International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 12 Dec 2021, pp: 1487-1501 www.ijaem.net ISSN: 2395-5252

Science versus Pseudoscience

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Date of Submission: 15-12-2021 Revised: 27-12-2021 Date of Acceptance: 30-12-2021

ABSTRACT
We live in the age of "Science" and are overwhelmed by its impact on our lives. evolution of mankind was hastened by science to the extent that humans are saved from being extinct unlike other species more powerful than us-dinosaurs and like. What else other than Science saved us from getting wiped out from the earth in the current pandemic times when Corona was out to obliterate the human race.
Humans are blessed with the power of thinking and the capability of thinking evolved science. However same thinking power is giving rise to fields of studies that resemble science but are not science in the real sense. These get categorized as "Pseudoscience"
This paper explores details of the two terms "Science" and "Pseudoscience" and explains their meaning and the similarity and distinction between them.
Key Words: Science, Pseudoscience, Difference between science and pseudoscience

INTRODUCTION

While researching Parapsychology- an unusual field of study, I came across a sentence, "Parapsychology is not science but Pseudoscience". This made me curious to understand the two terms and the difference between them and here I am with my new research paper.
This was clear from the above statement that it was intended to suggest that the field of study - Parapsychology is not scientific and hence not science. What is scientific and what is science after all?

What is Science

The Oxford dictionary gives the following meaning- "**Intellectual and practical activity encompassing the systematic study of the structure of the behaviour of physical and natural world through observation and experiment."**
NASA space people[1] has the following to say for science and scientific-

"Science consists of observing the world by watching, listening, observing, and recording. Science is curiosity in thoughtful action about the world and how it behaves.Anyone can have an idea about how nature works. Some people think their idea is correct because "it seems right" or "it makes sense." But for a scientist (who could be you!), this is not enough. A scientist will test the idea in the real world. An idea that predicts how the world works is called a hypothesis
Is my hypothesis correct?

If an idea, or hypothesis, correctly predicts how something will behave, we call it a theory. If an idea explains all the facts or evidence, that we have found, we also call it a theory.
"Scientific method" usually means a series of steps that scientists follow to discover how nature works.

From observation to theory

Sometimes the observations come before the idea or theory. For thousands of years, people observed certain "stars" wander around the night sky in looping patterns. Finally, in 1514 Nicolaus Copernicus came up with the idea of "Heliocentrism" (meaning Sun-centered). He thought the Sun was the center of the Universe, with Earth being one of many spheres orbiting the Sun. That idea explained the wandering patterns of the planets. It also predicted where they would "wander" next. This idea became a theory. Of course, we later improved that theory. After all, the Sun is not the center of the whole universe, but only our own solar system.
Sometimes science happens mostly inside a scientist's head.
Albert Einstein and his theories were like that. It took a long time before scientists were able to test them and show that they were correct.

- Science is not just a tidy package of knowledge.
- Science is not just a step-by-step approach to discovery.
- Science is more like a mystery inviting anyone who is interested to become a detective and join in the fun."

Thus, science emerges from testing a theory that could be based on observations.

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Ian Sample[2] talks about the definition of science which was developed over a period of one year by Britain's Science Council, here it goes: -

"**Science is the pursuit of knowledge and understanding of the natural and social world following a systematic methodology based on evidence.**"

It might have been the 16th-century philosopher Francis Bacon who coined the term "Science", but even if it wasn't, the word must have come into common usage around his time, in the western world at least.Not bad for a year's work ... But why bother with a new definition? In a statement from the Council, chief exec Diana Garnham says:In an era where practices such as homeopathy are becoming widespread, and 'detox' is an acceptable aim for a diet, a definition creates a clear distinction between what is genuine science, and what is pseudoscience."

The definition, here, talks about a systematic methodology that must be based on evidence. It does not talk about testing a hypothesis- it just says that it is the pursuit of understanding the natural and social world but does not say that there should be a theory but wants to have evidence on which methodology must be based to achieve the understanding of the natural and social world.

Another thinker Richard Feynman[3] discusses science in the following manner: -

"To doubt that what is being passed from the past is, in fact, true, and to try to find out ab-initio again from experience what the situation is, rather than trusting the experience of the past in the form in which it is passed down. And that is what science is: the result of the discovery that it is worthwhile rechecking by new direct experience, and not necessarily trusting the [human] race['s] experience from the past. I see it that way. That is my best definition.

There are other things.Another of the qualities of science is that it teaches the value of rational thought as well as the importance of freedom of thought; the positive results that come from doubting that the lessons are all true. You must here distinguishthe science from the forms or procedures that are sometimes used in developing science."

So far, we have gathered that Science is

- a systematic methodology that must be based on evidence in the pursuit of knowledge and understanding of the natural and social world.
- the systematic study of the structure of the behaviour of the physical and natural world through observation and experiment. It emerges from testing a theory that could be based on observations.
- the result of the discovery that it is worthwhile rechecking by new direct experience, and not necessarily trusting the [human] race['s] experience from the past.

As per Hansson, Sven Ove[4], "In a wider approach, the sciences are fact-finding practices, i.e., human practices aimed at finding out, as far as possible, how things really are."

Another way of defining science could be, "Science is a practical and intellectual activity that relies upon the systematic study of the structure and behaviour of every natural and physical object through the process of observation and experiment."(https://www.vedantu.com/physics/history-of-science)

According to Heather Doyle[5] –

"Science is . . .

- **Observing the world.**
- **Watching and listening**
- **Observing and recording.**

Science is **curiosity in thoughtful action** about the world and how it behaves.

Anyone can have an idea about how nature works. Some people think their idea is correct because "it seems right" or "it makes sense." But for a scientist (who could be you!), this is not enough. A scientist will test the idea in the real world. An idea that predicts how the world works is called a **hypothesis**.

Hmmm. Is my hypothesis correct?

If an idea, or hypothesis, correctly predicts how something will behave, we call it a **theory**. If an idea explains all the facts or evidence, that we have found, we also call it a **theory**.

"Scientific method" usually means **a series of steps that scientists follow to discover how nature works.**"

The above does not add much to the definition of science as we arrived at above, it is, indeed, a study of nature, be it natural or social world or physical objects and the study would be testing an idea/ hypothesis through observation and experiments.

However, views expressed by Steven D. Schafersman[8] add new meaning to science. As per them, Science is not merely a collection of facts, concepts, and useful ideas about nature, or even the systematic investigation of nature, although both are common definitions of science. **Science is a method of investigating nature--a way of knowing about nature--that discovers reliable knowledge about it.** In other words, science is a method of discovering reliable knowledge about nature.Reliable knowledge is the knowledge that

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has a high probability of being true because its veracity has been justified by a reliable method.Science is a method that allows a person to possess, with the highest degree of certainty possible, reliable knowledge (justified true belief) about nature. The method used to justify scientific knowledge, and thus make it reliable, is called the scientific method.

We add the above aspect of science in its meaning and restate what science means

- a systematic methodology that must be based on evidence in the pursuit of knowledge and understanding of the natural and social world.
- the systematic study of the structure of the behaviour of the physical and natural world through observation and experiment. It emerges from testing a theory that could be based on observations.
- the result of the discovery that it is worthwhile rechecking by new direct experience, and not necessarily trusting the [human] race[‘s] experience from the past.
- a method of investigating nature--a way of knowing about nature--that discovers **reliable knowledge** about it. In other words, science is a method of discovering reliable knowledge about nature. **Reliable knowledge is the knowledge that has a high probability of being true because its veracity has been justified by a reliable method.**

Etymologically, the word “science” is derived from the Latin word ‘Scientia’, meaning knowledge.Science is curiosity in thoughtful action about the world and how it behaves. The science broadly studies the following:

- **Natural Sciences -** It comprises the study of the material world. A Research gate paper[9] clarifies that Natural science is the science of naturally occurring objects or phenomena, such as light, objects, matter, earth, celestial bodies, or the human body. Natural sciences can be further classified into physical sciences, earth sciences, life sciences, and others. Physical sciences consist of disciplines such as physics (the science of physical objects), chemistry (the science of matter), and astronomy (the science of celestial objects). Earth sciences consist of disciplines such as geology (the science of the earth). Life sciences include disciplines such as biology (the science of human bodies) and botany (the science of plants).
- **Social Sciences –** It is the study of people and societies. Social science is the science of people or collections of people, such as groups, firms, societies, or economies, and their individual or collective behaviors. Social sciences can be classified into disciplines such as psychology (the science of human behaviors), sociology (the science of social groups), and economics (the science of firms, markets, and economies). The natural sciences are different from the social sciences in several respects. The natural sciences are very precise, accurate, deterministic, and independent of the person asking the scientific observations. However, the same cannot be said for the social sciences, which tend to be less accurate, deterministic, or unambiguous. For instance, if you measure a person’s happiness using a hypothetical instrument, you may find that the same person is happier or less happy (or sad) on different days and sometimes, at different times on the same day.

So much so for definition and meaning of the word Science; now that we have understood what the word ‘Science’ means, let us know more about its characteristics and how science evolved: -

Naresh Kumar [7] and some others suggest some characteristics which are possessed by a field of study to become science: -

1. **The general principle of causation** -It is self-evidently impossible to have any effects before it has happened— for example- precognition could not be scientific (C D Broad[6])
2. **Unique Definition** -The subject matter of the field of study must be uniquely defined, there must not be any ambiguity in the definition.
3. **Replicability-** The subject matter must be replicable.
4. **No design flaws in related experimentation-** The experimentation was done in the field must be free from flaws in the design which mar the credibility of findings.
5. **Empiricism: -**The subject matter of the field must be explainable by empirical evidence- Steven D. Schafersman[8]explains that Empirical evidence is evidence that one can see, hear, touch, taste, or smell. Empirical evidence is important because it is evidence that others besides yourself can experience, and it is repeatable, so empirical evidence can be checked by yourself and others after knowledge claims are made by an individual. Empirical evidence is the only type of evidence that possesses these attributes and is, therefore, the only type used by scientists and critical thinkers to establish scientific theories.
6. **Testability and Falsifiability**: A theory must be stated in a way that it can be tried to be disproven. Theories that cannot be tested or falsified are not scientific theories and any

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such knowledge is not scientific knowledge. A theory that is specified in imprecise terms or whose concepts are not accurately measurable cannot be tested and is therefore not scientific. Dr. Saul McLeod[9] elucidates Karl Popper's theory of falsification- The Falsification Principle, proposed by Karl Popper, is a way of demarcating science from non-science. It suggests that for a theory to be considered scientific it must be able to be tested and conceivably proven false. For example, the hypothesis that "all swans are white," can be falsified by observing a black swan.

For Popper, science should attempt to disprove a theory, rather than attempt to continually support theoretical hypotheses.According to Popper, scientific theory should make predictions that can be tested, and the theory is rejected if these predictions are shown not to be correct.

Karl Popper in The Logic of Scientific Discovery emerged as a major critic of inductivism, which he saw as an essentially old-fashioned strategy.

Popper replaced the classical observationalist- inductivist account of the scientific method with falsification (i.e., deductive logic) as the criterion for distinguishing scientific theory from non-science.

All inductive evidence is limited: we do not observe the universe at all times and in all places. We are not justified therefore in making a general rule from this observation of particulars.

According to Popper, scientific theory should make predictions that can be tested, and the theory is rejected if these predictions are shown not to be correct.

Popper gives the following example.

Europeans for thousands of years had observed millions of white swans. Using inductive evidence, we could come up with the theory that all swans are white.

However, the exploration of Australasia introduced Europeans to black swans. Poppers' point is this: no matter how many observations are made which confirm a theory there is always the possibility that a future observation could refute it. Induction cannot yield certainty. Theory to be scientific must always accept scope for falsification; it only takes one counter observation to falsify it. Science progresses when a theory is shown to be wrong and a new theory is introduced which better explains the phenomena.

The scientist should attempt to disprove his/her theory rather than attempt to continually prove it. Popper does think that science can help us progressively approach the truth but we can never be certain that we have the final explanation

7 **Parsimony**: When there are multiple explanations of a phenomenon, scientists must always accept the simplest or logically most economical explanation. Parsimony is a guiding principle that suggests that all things being equal, you should prefer the simplest possible explanation for a phenomenon or the simplest possible solution to a problem. For example, if you hear barking from inside your house, and you own a dog, it's more reasonable to assume that you're hearing your own dog right now than it is to assume that some other dog snuck in. This concept is called parsimony or "Occam's razor."

Occam's razorwas proposed by philosopher William of Ockham, who said that "plurality should not be posited without necessity", and in an earlier case also said that "it is useless to do with more what can be done with fewer".

Simply put, Occam's razor suggests that you should prefer the simplest possible explanation for a phenomenon if that explanation is equal to other possible explanations based on the other criteria involved.As such, Occam's razor is a philosophical razor, meaning that it's meant to serve as a guiding principle that helps find the most likely explanation for a phenomenon. It essentially represents the most common use of the principle of parsimony. Parsimony prevents scientists from pursuing overly complex or outlandish theories with an endless number of concepts and relationships that may explain a little bit of everything but nothing in particular. (source:https://effectiviology.com/parsimony/)

8 **Objectivity**Scientific knowledge is objective. Objectivity simply means the ability to see and accept facts as they are, not as one might wish them to be. To be objective, one has to guard against his own biases, beliefs, wishes, values, and preferences. The worst bias is "Confirmation bias" - **Confirmation bias** is the tendency to search for, interpret, favour, and recall information in a way that confirms or supports one's priorbeliefs or values.

Objectivity demands that one must set aside all sorts of subjective considerations, biases, and prejudices.

9 **Systematic Exploration**: Puja Mondal[10] posits," A scientific research adopts a certain sequential procedure, an organized plan or design of research for collecting and analysis of facts about the problem under study. Generally, this plan includes a few scientific steps—formulation of hypothesis, collection of

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facts, analysis of facts (classification, coding, and tabulation) and scientific generalization and predication."

10 **Precision and Accuracy-** Continuing Puja Mondal's thoughts-Scientific knowledge is precise. It is not vague like some literary writing. Tennyson wrote, "Every moment dies a man; every moment one is born", is good literature but not science. To be good science, it should be written as: "In India, according to the 2001 census, every 10th second, on the average, dies a man; every 4th second, on the average, an infant is born." Precision requires giving an exact number or measurement. Instead of saying "most of the people are against love marriages," a scientific researcher says, "Ninety percent people are against love marriages". **Accuracy:** Scientific knowledge is accurate. A physician, like a common man, will not say that the patient has a slight temperature or has a very high temperature but after measuring with the help of a thermometer, he will pronounce that the patient is having a 101.2 F temperature. Accuracy simply means truth or correctness of a statement or describing things in exact words as they are without jumping to unwarranted conclusions.

Any branch of inquiry that does not allow the scientific method to test its basic laws or theories cannot be called "science." For instance, theology (the study of religion) is not science because theological ideas (such as the presence of God) cannot be tested by independent observers using a replicable, precise, falsifiable, and parsimonious method. Similarly, arts, music, literature, humanities, and law are also not considered science, even though they are creative and worthwhile endeavors in their own right.

Now that we are aware of the meaning of science and its characteristics, let us move on to explore how science evolved.

History of Science

We have come a long way from primitive times when humans lived in caves and survived by preying on animals to the current lifestyles of living in palatial abodes and having sumptuous food and living in luxury. Our journey has been long and fruitful and we survived because of our adaptability to changes happening in the lap of mother nature. We have fought our way and survived whereas species physically more powerful have become extinct. Gone are Dinosaurs but frail humans survived. We survived because we could change with changing times and humans could change because God gifted them a special ability of thinking. We thought and could devise ways to overcome catastrophes with our thinking capabilities. Had it not been so the human race would have become extinct due to demonic devastation by Corona. We survived because we could think; think to understand what, why, and how about Corona and could adapt our way of living by wearing masks and maintaining social distancing. Not only this but to protect us we worked on medical sciences and invented vaccines to prevent our lives. From time immemorial this thinking capability has made us rule over other species. The thinking led us to evolve science which made us understand nature and the world around us. Science has been instrumental in our survival. The evolution of science had roots in our ancestors' philosophical thinking who questioned all they observed. How from philosophical thinking of understanding nature we have come to scientific thinking is a long journey. Since humans have thinking capability-why and how on their observations led to scientific revelations of nature-how else Newton's laws would have evolved just by questioning why the apple fell down and not go up and who does not know the famous "Eureka" of Archemedies ??

In this section, we shall understand how science evolved from ancient times to date. We shall delve into the history of science as brought out by a few thinkers.

Williams L Pearce[11] shares the following thoughts: -

"On the simplest level, science is knowledge of the world of nature. There are many regularities in nature that humankind has had to recognize for survival since the emergence of Homo sapiens as a species.Science, defined simply as knowledge of natural processes is universal among humankind, and it has existed since the dawn of human existence."

A brief history of science is found in a paper in research gate[12]; the following excerpts make us aware of how science evolved: -

"Although instances of scientific progress have been documented over many centuries, the terms "science," "scientists," and the "scientific method" were coined only in the 19th century. Prior to this time, science was viewed as a part of philosophy, and coexisted with other branches of philosophy such as logic, metaphysics, ethics, and aesthetics, although the boundaries between some of these branches were blurred.

In the earliest days of human inquiry, knowledge was usually recognized in terms of theological precepts based on faith. This was

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challenged by Greek philosophers such as Plato, Aristotle, and Socrates during the 3rd century BC, who suggested that the fundamental nature of being and the world can be understood more accurately through a process of systematic logical reasoning called rationalism. In particular, Aristotle's classic work Metaphysics (literally meaning "beyond physical [existence]") separated theology (the study of Gods) from ontology (the study of being and existence) and universal science (the study of first principles, upon which logic is based). Rationalism (not to be confused with "rationality") views reason as the source of knowledge or justification and suggests that the criterion of truth is not sensory but rather intellectual and deductive, often derived from a set of first principles or axioms (such as Aristotle's "law of non-contradiction").

The next major shift in scientific thought occurred during the 16 th century when British philosopher Francis Bacon (1561-1626) suggested that knowledge can only be derived from observations in the real world. Based on this premise, Bacon emphasized knowledge acquisition as an empirical activity (rather than as a reasoning activity) and developed empiricism as an influential branch of philosophy. Bacon's works led to the popularization of inductive methods of scientific inquiry, the development of the "scientific method" (originally called the "Baconian method"), consisting of systematic observation, measurement, and experimentation, and may have even sowed the seeds of atheism or the rejection of theological precepts as "unobservable."

Empiricism continued to clash with rationalism throughout the Middle Ages, as philosophers sought the most effective way of gaining valid knowledge. French philosopher Rene Descartes sided with the rationalists, while British philosophers John Locke and David Hume sided with the empiricists. Other scientists, such as Galileo Galilei and Sir Issac Newton, attempted to fuse the two ideas into natural philosophy (the philosophy of nature), to focus specifically on understanding nature and the physical universe, which is considered to be the precursor of the natural sciences. Galileo (1564-1642) was perhaps the first to state that the laws of nature are mathematical, and contributed to the field of astronomy through an innovative combination of experimentation and mathematics.

In the 18 th century, German philosopher Immanuel Kant sought to resolve the dispute between empiricism and rationalism in his book Critique of Pure Reason, by arguing that experience is purely subjective and processing them using pure reason without first delving into the subjective nature of experiences will lead to theoretical illusions. Kant's ideas led to the development of German idealism, which inspired the later development of interpretive techniques such as phenomenology, hermeneutics, and critical social theory.

At about the same time, French philosopher Auguste Comte (1798–1857), founder of the discipline of sociology, attempted to blend rationalism and empiricism in a new doctrine called positivism. He suggested that theory and observations have circular dependence on each other. While theories may be created via reasoning, they are only authentic if they can be verified through observations. **The emphasis on verification started the separation of modern science from philosophy and metaphysics and further development of the "scientific method" as the primary means of validating scientific claims.** Comte's ideas were expanded by Emile Durkheim in his development of sociological positivism (positivism as a foundation for social research) and Ludwig Wittgenstein in logical positivism.

In the early 20 th century, strong accounts of positivism were rejected by interpretive sociologists (anti-positivists) belonging to the German idealism school of thought. Positivism was typically equated with quantitative research methods such as experiments and surveys and without any explicit philosophical commitments, while anti-positivism employed qualitative methods such as unstructured interviews and participant observation. Even practitioners of positivism, such as American sociologist Paul Lazarsfield who pioneered large-scale survey research and statistical techniques for analyzing survey data, acknowledged potential problems of **observer bias** and structural limitations in positivist inquiry. In response, anti-positivists emphasized that social actions must be studied through interpretive means based upon an understanding of the meaning and purpose that individuals attach to their personal actions, which inspired Georg Simmel's work on symbolic interactionism, Max Weber's work on ideal types, and Edmund Husserl's work on phenomenology.

In the mid-to-late 20th century, both positivist and anti-positivist schools of thought were subjected to criticisms and modifications. British philosopher Sir Karl Popper suggested that human knowledge is based not on unchallengeable, rock-solid foundations, but rather on a set of tentative conjectures that can never be proven conclusively but only disproven. Empirical evidence is the basis for disproving these

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conjectures or "theories." This metatheoretical stance, called post-positivism (or post-empiricism), amends positivism by suggesting that it is impossible to verify the truth although it is possible to reject false beliefs, though it retains the positivist notion of objective truth and its emphasis on the scientific method."

So, we see how philosophical thinking was the basis from where current science got evolved over centuries. It is only this thinking capability that has stood us in good stead and we are continuously improving our way of life through scientific innovations and are successfully fighting our battle for survival. Science has revolutionized our way of life in the last few decades as is observed by senior citizens today when they compare the communications that used to happen in 1950s and now. A message to reach remote places used to take days and now in a flash of seconds we are able to communicate even visually. Our survival depends on the science that we witnessed during Corona Pandemic.

Science as we saw in earlier paragraphs were basically divided into two aspects-Natural Sciences and Social Sciences.

There are fields of study which claim to be science but they are not accepted by mainstream science. They are either non-science or at best pseudoscience which are close to science but are not science.

The remaining part of the paper will discuss Pseudoscience, its meaning, and how it differs from Science.

Pseudoscience

Science and Pseudoscience both attempt to increase our knowledge base about the physical world and mother nature around us. Both put forth theories and do analysis to infer about the world around us. The similarity is in a wider sense but the two terms differ widely.

In this section, we shall understand Pseudoscience and explore the difference between Science and Pseudoscience.

As perHansson Sven Ove[4], the word Pseudoscience was derived from the Latin word "pseudoscientia" which was used in the first half of the 17th century in discussions about the relationship between religion and empirical investigations (Guldentops[13]). The oldest known use of the English word "pseudoscience" dates from 1796, when the historian James Pettit Andrew referred to alchemy as a "fantastical pseudo-science" (Oxford English Dictionary). The word has been in frequent use since the 1880s (Thurs and Numbers[14]). Throughout its history, the word has had a clearly defamatory meaning (Laudan[15]; Dolby[16]).It would be as strange for someone to proudly describe her own activities as pseudoscience as to boast that they are bad science. Pseudoscience has as an essential characteristic a derogatory connotation. Whereas science, usually involves an acknowledgment that it has a positive role in our strivings for knowledge.

Etymology provides us with an obvious starting point for clarifying what characteristics pseudoscience has in addition to being merely non- or un-scientific. "Pseudo-"means false. In accordance with this, the Oxford English Dictionary (OED) defines pseudoscience as follows:"A pretended or spurious science; a collection of related beliefs about the world mistakenly regarded as being based on scientific method or as having the status that scientific truths now have."

The definition talks about a misconception about a field that is not scientific but appears to be scientific.

The common-sense approach to understanding Pseudoscience is that a field that does not possess some characteristics of science could be pseudoscience. I said 'some characteristics' and not all characteristics because if a field does not possess any of the science characteristics, then it will be non-science.

Pseudoscience does not possess the following characteristics: -

- **The general principle of causation** -It is self-evidently impossible to have any effects before it has happened—Pseudoscience may have effect before the cause -a prominent example is paranormal happening of precognition events where the effect is before the cause and hence it could not be scientific but is pseudoscientific.
- **Unique Definition** -The subject matter of the field of study must be uniquely defined, there must not be any ambiguity in the definition. A field of study where the definition is not definitive and is unambiguous is not scientific but could be a pseudoscientific study—an example is Parapsychology where the term 'psi' the core element of parapsychology is defined differently by authorities studying this field.
- **Testability and Falsifiability**: A Pseudoscience field of study cannot be tested or falsified. Life after death is a field of study which cannot be tested as a dead person cannot come back (because the ticket is one way) and reveal whether there is life after death, hence the subject matter is not testable; hence, this field of study is not scientific, at best it could

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be only pseudoscience. Falsification is an essential part of a scientific theory. The Falsification Principle, proposed is a way of demarcating science from non-science. It suggests that for a theory to be considered scientific it must be able to be tested and conceivably proven false. For example, the scientific hypothesis that "all swans are white," can be falsified by observing a black swan. But all theories cannot be falsified. The field of study "Life after death" cannot be falsified, hence, it is not scientific and at best is pseudoscientific

- **Empiricism:** -The subject matter of a scientific field must be explainable by empirical evidence- Steven D. Schafersman[8]explains that Empirical evidence is evidence that one can see, hear, touch, taste, or smell. Empirical evidence is important because it is evidence that others besides yourself can experience, and it is repeatable. Empirical evidence is the only type of evidence that possesses these attributes and is, therefore, the only type used by scientists and critical thinkers to establish scientific theories. Pseudoscience will lack empiricism; the most glaring example is the field of study of paranormal events-Extra Sensory Perception whose foundation is that these events are perceived without the use of the above five senses viz., seeing, hearing, touching, smelling, and tasting. Hence this field of study is not scientific, at best it could be pseudoscientific.

Pseudoscience, thus, may lack some of the characteristics of science. But how exactly pseudoscience can be defined will be explored in the following paragraphs.

Many writers on pseudoscience have emphasized that pseudoscience is non-science posing as science. The foremost modern classic on the subject (Gardner[17]) bears the title Fads and Fallacies in the Name of Sciencethat describes the fallacies prevailing as science.This and many other authors assume that to be pseudoscientific, an activity or a teaching has to satisfy the following two criteria (Hansson[18]):

1. it is not scientific, and
2. its major proponents try to create the impression that it is scientific.Proponents of pseudoscience often attempt to mimic science by arranging conferences, journals, and associations that share many of the superficial characteristics of science but do not satisfy its quality criteria.

The problem with the definition based on (1) and (2) is that it is too wide. There are phenomena that satisfy both criteria but are not commonly called pseudoscientific. One of the clearest examples of this is fraud in science. This is a practice that has a high degree of scientific pretense and yet does not comply with science, thus satisfying both criteria. Nevertheless, fraud in otherwise legitimate branches of science is seldom if ever called "pseudoscience".

What then is pseudoscience??

As per Hansson[18]"Pseudoscience is an antithesis of science in the individuated rather than the unindividuated sense. There is no unified corpus of pseudoscience corresponding to the corpus of science. For a phenomenon to be pseudoscientific, it must belong to one or the other of the particular pseudoscience. In order to accommodate this feature, the above definition can be modified by replacing (2) with the following

2a) It is part of a non-scientific doctrine whose major proponents try to create the impression that it is scientific.

Pseudoscience often involves a representation of science as a closed and finished doctrine rather than as a methodology for open-ended inquiry.

We have so far understood that a non-scientific doctrine when being projected to create an impression that it is scientific is the essence of Pseudoscience. How the impression is created; what aspects are there in the spurious characteristics which when embedded in a field makes it fall under the category of Pseudoscience is not very clear.

Let us examine the definition of Pseudoscience as propagated by Paul Thagard[19]: -

"A theory or discipline that purports to be scientific is pseudoscientific if and only if:

- It has been less progressive than alternative theories over a long period of time and faces many unsolved problems.
- Science explains using mechanisms, whereas pseudoscience lacks mechanistic explanations.
- Science uses correlation thinking, which applies statistical methods to find patterns in nature, whereas pseudoscience uses dogmatic assertions, or resemblance thinking, which infers that the things are causally related merely because they are similar.
- Practitioners of science care about evaluating theories in relation to alternative ones, whereas practitioners of pseudoscience are oblivious to alternative theories.
- Science uses simple theories that have broad explanatory power, whereas pseudoscience

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uses theories that require many extra hypotheses for particular explanations.

- Science progresses over time by developing new theories that explain newly discovered facts, whereas pseudoscience is stagnant in doctrine and applications.

Now we have some clarity that pseudoscience would have loose ends and may lack a mechanistic approach and may only be a narration (without statistical analysis to understand patterns in nature) to put forth dogmatic assertions to infer that the things are causally related because they are similar i.e., no deterministic approach is taken to explain causal aspects of the phenomenon. Another feature as pointed out by the above author is that Pseudoscience is stagnant in its doctrine whereas Science progresses over time and new theories evolve when new aspects are observed. Science weighs alternatives whereas Pseudoscience sticks to only one theory and is dogmatic about it.
There is some clarity but still, we lack specific measurable tools to examine whether a field of study in Science or Pseudoscience.

Hansson[4] suggests that to demarcate science and pseudoscience, there could be a list of criteria. He goes on to state, "Most authors who have proposed demarcation criteria have instead put forward a list of such criteria. A large number of lists have been published that consist of (usually 5–10) criteria that can be used in combination to identify a pseudoscience or pseudoscientific practice. One such list reads as follows:

1. Belief in authority: It is contended that some person or persons have a special ability to determine what is true or false. Others have to accept their judgments.
2. Unrepeatable experiments: Reliance is put on experiments that cannot be repeated by others with the same outcome.
3. Handpicked examples: Handpicked examples are used although they are not representative of the general category that the investigation refers to.
4. Unwillingness to test: A theory is not tested although it is possible to test it.
5. Disregard of refuting information: Observations or experiments that conflict with a theory is neglected.
6. Built-in subterfuge: The testing of a theory is so arranged that the theory can only be confirmed, never disconfirmed, by the outcome.
7. Explanations are abandoned without replacement. Tenable explanations are given up without being replaced so that the new theory leaves much more unexplained than the previous one."

Before we arrive at the final characteristics of Pseudoscience, let us look at the views of some other thinkers: -
Edzard Ernst[20] gives views of an author Keith Stanovich, who in his book 'Decision Making and Rationality in the Modern World,makes a fresh attempt to give a list of criteria that he deems important to describe Pseudoscience –
As per him Pseudoscience has

• **The use of psychobabble** – words that sound scientific, but are used incorrectly, or in a misleading manner. For example, "energy therapies" for psychological problems are often premised on biofeedback, meridian lines, quantum energies, and a host of other concepts that may sound impressive, but lack evidence.

• **A substantial reliance on anecdotal evidence**. Evidence for pseudoscience is typically anecdotal and consequently difficult to verify. For a class example, instructors may want to show students the Q-Ray bracelet website and read the many quotes submitted by Q-Ray users. Although the quotes sound compelling, there is no scientific evidence to support any claims attached to them. In fact, the Q-Ray company lost a lawsuit in 2011 and was ordered to refund over $11 million dollars to people who purchased a Q-Ray bracelet.

• **Extraordinary claims in the absence of extraordinary evidence** (Truzzi[21]; Sagan[22]). In pseudoscience, assertions are often highly implausible in light of existing knowledge yet are not backed by convincing evidence. For a class example, instructors may wish to describe how infomercials promoting Q-Ray bracelets state that the "bracelet rips [pain] right out of the body." and are "designed to optimize your natural positive energy."The claims made for paranormal events (ESP, PK, and life after death) make extraordinary claims but do not provide extraordinary evidence

• **Unfalsifiable claims** – Most pseudoscientific claims are incapable of being refuted in principle. For example, proponents of traditional Chinese medicine (TCM) believe the human body has an invisible energy force called Qi (Zollman and Vickers[23]). Qi is a crucial component of TCM, even though it cannot be measured or tested scientifically.Also, it cannot be falsified.

• **An absence of connectivity to the other research** (Stanovich[24]). Connectivity refers to the extent to which assertions build on extant knowledge. For example, homeopathic practitioners state that homeopathic treatments become stronger as they become more dilute, and that water has memory. Both of these claims run

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counter to established scientific knowledge (Singh and Ernst[25]).

• **Absence of adequate peer review**. Peer review is far from perfect, but it is a key safeguard against error. Instructors may wish to encourage students to contrast the claims advanced by the authors of peer-reviewed versus non-peer-reviewed articles.

• **Lack of self-correction**. Pseudoscience frequently persists despite refutation. Often, proponents of pseudoscience will use the idea that since the treatment or idea has been used for thousands of years it must be correct (e.g., astrology), an error often called the ad antiquetem fallacy (or, the argument from antiquity).

Adding to above some other interesting facts about Pseudoscience from another paper titled Distinguishing Science from Pseudoscience: -

Pseudoscience is invariably

- **Indifferent to facts: -** fictitious facts are often central to the pseudoscientist's argument and conclusions! This can also be seen in the fact that pseudoscientists never revise.
- **Starting with an implausible hypothesis**—usually, one which is appealing emotionally—and then looking only for items that appear to support it. Conflicting evidence is ignored. Generally speaking, the aim of pseudoscience is to rationalize strongly held beliefs, rather than to investigate and find out what's actually going on, or to test various possibilities. Example is ESP
- **Usually indifferent to criteria of valid evidence-**The emphasis is not on meaningful, controlled, repeatable scientific experiments—instead, it is on unverifiable eyewitness testimony, stories, faked footprints, blurry photos, and tall tales, hearsay, rumor, and dubious anecdotes. Genuine modern scientific literature is not cited. Real research is never done.
- **Heavily Relying onsubjective validation: -** It can be explained by the following example: Joe Blow puts jello on his head and his headache goes away. To pseudoscience, this means jello cures headaches. To science, this means nothing, since no experiment was done. Many things were going on when Joe Blow's headache went away— the moon was full, a bird flew overhead, the window was open, Joe had on his red shirt, etc.— and his headache would have gone away eventually in any case, no matter what. This demonstrates subjective validation which is pseudoscientific; to make it scientific validation A controlled experiment could be done to study the effectiveness of a headache remedy, for example, would put a large number— thousands or tens of thousands— of people suffering from headaches in identical circumstances, except for the presence or absence of the remedy it is desired to test, and compare the results… which would then have some chance of being meaningful.
- **Often contradicting itself: -**In a meaningful description of the physical world we live in, mathematical or factual or logical contradictions simply could not exist. In pseudoscience, they are par for the course! We should not be surprised when a book on dowsing for water, in Chapter 1, assures us that dowsers prefer newly-cut twigs, because only "still living" wood can channel and focus the "earth radiation" used in dowsing, while Chapter 5 states that nearly all dowsers use metal or plastic rods!
- **Deliberately creating mystery where none exists: -** Pseudoscience creates mysteryby omitting crucial information, background, and important details. Anything can be made "mysterious," if you omit to tell what is known about it, or present completely imaginary details. The "Bermuda Triangle" and "Sea Mystery" books are classic examples of this tactic, as are most books on haunted houses.
- **Pseudoscientific theories are not progressing with time:** In a pseudoscientific theorythere is not much progress made, no new information uncovered; new theories are not forthcoming; old concepts are never modified or discarded in light of new discoveries since there are no new discoveries for pseudoscience. The older the idea, the more respect is given it. ESP experiments started at about the same time as research into the nature of electromagnetic radiation. They're still guessing cards in the ESP labs and yet applications of electromagnetism have completely revolutionized the world, time and time again, since the 1880s.

I think now we have a fair idea about Pseudoscience and would now assimilate the gathered knowledge to deduce the characteristics of Pseudoscience and thereafter we shall tabulate a comparison of science and pseudoscience and conclude the paper.

Characteristics of Pseudoscience

A field of study would be termed Pseudoscience if

- **It lacks Empiricism**- Empirical evidence is evidence that one can see, hear, touch, taste, or smell. Pseudoscience evidences may not be

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empirical, for example, ESP, ADC-After death communication, etc.

- **It is not testable-** Life after death is a field of study which cannot be tested as a dead person cannot come back (because the ticket is one way) and reveal whether there is life after death, hence the subject matter is not testable. Such fields of study come under Pseudoscience.
- **It cannot be falsified-** Scientific theories leave a way for it to be falsified. The Law of gravity will be falsified if we could have an incident where things thrown up do not fall back on earth. A theory that all swans are white can be falsified if we get a black swan. But Pseudoscientific theory does not leave a way to falsify- For example, proponents of traditional Chinese medicine (TCM) believe the human body has an invisible energy force called Qi. Qi is a crucial component of TCM- it cannot be falsified. Survival theory says that all living things have a soul which does not perish with death—there is no way to falsify it. Such theories are pseudoscientific theories.
- **It violates the general principle of causation**--It is self-evidently impossible to have any effects before it has happened—Pseudoscience may have an effect before the cause. A prominent example is the paranormal happening of precognition events where the effect is before the cause and hence it could not be scientific but is pseudoscientific.
- **Its definition is ambiguous and is not uniquely defined: -** A field of study where the definition is not definitive and is unambiguous is not scientific but could be a pseudoscientific study—an example is Parapsychology where the term 'psi' the core element of parapsychology is defined differently by authorities studying this field.
- **It is not progressive: -**Science progresses over time by developing new theories that explain newly discovered facts, whereas pseudoscience is stagnant in doctrine and applications. In a pseudoscientific theorythere is not much progress made, no new information uncovered; new theories are not forthcoming; old concepts are never modified or discarded in light of new discoveries. ESP experiments started at about the same time as research into the nature of electromagnetic radiation and even today they're still guessing cards in the ESP labs; whereas applications of electromagnetism have completely revolutionized the worldtime and time again since its discovery.
- **It lacks replicability: -** Scientific evidence is replicable whereas, in Pseudoscience, reliance is put on experiments that cannot be repeated by others with the same outcome.
- **It lacks objectivity and relies more on subjective validation: -** In pseudoscience, the emphasis is not on meaningful, controlled, repeatable scientific objective experiments—instead, it is on subjective evidence like unverifiable eyewitness testimony, stories, faked footprints, blurry photos, and tall tales, hearsay, rumor, and dubious anecdotes. Genuine modern scientific literature is not cited. Real research is never done.
- **It propagates Extraordinary claims in the absence of extraordinary evidence--**In Pseudosciences, assertions are often highly implausible in light of existing knowledge yet are not backed by convincing evidence/ The paranormal events (ESP, PK, and life after death) make extraordinary claims but do not provide matching extraordinary evidence. The experimental results in ESP, even though, statistically significant are just marginally significant and do not provide extraordinary evidence needed for corresponding tall claims
- **It normally avoids causal research;it deliberately creates mystery where none exists**- It does so by omitting crucial information, background, and important details. Anything can be made "mysterious," if you omit to tell what is known about it, present completely imaginary details, and do not pursue causal research to understand the causal reasons. The "Bermuda Triangle" and "Sea Mystery" books are classic examples of this tactic, as are most books on haunted houses.
- **It presents half-truths.** For the other half of its belief, it takes shelter behind the statement that "**further research**" is needed to clarify the validity of unproved beliefs--Parapsychological research tends to prove the existence of Telepathy, Clairvoyance, precognition, and Psychokinesis but shrugs about their causal research on the pretext that further research is needed to uncover causal aspects. There is no controversy among astronomers concerning astrology— they unanimously agree it is nonsense but astrologers stick their ground and expect that further research will take place to prove their belief.
- **Its experiments are mostly not scientifically sound. —** Most of them suffer design flaws. Not only that but pseudo-scientists frequently weed out data that negates their belief and only

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use data that give positive anchors to their belief and theory. Some of them even stoop down to the level of doing trickery or fraud to prove that their theory is scientific. It is found that many a time the ESP experiments where results were not statistically significant were suppressed and not reported and only the ones where results were statistically significant got a place in parapsychological journals.

- **Its incompatibility with different branches of science**- The Pseudoscientific theories do not support or get supported by different branches of science
- **Lastly - Theories that are pseudoscientific normally eventually get contradicted and discredited or get explained differently.**

The above gives a detailed account of various characteristics of Pseudoscience and I hope that the readers, by now, must have got good clarity about science and Pseudoscience and the difference between them.

To make things clearer, I shall conclude the paper with a table giving their comparison point by point:

S.No.	Science	Pseudoscience
1	Reproducible, reliable results are demanded; experiments must be precisely described so that they can be duplicated exactly or improved upon in sensitivity and volume of cases or events.	Results cannot be reproduced or verified. Studies, if any, are always so vaguely described that one can't figure out just what was actually done or how it was done.
2	Failures are searched for and studied closely since incorrect theories can often make correct predictions by accident but no correct theory will make incorrect predictions.	Failures are ignored, excused, hidden, lied about, discounted, explained away, rationalized, forgotten, avoided at all costs.
3	Convinces by appeal to the evidence, by arguments based upon logical and/or mathematical reasoning, by making the best case the data permit. When new evidence contradicts old ideas, they are abandoned.	Convinces by appeal to faith and belief. Pseudoscience in almost every case has a very strong quasi-religious element: it tries to convert, not to convince. You are to believe in spite of the facts, not because of them. The original idea is never abandoned, whatever the evidence.
4	Uses careful observation and experimentation to confirm or reject a hypothesis. Evidence against theories and laws is searched for and studied closely.	Starts with a hypothesis looks only for evidence to support it. Little or no experimentation. Conflicting evidence is ignored, excused, or hidden. The original idea is never abandoned, whatever the evidence.
5	Reproducible results are required of experiments. In case of failures, no excuses are acceptable	Results cannot be reproduced or verified. Excuses are freely invented to explain the failure of any scientific test.
6	Personal stories or testimonials are not accepted as evidence	Personal stories or testimonials are relied upon for evidence.
7	Argues from scientific knowledge and from the	Argues from ignorance. The lack of a scientific explanation is used to support ideas.

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	results of experiments.	
8	Convinces by appeal to evidence, by arguments based on logical and/or mathematical reasoning.	Attempts to persuade by appeal to emotions, faith, sentiment, or distrust of established fact.
9	Follows the evidence where it leads to	Starts with a conclusion, then backward to confirm
10	Peer review. Literature is written for fellow scientists who are specialists and experts.	No peer review. Literature is written for the general public without checks or verification.
11	Embraces criticism and moves forward to progressive research further	Hostile to criticism
12	Progresses; as time goes on, more and more is learned.	No progress; nothing new is learned as time passes. There is only a succession of fads.
13	Properly considers all evidence and arguments	Cherry picks only favourite evidence, relies on testimonials or weak evidence
14	Changes with new evidence	Dogmatic and unyielding
15	A branch of science is compatible with other branches of science	It is often conflicting with other branches of science
16	Science is founded on a causal base. Theories are tested to reach the root cause of the phenomenon	Pseudoscience lacks causal research
17	Shreds of evidence are commensurate to the stature of claims	Pseudoscience propagates Extra-ordinary claims in the absence of extraordinary evidence
18	Relies on objectivity	Founded on subjectivity
19	Science believes in the causation principle i.e., the effect cannot precede cause	It often violates the general principle of causation- e.g., Precognition

Source: Distinguishing Science from Pseudoscience[26], Artemio Larrauriguchia[27]

Note: - Some examples of fields of studies which come under the category of Pseudoscience are - Astrology, Homeopathy, Parapsychology, Colour Therapy, Dowsing, Hypnosis, Reiki energy Healing etc…

At the start of the paper, I stated that I am researching Parapsychology, which is currently termed as Pseudoscience. I do not contest this. But I do believe that the experimental evidence put forth for Telepathy / Clairvoyance can't be brushed aside as mere rubbish. The research so far is credible beyond doubt but still, Parapsychology is not science because it deals with ESP which is founded on a theory that its components Telepathy, Clairvoyance and Precognition get perceived without the use of known five senses- seeing, hearing, smelling, tasting and touching and hence it lacks empiricism which is a requirement for a field of study to be science. It is unfortunate that research efforts so far have been in the direction of proving experimentally or in other ways, to prove its basic existence. No Causal research has been undertaken. I believe that only causal research would enable us to understand the mystery behind the paranormal including ESP, Psychokinesis, and the phenomenon of Life after Death. Maybe causal parapsychological research will lead to the discovery of a real sixth sense in humans and the current paranormal will no longer remain paranormal. If we look in past – to Primitive man - Thunder, Lightning, and Rainbows were paranormal till science advanced to explain their

causes and today these are considered scientific phenomenon. In the same way, Parapsychology one day will move from "Pseudoscience" to "Science" when science advances and we discover real sixth sense in humans and know the basic causes behind ESP, PK, and Life after death. This will be possible only through Causal Parapsychological Research.

The point I wish to make here is that a field of study may not remain "Pseudoscience" forever and causal research may uncover causal roots and put the fields on solid foundations to get them accepted by mainstream science as was the case with Thunder, Lightning, and Rainbows.

With this, I conclude this paper. I hope I have been able to do justice to the topic of the paper and have covered almost all aspects of Science and Pseudoscience.

Finally,let us remember what Phil Plait once rightly said, "**Pseudoscience is like a virus. At low levels, it's not a big deal, but when it reaches a certain threshold, it becomes sickening**"

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