Demystifying Science: A Brief History of the Word "Scientist" and the Development of Science as a Profession

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Abstract

The National Education Policy 2020 puts emphasis on ensuring the unity and integrity of all types of knowledge through a 'multi-disciplinary education' (which transcends traditional subject boundaries and includes science, social science, arts, and humanities). In this paper, an attempt has been made to trace the history of the origin and evolution of the word "scientist" and provide an overview of the journey from the genesis of the term to its widespread acceptance. In addition, this paper outlines the history of the metamorphosis of science into a profession and discusses the important implications for an inclusive and authentic science education. It is anticipated that the history of the word 'scientist' and the underlying issues raised in this paper will serve as an interdisciplinary introduction for those with an interest in science education, science and society, and science and human values. This article will also be useful as supplementary reading for science teacher education courses focusing on philosophical and sociological issues.

Keywords: *Sociological aspects of science, mystification of science and scientists, origin and development of the word "scientist", professionalization of science.*

In contemporary society, the terms "science" and "scientific" are frequently employed in an ambiguous, rhetorical, and preposterous manner. The society at large and at times the academic discourse itself, attempt to exalt a particular field of knowledge to "scientific" status by demonstrating that it generates reliable results by employing rigorous methods. People also use the terms "scientific discoveries" and "scientific opinions" to support advertising claims for a variety of products. The terms "science", "scientific", and "science" are clearly regarded as honorifics. In addition, the terms "science" and "scientific" are used to demonstrate a type of intellectual authority and to allude to a trustworthy method for justifying various types of opinions. In present times, everyone is expected to believe "scientific" claims, regardless of their understanding of science and how science operates. However, the precise meaning (and pompous use) of these words is relatively new. To put it another way, the words "science" and "scientist" did not always mean what they signify in present times. Many people may not be aware that while the words "science" and "scientific" entered the English language more than 400 years ago, the word "scientist" is only about 200 years old! In this paper, I will trace the history of the word "science" and "scientist", and the resulting professionalisation of science.

From Scientia to Science

The word science is derived from the Latin term scientia, which means knowledge and encompassed all potential forms of knowledge. It entered the English language around the year 1600 as an importation from French language. This all-encompassing meaning of the word scientia remained popular in the Aristotelian conception of knowledge until a 6th Century Latin translator of Aristotle (supposedly, Boethius, a Scholastic) translated the adjective *scientificus* to mean "certain knowledge arising from demonstrable proof". By repeatedly using the word in the same sense, the Schoolmen coined this word (*scientificus*) to refer to "demonstrable knowledge or science". The word entered the Italian language as *scientifico,* and in French as *scientifique* with this meaning and finally entered into English lexicon during the 1600s. The word soon acquired the connotation of accurate and *systematised* knowledge. The tautological phrase, 'scientific knowledge' became a popular way of distinguishing 'common knowledge' and 'scientific knowledge' (See, Ross, 1962). With this distinction, the word 'science' did no longer remain synonymous with the word 'knowledge'. The word science was now identified with a 'firmer and less fallible kind of knowledge', either derived through deductive logic (as in Euclid's geometry) or acquired using observations and experiments (as advocated by Francis Bacon). Despite these refinements in the meaning of the word, in common speech, science continued to be understood as "any knowledge acquired by study or any skill acquired by practice" for about fifty years, i.e., 1800 to 1850. However, the broad tendency of the period was to identify 'philosophy' with the theological and metaphysical, and science with the experimental and physical realms of knowledge (ibid., p. 68). Gradually, the meaning of the word science as denoting 'natural and physical knowledge' became dominant and popular and the broad usage of the word were lost because of disuse. With the growing success of the physical sciences during the 19th century, the word science became exclusive for physical and natural sciences.

Similarly, the basic meaning of the Sanskrit word *vijnanam* is "knowledge, intelligence, wisdom, or understanding". In this sense, this knowledge may encompass all knowledge forms. However, in modern Sanskrit, *vijnanam* can also mean "worldly or cosmic knowledge, knowledge gained from worldly experience" (Apte, 2002). Similarly, Arabic texts from the Islamic era did not use the term "science" in its modern sense. Synonymous with the term scientia, they had the word *ilm* (plural: *ulum*), which represented knowledge of religion and other subjects in addition to knowledge of the material world. During the Ottoman Empire, fun (plural: *funun*) was coined to describe scientific knowledge and meant tool or technique or method (Iqbal, 2007). However, many people continued using the Arabic term *ilm* to refer to both religious and scientific knowledge. Perhaps the need to distinguish the two were not felt in the Indian and Arab civilisations because their cosmological knowledges could entail both theological and material concerns. In other words, the way we understand and use the word science today, in the English language and in everyday speech, has nothing to do with its original Latin meaning; we use science in a very narrow sense. For instance, historical knowledge is not considered a science, and mathematics is not regarded as a true science because it has no direct relationship to the physical universe. Today, however, the question of whether all human knowledge is some form of science or whether there are some areas of knowledge beyond the methodology of science is the subject of intensive philosophical debate (see, Sarukkai, 2012 for details).

Much has been written on the epistemology of science. The nature of science remained a central question for the philosophers of science for many years. The philosophical issues raised by Karl Popper, Thomas Kuhn, Paul Feyerabend, Imre Lakatos,

and others (example, problems of induction, problems of demarcation, value-ladenness of observations, problems of a 'scientific method', etc.) also examined and questioned the intellectual authority of science. In the early work, a description of a scientific method is found. Many of these philosophers identified the 'nature of science' as its 'abstract method'. This idea of a specific 'scientific method' was thought by philosophers to be non-problematic until it was thoroughly considered. In most of the philosophical works done in the twentieth century, the logical structure of science was debated. Logical positivists believed that the logical structure of science should be studied, but the study of its historical or psychological aspects is not necessary. Philosophers resorted to mathematical-logic in order to fully characterise the nature of scientific phenomena and (perhaps deliberately) excluded the actual practice of science, the history of science and its social structures from the realm of their thinking. Thomas Kuhn (1962), in his influential text The Structure of Scientific Revolutions, first included the history of science in philosophical debates about the 'nature of science' and since then there have been many such studies in the history of science, sociology, feminism, anthropology, psychology, and other allied fields which have problematised the 'unbiased', 'ahistorical', 'eternal', and 'universal' claims of scientific knowledge and scientific work. These interdisciplinary studies, which are sometimes labeled under the term 'Science Studies', have shown science as a socially organized enterprise, shaped by human values, beliefs and commitments on many levels (see, Hussain, 2023).

In recent years, feminists, post-colonialists, and left-leaning theorists have put forward ideas about the origin, nature, and status of science in the multidisciplinary literature of science studies. It has become apparent that 'modern science', a specific form of knowledge production, is a relatively recent local activity whose origin is also attributed to industrial capitalism. However, science in the broadest sense of systematic knowledge was never confined to the West. Ancient and modern cultures, including Arabia, India, China, the Americas, Africa, and the Pacific, possess examples of this kind of science (Cunningham and Williams, 1993).

The conventional historians of science contend that between 1450 and 1700 A.D., a number of significant events in Europe gave birth to modern science. This period was famously dubbed the "Scientific Revolution" by the French historian Alexandre Koyere (1956). He believed that the intellectual changes that came about during this particular period constituted the most profound revolution the human mind had undergone since ancient Greece (Koyre, 1956).

Today, however, many sociologists of science deny the existence of any unified, cataclysmic, and dramatic event that fundamentally and irreversibly altered people's knowledge of the natural world and the appropriate methods for acquiring that knowledge in an instant. In other words, these individuals believe that what some historians of science refer to as the "Scientific Revolution" was not a dramatic event, but rather a diverse intellectual effort by specialists and laymen that was shaped by a variety of beliefs, practices, and influences (see Shapin, 1998).

In essence, the contemporary scholarship in science studies contends that the emergence of modern science in Europe was not a supernatural event in which the efforts of a handful of intellectual elites led to a scientific revolution. Rather, in the early period, the interaction between intellectuals, artisans, and other such laymen culminated in the establishment of a new epistemology, a new scientia grounded in nature. Consequently, it is essential to recognise that the Scientific Revolution was a grassroots intellectual revolution. During the period between 1450 and 1700 A.D., even common working-class people were capable of posing questions to all those great people who were called

Philosophers and could sharply criticise their works. In the early days of science, only those possessing the interest, the leisure, and the means to do so conducted research. In those days, there were hardly any professional positions available in the field of science.

History of the Word Scientist

Significantly, in the early 1800s, practitioners of science in Europe, particularly Britain, traversed across science, theology, political economy, and even literature. There was no well-established notion of a 'professional of science' (Stevenson & Byerly, 2000). In Victorian journals, both experts and commoners would write about science and engage in scientific debate. 'Natural philosopher' (or sometimes, 'Experimental philosopher') was the closest contemporary equivalent to 'scientist' at the time. Since the term 'scientist' was not in use at the time, career opportunities in science were limited. During the early seventeenth century, when scientific research was flourishing, it was common for intellectuals of England to experiment and collect data 'for the advancement of knowledge'. The motivation behind this endeavor was 'personal intellectual curiosity' rather than 'human welfare'. This is the reason why people of that era viewed scientific work as more of an intellectual pastime than a profession. If we examine the list of prominent members of the Royal Society of England (who were counted as Natural Philosophers) at the dawn of modern science, we find a remarkable diversity in their social and educational background: bishops, architects, poets, and gentry. However, it is also true that due to the class distinctions of the period, it was difficult for individuals to establish themselves in Natural Philosophy without the patronage of an influential person (ibid., 2000).

Before 1840, those engaged in scientific pursuits were known as Natural Philosophers or Men of Science. But gradually, the scope of Philosophy shrank, and Natural Philosophy (as science was previously known) became a separate entity. Since science now had a very distinct meaning, a new term was required for practitioners of science. In 1962, a chemistry professor and historian of science Sydney Ross published an article in the Annals of Science that sheds much light on our present understanding of the origin of the word scientist. He notes that the appellative scientist, which is seen as an honorific and is aspired for by professionals from different disciplines, is not centuries old, but of relatively recent origin. Further, he outlines the "now old and forgotten controversy" surrounding the etymology of the word and highlights how the word 'scientist' had to face a fierce competition with other words. Highlighting the importance of the history of the word, Ross (1962) writes:

> "...The history of a word is never solely a matter of etymology: the need for a new word is socially determined, right at the start, and any subsequent changes of denotation, as well as the cluster of connotations surrounding it, are also in response to demands from society. The word cannot be isolated from its historical background....To the historian of science the present story [of the word "scientist"] is significant because it marks in a dramatic way the transition of the cultivation of science from the hands of the amateur to those of the professional". (Ross, 1962; p. 65)

According to him, William Whewell1, an influential figure in the 19th-century British scientific community, coined the term scientist in 18342, which first appeared in the March 1834 issue of Quarterly Review, a literary and political journal. Whewell created the word while writing an anonymous review of Mary Somerville's3 book On the *Connexion* of the Physical Sciences (in which she synthesised the most recent developments in astronomy, physics, chemistry, botany, and geology). Before Whewell, several attempts were made to find a general word that could refer to everyone involved in scientific pursuits (mathematician, chemist, 'physicien'). While the word 'philosopher' was discarded for being

too broad (by a philologer and metaphysician, Mr. Coleridge), the French word *savan* was thought of as very presumptuous (besides being non-English), and thus not found suitable for the purposes. Thereafter, some individuals unsuccessfully attempted to translate the German term natur-forscher, but were unable to come up with an English equivalent. Whewell recounted how at their numerous meetings, the members of the British Association for the Advancement of Science struggled to find a term by which they could collectively refer to those with knowledge of the physical world, which could be used for everyone engaged in scientific work (Whewell, 1834; cited in Ross, 1962, p. 71). Therefore, he humorously suggested that the word 'scientist' is equivalent to 'economist', 'atheist', and 'sciolist' (one who has superficial learning and talks with the pretensions of expertise). As suggested by his use of the terms sciolist and atheist, it appears that Whewell did not consider his new word (scientist) very seriously when he first proposed it (Ross, 1962, pp. 71–72). However, six years later, in his book The Philosophy of Inductive Sciences (1840), Whewell proposed more seriously the term 'scientist' as a general term to refer to 'cultivators of science'. To quote Whewell:

> "...As we cannot use physician for a cultivator of physics, I have called him a Physicist. We need very much a name to describe a cultivator of science in general. I should incline to call him a Scientist. Thus we might say, that as an Artist is a Musician, Painter, or Poet, a Scientist is a Mathematician, Physicist, or Naturalist." (Whewell, 1840, p. cxiii; cited in Ross, 1962, pp. 71-72)

Controversy over the word 'Scientist'

Today, it may be difficult to believe that the term 'scientist' did not have a favorable reception when it first came about, as it encountered severe criticism. A controversy raged in Britain's prominent newspapers and journals for approximately forty years and was only gradually resolved (Science-gossip, N.S., 1894,1, 242-3; cited in Ross, 1962). Interestingly, the argument presented in support of the word by American linguist Fitzedward Hall, who had previously studied and taught in India, extinguished the controversy. The history of this controversy has also been meticulously documented by Sydney Ross (1962). I have endeavored to provide a readable summary of Ross's documentation in this section.

Ross (1962) notes that initially the term 'scientist', coined by Whewell, was not greatly valued for its usefulness and was not taken very seriously. For instance, until very late in his career, Michael Faraday, for whom Whewell had once created words such as 'cathode', 'anode', and 'ion' did not care much for the term 'scientist', preferring instead to refer to himself as 'Experimental Philosopher'. In a similar vein, Lord William Kelvin promoted for the use of the word 'naturalist' instead of 'scientist' to refer to the work of a 'person well-versed in natural philosophy'.

Presumably unaware of its inherent linguistic inadequacy, Americans adopted the term 'scientist' quickly than the British. While eminent Englishmen objected to the fundamental inconsistencies in the construction of the word, many British authors continued to use 'Man of Science' instead of 'Scientist' until the 1910s (as they detested the so-called 'trans-Atlantic', i.e., American origin of the term Scientist). In his 1874 Letter to the Academy, linguist Alexander J. Ellis, who was also the president of Britain's Philological Society, referred to the term scientist as 'an American barbarous trisyllable' (Ross, 1962; pp. 75–76). Approximately twenty years later, J. T. Carrington, the editor of the British magazine Science-Gossip, spearheaded the campaign against Whewell's new word 'scientist'. He invited eight prominent British citizens of the time, including Michael Faraday, Lord William Kelvin, Sir John

Lubbock (a British banker and polymath), and Grant Allen (a Canadian science-fiction author), to remark on the utility of this new word (scientist). Five of them expressed their dislike for the new term 'scientist', coined by Whewell, and stated that they were not going to use it. While Sir John Lubbock advocated for the continued use of the term 'philosopher', Grant Allen predicted that despite their contempt for the word, Britons would be compelled to use it in the future. Two examples illustrate the intensity of this hostility towards the term 'scientist'. Thomas Henry Huxley, an acclaimed natural philosopher of the time (also known as Darwin's Bulldog for his support of Charles Darwin's theory of evolution), severely criticised the term 'scientist' in a letter to Carrington:

> "Sir, to anyone who respects the English language, I think "Scientist" must be about as pleasing a word as "Electrocution4". I sincerely trust you will not allow the pages of Science Gossip to be defiled by it." (Thomas Henry Huxley, 10 December, 1894; cited in Ross, 1962; p. 78)

On the contrary, another prominent natural philosopher of the same era, Sir Alfred Russel Wallace (known for independently conceiving of the theory of evolution by means of natural selection), endorsed the utilisation of the word 'scientist' in his letter to Carrington:

> "Dear Sir, I thought the very useful American term "scientist" was now adopted, and I see Dr. Armstrong used it at the Chemical Society, yesterday. As we have Biologist, Zoologist, Geologist, Botanist, Chemist, Physicist, Physiologist, and Specialist why should we not use 'Scientist'? It seems to me that it has, as the Americans say, 'come to stay', and it is too late in the day to object to it". (Alfred Russel Wallace, 8 December, 1894; cited in Ross, 1962; p. 77)

However, the strongest defense of the term 'scientist' was put forward by the American linguist FitzEdward Hall (1825-1901)5. Hall, who was deeply critical of the lexical deterioration caused by Americans in the English language, was equally frustrated by the tendency of some British writers to ridicule every word they suspected to be of American origin. He collected instances of the widespread publication of contempt and condemnation of the word scientist in English newspapers (e.g., The Guardian, London Daily News, etc.) and periodicals (e.g., Science-Gossip) (Hall, 1895, pp. 2–3; cited in Ross, 1962, p. 79). In response to Huxley's unwarranted criticism and all these absurd digressions, Hall argued that the practicality of the term 'scientist' considerably outweighs the irregularities of its creation. Citing the formation of several other highly acceptable English words, Hall advocated for the adoption of the word scientist and anticipated that its use would not cause undue difficulty for linguists:

> "Anomalous in structure as scientist admittedly is, still, now that, after Dr. Johnson's6 rimist [or rhymist] we have got, composedly, to landscapist, *red-tapist, routinist,* and *faddist, there seems to be every likelihood that utility will soon legitimate it, as it has legitimated botany, facsimile, idolatry, monomial, orthopedic, posthumous, racial, suicide, telegram, tractarian7, and vegetarian*, to name a few established irregularities" (Hall, 1895; cited in Ross, 1962, p. 81)

The debate over the appropriateness of the word scientist persisted in later years. Nevertheless, despite some disdain and contempt for the word, it became firmly established in the English language. As opposed to their predecessors, the next generation of writers did not question the validity of the term 'scientist.' The detailed arguments in favour of the term scientist presented in Hall's essay substantially undermined the detractors' argument. Curiously, no one objected to the notion that scientist is a term that was invented as "an exclusive title held by a small group of professional men" (ibid., p. 75). Also, no one objected to the implication that the knowledge of this small group would be regarded as superior to all other types of knowledge that were discredited as 'nescience'. Few people

would have realised at the time that this would aid in the establishment of a powerful institution called "Big Science" (that is, the provision of large-scale instruments and facilities by a national government, group of governments, or international agencies, in which research is conducted by teams or groups of scientists). By the beginning of the 20th century, the term proposed by Whewell had become a coveted appellation8, to which many aspired.

Although Whewell defined 'scientist' as 'a cultivator of science in general', English dictionaries in later years added more to Whewell's original definition (ibid., p. 29). For example, according to the Oxford English Dictionary, a scientist is "a person who conducts scientific research or investigation; a specialist in science or a student of science, especially one or more of the natural or physical sciences" (Oxford English Dictionary, 2014). Similarly, the Merriam-Webster dictionary defines a scientist as "a person educated, or trained, in the sciences, especially the natural sciences; and whose job is to conduct scientific research or solve scientific problems" (Merriam Webster Dictionary, 2015). Shortly thereafter, the narrower descriptions of science and scientist were adopted in everyday speech, and the word continued to play a role in future sociocultural development. It appears that this newly coined English term has equivalents in quite a few of other languages. In a comparable way that Vaigyanik was coined in the Hindi language, Mahir-e-Science and Sainsdaan were coined in the Urdu language9. With the passage of time, scientists have come to be regarded as the sole source for developing authentic ideas about the universe and its functioning.

In other words, many people started to perceive the knowledge produced about our world by philosophers, artists, writers, historians, and theologians, among others, as faulty, unreliable, erroneous or irrelevant. To them, only scientifically produced knowledge constitute genuine knowledge. The belief of some that science could resolve all questions of life remained an issue of anxiety for many. For instance, one of the major concerns with the inventions and expansion of modern science in Britain was whether the new professional scientists, in their efforts to answer all questions pertaining to human life (such as the origin of life, human existence, divinity, and the afterlife), would promote "safe religious beliefs" or "dangerous secular materialism" (Holmes, 2008, p. 450).

Popularisation of the word scientist and 'professionalisation' of science

One of the primary reasons for the opposition to the word "scientist" was that it also referred to an official title and conveyed a sense of specialisation and professionalism. This was inconsistent with the self-image of the personalities and scientific works of the gifted amateurs who were doing science at the time. Rather, the accomplished amateurs had a mental picture of the ideal scientist —He was a man educated in the liberal arts10 who engaged in science-related activities as a scholarly and altruistic hobby and who could devote a great deal of time to studying science without forfeiting his status as a "private gentleman" of wider culture. In particular, it was considered a grave insult to be considered as someone who "does science for money". Even scientists like Humphrey Davy and Michael Faraday were so influenced by this mindset that they rejected opportunities to increase their wealth by restricting the patenting or other forms of publication of their works. During this time period, both amateur and professional scientists (who maintained the same values as amateur scientists) pursued science for its own sake (rather than as a means for earning money) and saw themselves as benefactors of humanity. Adopting the term 'scientist' meant converting science into a business in their eyes. For them, to do so would be to 'degrade their labours of love to a drudgery

for profits or salary' (Ross, 1962, p. 66).

The extent to which science was professionalised after the word 'scientist' became prevalent can also be inferred from the fact that, around 1850, the Royal Society of England revised its membership requirements so that only recognised "scientists" could join.11 In the nineteenth century, however, science began to emerge as a standard and recognised profession, initially in universities, although even there it had to fight hard for acceptance as an academic subject alongside the liberal arts, which had been a part of the university curriculum since the Middle Ages.12 However, after German universities introduced science into their curricula, other nations eventually began to do so as well. In later years, educational reforms brought technical education on par with traditional professions such as medicine, jurisprudence, and theology (Ross, 1962; p. 45).

As a consequence of the word 'scientist' becoming a professional job title, anyone could now aim to pursue a career in science. As a result of the curriculum and certification provided by various universities, science became one of the many career options for students preparing to enter various professions, and the connotations of the word 'scientist' became as valuable as those of the titles 'physician,' 'lawyer,' and 'clergyman' (ibid). This made it possible to obtain the professional title of scientist through universities, which were now governing who could be a scientist and how. Clearly, this official method of creating scientists by universities also spawned numerous rules and regulations, which had a significant impact on the chances of being or becoming a scientist. This regulation has now begun dictating everything, including the number of science personnel, their sociocultural background, their access to science, their salaries, the distribution of work within a particular category of science, and the public's perception of science and scientists. This regulation gradually segregated the educational process of becoming and being a scientist into two separate events. Becoming a scientist now necessitates training to earn a livelihood through science (Kirch &Amorso, 2016, p. 31).

Currently, the majority of grants for conducting professional scientific research in any country are awarded by national-level government agencies or corporations. In most instances, such grants are restricted to applicants who work in colleges, universities, research institutions, or (in some instances) major business enterprises. Due to the increasing technicality of the various sciences and the continuous development of knowledge in them, it has become exceedingly difficult for individuals with neither full-time training nor full-time employment in science to independently achieve scientific results and have them recognised. Today, in order to be recognised as a scientist, a Ph. D. in a scientific field and a salaried position are required.

Given the massive accumulation of knowledge, students must now commit years to studying and comprehending the copious amount of information already acquired in any field of science. Without a Ph.D. in any field of science, it is nearly impossible for someone to publish their work in reputable scientific journals today. Even if someone attempts, their chances of success is limited. The case of Albert Einstein, a then-unknown clerk of the Swiss Patent Office, who astounded the entire discipline of physics in 1905 by having three of his research papers published in Annalen der Physik was remarkable at the time, and it will be even more unlikely in the future (Stevenson & Byerly, 2000). James Lovelock is another example of "an independent scientist" comparable to Albert Einstein. His Gaia Theory provided a new framework for thinking about nature and altered how we view our relationship with the Earth.13 Today, despite one's brilliance, it is more difficult to advance rapidly to prominent positions in science than it was in the past. By the age of 26, many of history's greatest scientists, including Kepler, Newton, James

Clerk Maxwell, William Thomson (Lord Kelvin), and Josiah Gibbs, happened to be full professors. Today, contributions to a broad field of knowledge may qualify a person as a scientist.

Mystification of the Personality of the Scientist

According to Ross (1962), a dangerous, and erroneous belief about scientists swiftly took root in the public's mind. That is, an image of the "ideal scientist" began to form in their psyche. This ideal scientist was a new "omniscient expert," the equivalent of the priest or occult doctor in ancient civilisations, whose scientific assertions could be accepted with the trust of a child! In addition, this widespread perception of scientists gradually strengthened the myth of the infallibility of science in the minds of ordinary people.

The further development of the word 'scientist' and the regulation of the process of becoming a scientist also contributed to this public perception of scientists, as they led to the emergence of a mythology regarding the temperament, attitude, and personality necessary to become a scientist (Kirch & Amorso, 2016; p. 31). In other words, a 'scientist' was now conceived of as a person who must possess the so-called 'scientific attitude' or 'scientific temper'. Thus, he or she must be sceptical of even expert or official knowledge and uses the 'scientific method' (ibid., p. 32). It is evident that, with the passage of time, the professionalisation of the term scientist led to the mystification of science and scientists as a result of myths surrounding the personalities of scientists, their method of work, and their distinctive attitude.

Robert K. Merton, the founder of the institutional sociology of science, presented a very idealistic and heroic picture of science and scientists in his 1942 description of the 'normative structure of science.' Merton identified four 'institutional imperatives' or values and standards that, in his view, 'ensure the functionality of science': (i) Universalism: Science transcends the boundaries of time and space; (ii) Communism: Science, being democratic and transparent, is a body of public knowledge; (iii) Disinterestedness: Science is done for the sake of science and not for the scientist's personal gain; and (iv) *Organised Scepticism*: Science questions everything; it does not distinguish between the sacred and the profane (See, Hussain, 2023).

Although Merton was well aware that scientists do not have superior ethical standards merely because they are scientists, he believed that the practicality of these institutional norms for the scientific subsystem was demonstrated by the fact that the scientific community reacts strongly to those who deviate from these institutional norms of science and also imposes restrictions on them. Clearly, such a characterization of Merton's 'normative structure of science' was very comparable to positivism, an idealisation whose objective was more prescriptive than descriptive. Merton, like philosophers of science (such as Karl Popper's "demarcation problem"), presented science as it should be rather than as what it actually is (Hussain, 2023). Since then, characteristics such as curiosity, perseverance, open-mindedness, seriousness, ambivalence, honesty, and intelligence are frequently associated with a positive scientific attitude or temper in general. Later, a number of sociologists (belonging to the 'strong programme or new sociology of science') employed case studies to demonstrate the discrepancies between Merton's theory and the actual practices of scientists (Barnes & Dolby, 1970).

Similarly, the mystification of the personality of scientists in school science was so great that in a study conducted about half a decade ago to understand the mental images of American high school students related to science and scientists, Margaret Mead and Rhoda Metraux (1975) found that most students had a stereotypical image of scientists:

> "He is a very intelligent man—a genius or almost a genius. He has long years of expensive training—in high school, college, or technical school, or perhaps even beyond—during which he studied very hard. He is interested in his work and takes it seriously. He is careful, patient, devoted, courageous, open minded. He knows his subject. He records his experiments carefully, does not jump to conclusions, and stands up for his ideas even when attacked. He works for long hours in the laboratory, sometimes day and night, going without food and sleep. He is prepared to work for years without getting results and face the possibility of failure without discouragement; he will try again. He wants to know the answer. One day he may straighten up and shout: "I've found it! I've found it!" (Mead & Metraux, 1975; p. 387).

The only image of scientists in the mind of a four- to six-year-old student who has never come across a professional scientist is cultivated through popular media such as animated films, motion pictures, advertisements, comics, and the wide world of the internet. Such common mental representations of scientists that emerge in children's minds are typically of white males (such as Albert Einstein, Isaac Newton, Galileo Galilei, and Charles Darwin) and very rarely of women (such as Marie Curie or Janaki Ammal); such images are rarely of scientists of non-European or Indian descent (J.C. Bose, C.V. Raman, and A.P.J. Abdul Kalam). Sometimes, these mental images consist of fictitious characters working in a laboratory surrounded by chemicals and scientific apparatus while wearing lab coats and glasses. Now, when these children go to school and learn that scientists are expected to work diligently, work for the greater good of humanity, be open-minded, be unbiased, be rational, and be skeptical of ideas lacking empirical evidence, they may additionally realise that scientists are expected to observe the world meticulously describe their observations in comprehensively, and conduct rigorous tests and experiments. By means of such works, scientists may educate individuals who are unable to understand how the world functions. A child who hears such descriptions of scientists in school may find these individuals intimidating, outstanding, or even a little bit odd. Some of our students view themselves as scientists, while others do not, because popular culture and school science contain so many clear descriptions and broad sets of qualifications associated with becoming a scientist, in addition to so many preconceived notions of what scientists are expected to do. Consequently, on the basis of these images and experiences, some students in our schools enjoy science but have no desire to become scientists.

Surprisingly since the publication of this study, numerous studies on students' perceptions of images of scientists in different contexts have been conducted around the globe. These studies have revealed that students and teachers from different contexts and levels have stereotypical perceptions of scientists (Shibeci & Sorensen, 1983; Huber & Burton, 1995; Newton & Newton, 1992, 1998; Song, Pak, & Jung, 1992; Chiang & Guo, 1996; Shi, 1998; Moseley & Norris, 1999; Rahm & Charbonneau, 1997; McDuffie, 2001; Phung, 2002; Hussain, 2017, 2021).

Nobel Prize-winning scientist Sir Peter B. Medawar cautioned in his famous book Advice to a Young Scientist, written for young people taking up science as a career, that scientists are not a homogenous group, but are as diverse as any other group of professionals. In Medawar's words:

> "In science a beginner will certainly read or be told "The scientist this" or "The scientist that." Let him not believe it. There is no such person as the scientist. There are scientists, to be sure, and they are a collection as various in temperament as physicians, lawyers, clergymen, attorneys, or swimming-pool attendants." ... Scientists are people of very dissimilar temperaments doing different things in very different ways. Among scientists are collectors, classifiers and compulsive tidiers-up; many are detectives by temperament and many are explorers; some are artists and

> others artisans. There are poet-scientists and philosopher-scientists and even a few mystics. What sort of mind or temperament can all these people be supposed to have in common? Obligative scientists must be very rare, and most people who are in fact scientists could easily have been something else instead... but I am ashamed to say that after "and even a few mystics" I should now add "and even a few crooks" (Medawar, 1979, p. 3-4).

Curiously enough, despite the efforts of hundreds of teachers, teacher educators and scientists themselves to challenge and restructure these images and ideas, stereotypical images of scientists have persisted in popular culture and school science! The issue with stereotypes is that they are in no way accurate. Due to the fact that a stereotype employs a fictional character to represent an entire group or culture, it does not and cannot accurately portray that group or culture.

Implications for Science Education

In popular conception, science is viewed as a universal, unbiased, objective, and non-historical subject in which emotions, values, beliefs, and human relationships have no relevance. In general, science education does not emphasise the human and social aspects of science, either at the school level or during the preparation of science teachers. On the one hand, irrefutable evidence is accumulating that in our country, students at every educational level are not able to acquire even basic scientific knowledge (NCERT, 2006; Correa, et. al., 2014), at the same time, a survey by Raza et. al. (2009) indicates that the public of our country is in some ways 'scientifically illiterate'. In the context of some developed countries, such as Australia, it has been observed that as a result of the tedium and monotony of science education and the myths surrounding it, many students and teachers have been leaving science for other subjects (Matthews, 2015). In order to make science education interesting for children of all backgrounds, an important step would be to reveal the human face of science and lift the veil of mystique surrounding science and science-related professions.

There is a significant disparity between the depiction of scientists in popular media and literature and their actual appearance and behaviour. Although studies in the sociology of science have shown for a long time that scientists are human beings just like any other group of professionals, very few teachers today challenge stereotypical images of science and scientists in order to present an authentic and inclusive picture of science and scientists to their students in the course of their science instruction—a picture that shows science and scientists in all their splendour and imperfections and presents science as a human subject.

Given that teachers have the power to challenge children's preconceived notion and install in them the correct way of thinking, they must understand that the purpose of science education is not only to create 'future scientists,' but also to make scientific knowledge and ways of thinking accessible to 'all types of students'. All students, regardless of their gender, ethnicity, religion, economic status, or family background, must see science as a fascinating subject and an attractive career option. Teachers must ensure that students and citizens of all backgrounds appreciate the merits and limitations of science and the scientific method, rather than being intimidated or enamoured by it. Science education must acknowledge that all students are unique and deserving of learning science. Education in science must be tolerant and respectful of the vast diversity among science students. Science must be made accessible, particularly to those student groups that have been excluded from science education and science-related careers historically. Through their teaching and other activities, science teachers must convey that science is not the workmanship of privileged, intelligent, and elite individuals, but that people of any gender, caste, religion, colour, race, and

family background can do scientific work and become scientists (Hussain, 2017). This becomes even more essential in the Indian context, as the majority of schoolchildren in India receive their first and only science education at the secondary level. Only a small percentage of children who study science in school will pursue science-based careers or undertake science-related hobbies in their leisure time. For the remaining students, science is just one aspect of their general education. In addition, science is viewed as a 'masculine subject' in India, whereas social sciences are relegated to a 'feminine' status (Kumar, 2012; Thomas, 1990).

As has been revealed by my own analysis of science textbooks (produced by the NCERT since last five decades), science methods textbooks (written by various Indian authors which are followed by pre-service teacher education students), and syllabi on science pedagogy, scientific knowledge is typically viewed and taught as a non-problematic, unambiguous, and repeatable set of facts (emerging from a systematic scientific methodology based on observations confirmed by experiments). Presently, the social characteristics of science (that make it authentic) are not taught to the majority of science students and aspiring teachers of science. I believe that science classrooms that disregard the sociological understanding of science not only present an inaccurate image of science, but also discourage a particular group of students from pursuing it further (see, Hussain, 2017, 2021, 2023). In contrast, if students are exposed to more realistic and accurate views of science in science classes, they will be better able to appreciate science and better equipped to evaluate scientific claims and issues. If we strive for authenticity, we can simultaneously promote inclusiveness. Science can be made more appealing to learners from marginalised and disadvantaged communities if science teachers accept and incorporate the characteristics of actual science into science classrooms. Because by doing so, the monotonous mask covering the visage of science will be removed, revealing its human side.

The ideas for reforming science education enumerated in the National Education Policy 2020 and the Pre-draft of the National Curriculum Framework for School Education 2023 require that the facts, processes, and nature of science be taught in an integrated manner. The ability of science teachers to comprehend the epistemology underlying curriculum reforms and make the necessary adjustments to their beliefs and practices is essential for the effective implementation of this new approach to science education. During pre-service and in-service teacher preparation, it is crucial that teacher educators address teachers' beliefs and knowledge about science, scientists, and science education. It is vital that teacher-educators take the first step in this direction, despite the fact that examining and reexamining our beliefs and assumptions is a complex, ongoing process that cannot be completed in a few months or years. Teacher educators must continually consider how stereotypes related to scientists and science can be challenged and the groundwork for more balanced perspectives can be laid (Hussain, 2021). It will also go a long way in making science accessible and interesting to all.

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Notes

1. William Whewell was a British polymath, a scholar with a broad range of expertise. He wrote exhaustively on a variety of topics, such as mechanics, mineralogy, geology, astronomy, political economy, theology, educational reform, international law, and architecture. In addition, his works on subjects such as the philosophy of science, the history of science, and moral philosophy remain acclaimed in their respective disciplines of study. He was a founding member of the British Association for the Advancement of Science, a Fellow of the Royal Society, the President of the Geological Society, and for a long time the Master of Trinity College, Cambridge. Eminent scientists of the time, such as John Herschel, Charles Darwin, Charles Lyell, and Michael Faraday, sought Whewell's philosophical and scientific counsel, and especially advice on technical matters. Whewell created the words "anode", "cathode", and "ion" for Michael Faraday.
2. According to a different source, Whewell coined the term "scientist" in 1833 in response to a challenge put forth by the English poet S.T. Coleridge (see Snyder, 2017).
3. Mary Somerville (1780–1872) was a Scottish native. She, like Whewell, was a polymath who studied astronomy and mathematics. According to Wikipedia, she was the first female member of the Royal Astronomical Society, along with Caroline Herschel. She was one of the most prominent science writers of the 1830s (along with Marie-Anne Pierrot Paulz, the wife of the renowned chemist Lavoisier), championing and promoting science. Somerville compiled the most recent advancements in astronomy, physics, chemistry, botany, and geology in her book On the Connexion of the Physical Sciences. When philosopher and economist John Stuart Mill organised a massive petition to Parliament to grant women the right to vote, he was the first to convince Somerville to sign. Somerville, like other

science writers of her time, synthesised and reviewed scientific research, which served as a source of new ideas for emerging and aspiring natural scientists at the time (https://en.wikipedia.org/wiki/Mary_Somerville.Accessed, 28 April 2019).

4. In this letter, written in a very short-tempered and irritable manner, Huxley attempted to demonstrate by mentioning the word 'electrocution' that the way 'electrocution' (death penalty by electric shock) is a 'blend' of 'electricity' and 'execution' (hanging) is an ignorant Americanism; similarly, the term 'scientist' is also an unscholarly Americanism.
5. Fitzedward Hall, an American orientalist and philosopher, was a linguist. He was also a pioneering member of the Oxford English Dictionary (OED) team. His life was largely spent in England and India. After graduating from Harvard in 1846 with a bachelor's degree, he abruptly left for India, reportedly in pursuit of a runaway brother, according to Wikipedia. His ship was damaged during the voyage, leaving him adrift near the port of Calcutta. Later, while in India, he studied Indian languages, and in January 1850 he was appointed as tutor at the Government Sanskrit College in Banaras. In 1852, he was the first American to edit the text of the treatises on Vedanta--Atmabodha, and Tattvabodha. He began teaching Sanskrit and English at the Government Sanskrit College in 1853. In 1855 and 1856, he was designated Inspector of Public Instruction in Ajmeri-Merwara and the Central Provinces, respectively. In 1862, he was appointed Professor of Sanskrit, Hindustani, and Indian Jurisprudence as well as Librarian of the India Office at King's College London (https:// en.wikipedia.org/wiki/Fitzedward_Hall;Accessed, 28 April 2019).
6. The dictionary published by Samuel Johnson in 1755 is frequently referred to as the first authoritative English dictionary. Some of this dictionary's definitions of English words are notorious for their eccentricity. Here, Hall refers to the inclusion of the word rimist in the same dictionary.
7. The term 'Tractarian' was used to describe supporters of the 'Oxford Movement' in England; The Tractists were individuals who read the pamphlet 'Tracts for the Times' and adhered to its principles. Initiated in the 1830s by high church members of the Church of England, the Oxford Movement eventually evolved into Anglo-Catholicism. The Oxford Movement, whose original adherents were primarily affiliated with the University of Oxford, advocated for the incorporation of some of the older Christian traditions into Anglican liturgy and theology. The Oxford movement philosophy was known as Tractarianism, after the Tracts for the Times, a series of publications published between 1833 and 1841.
8. Ironically, 63 years later, one of Thomas Huxley's biographers—Cyril Bibby—in the title of his 1959 book on Huxley, quite innocently affixed Huxley's abhorred word scientist to him. The title of the book was "T. H. Huxley: Scientist, Humanist, and Educator" (See, Ross, 1962).
9 In addition, the word gyani (a knowledgeable person) was still widely used in Sanskrit. Similarly, in the Arabic language, rather than coining a separate term for scientist, the word Alim (knowledgeable/well-versed in knowledge) continued to be frequently utilised.
10. From the time of Plato to the Middle Ages, the liberal arts comprised the traditional academic curriculum of Western higher education. The liberal arts were an extension of ancient Greek methods of acquiring knowledge, which began with the desire to develop "a universal understanding". This curriculum, known as the Liberal Arts, was divided into two parts: the introductory academic programme of the trivium (consisting of rhetoric, grammar, and logic) and the quadrivium (consisting of astronomy, mathematics, geometry, and music).

11. Nonetheless, by the end of the nineteenth century, a significant number of scientists held professional positions at universities, national scientific academies, or museums. However, there were still "gentleman scientists" (and they were all men) who were not compensated for their scientific labour and were, therefore, "amateurs." It was believed that they laboured for the love of science rather than for financial gain, although their contributions may have been on par with "professional" scientists'. Charles Darwin is a prominent example of such a "gentleman scientist." Having sufficient personal resources to sustain himself as a "country gentleman," he devoted himself completely to his research on biological evolution while keeping constant communication with other leading biologists and geologists. His research was not motivated by the pursuit of a particular position or financial gain (see Stevenson & Byerly, 2000).
12. In the Indian context, suspicion and hostility towards science due to its association with colonial rule developed as part of a nationalistic consciousness, and as a result, science as a subject had a difficult time gaining a foothold in Indian universities. Similarly, science had to fight hard to be included in the curriculum of Indian schools (see Krishna Kumar's (1997) book titled, What is Worth Teaching).
13. The journal "Nature" initially rejected Lovelock's paper because it lacked a name associated with a scientific organisation, with the comment: "We do not publish papers from home addresses." They mostly come from cranks". Lovelock obtained a visiting professorship at Reading University in order to deal with this problem. Twenty years later, Nature acknowledged his contribution and acknowledged that he was a genuine 'independent scientist'. In the February 1975 issue of New Scientist, Lovelock was eulogised as follows: "In some ways, Jim Lovelock, begetter of the Gaia hypothesis, is one of the last of the old-style natural philosophers. A scientist who works from his own home because he believes that lack of security encourages creativity, he has invented, among other things, "a magnificent Pandora's box", the electron capture detector gas chromatograph" (The New Scientist, 6 February 1975, p. 307; for more information, see Highfield, 2022).