute accuracy. There would be some inherent uncertainty in their Simultaneous measurement which is enumerated by Heisenberg's Uncertainty principle.

### (II) Relativistic Principles:-



According to this principle, although the laws of nature are absolute and Universal, the concept of space and time is not absolute and not static as pictured in classical science. Space and time are not independent either, but intertwined with each other. They are not static but dynamic and malleable too. Measure of space and time depends on the state of relative motion of the observer. For an observer moving with a speed comparable to that of light in vacuum; space contracts and time would dilate at such speed of motion which is not normally experienced in everyday world. Not only space and time become inter convertible, so also are mass and energy. Speed of light in vacuum is the ultimate speed; a cosmic speed limit.

### **(iii) Gödel's Incompleteness theorem:-**

It is known that science is a precise quantitative study on the basis of abstract mathematical framework that uses mathematical logic. It was believed that through this logico-rational route in utilizing the power of human reason and intellect, one can arrive at all the truth and solve all mysteries of nature. However in 1935, Kurt Gödel, a mathematician, proved that there exists no complete and consistent mathematical system, which can arrive at all the truths supposed to be present within the system. If religion is a theological system of knowledge with a belief of some existing truth that can never be proved; then mathematics, according to Gödel, is not only a religion; it is the only religion that can prove itself to be a religion. What a sobering lesson for science enthusiasts to learn!

## **Conclusion**

It does not matter in any way. As long as Science as a system of knowledge like any other system of knowledge; is understood in its proper perspectives, it would continue its journey in spite of the natural boundaries of indeterminacy, relativism and incompleteness. Science would continue to serve humanity through its judicious marching forward until it reaches the inevitable barriers on the frontiers of reason. Therefore the classical mindset of over-enthusiasms with Science as the sole route to all truth and all knowledge should be abandoned and science should not be denigrated to the level of a belief system to nurture "Scientism". The purpose of science is to expand our understanding about the world using logico-rational methodology within the carefully carved out natural boundaries by the researchers in science. Therefore it should not be broadly generalized for all fields of academic expertise dismissing many of them as inferior or untrue. It would restrict thereby human inquiry rather than promoting it. The classical mind-set promoting scientism views that science and scientific methods are the only objective means and are the best way by which all knowledge can be acquired. This certainly puts an exaggerated trust over the efficacy of methods of natural science endorsing its application to social sciences. Claiming of



certainty by this method in social sciences would be rather impossible because the objective methodology involved in science eliminates human factors. Social sciences such as political science, economics, psychology and philosophy etc. center almost purely on psychological, emotional, cultural and spiritual dimensions of human experiences.

There should be, of course, no denying to celebrate science for its achievements and its remarkable ability to explain a wide variety of phenomena in natural world, But to claim that there is nothing knowable outside the scope of science would be very much like a successful fisherman arrogantly saying whatever he cannot catch in his fishing net does not exist.