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Department of Philosophy, Imo State University, Owerri, Nigeria

THE ONTOLOGICAL STATUS OF SCIENTIFIC KNOWLEDGE

M. S. C. Okolo
Communication and General Studies Department,
Federal University of Agriculture,
Abeokuta, Ogun State, Nigeria
mscokolo@hotmail.com
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Abstract
The ability of science to appeal to and provide solutions to human's practical needs has made it the most sought after and the favourite candidate for the organisation of society. As a result, human progress is equated with scientific progress as if they are synonymous with each other. That is, scientific knowledge in contemporary society is seen as having the last say in establishing all matters of fact, and in solving problems of all kinds. Yet, the belief that all human problems can be reduced to scientific knowledge and resolved by it appears more and more doubtful given some weighty concerns of humans that fall outside the ambit of scientific intervention. How can science, for instance, resolve the issue of faith, trust, love, which are some of the perennial concerns that engage humans from generation to generation? What is the evidential status of the axioms that science needs as a stepping stone to launch its experiments and claim its reality? These disturbing issues point to the inadequacy of science to account for the totality of the authentic knowledge required by humans to both live a meaningful and well-ordered existence. The issues that fall outside the capability of science to handle but are nonetheless essential for humans to authenticate their existence are within the purview of ontology. Ontology is concerned with the ultimate nature of things, with reality that does not need to submit to empirical verification before validating its relevance. It is to ontology then that science turns to for the initial guide in its journey towards establishing concrete reality. On the other hand, ontology looks to science for the empirical manifestation of its ideas concerning the ultimate nature of things. To this end, this study is premised on two claims: first, the logical relation that exists between science and ontology is based on symbiotic benefit; second, a balanced epistemology must be founded on the ontological status of scientific knowledge.
Keywords: Ontology, Science, Knowledge, Scientific method

Introduction: Clarification of Concepts and Scope of Paper

Science is usually taken to be the realm of empirical enquiry which stems from the attempt to comprehend the world as we perceive it, to predict and explain observable events, and to formulate the 'laws of nature' (if there be any) according to which the course of human experience is to be explained (Scruton, 1991, pp.4-5). Increasingly, there is a fundamental shift towards the 'scientification' of our world to the point that authentic knowledge is seen as the exclusive preserve of the sciences. To sustain this drift, there is a conscious attempt to channel resources of the production of knowledge to the domain of the sciences. Bohme (2012) insists that 'our society's fundamental drift towards rationalization and scientification amounts to - the reconstruction of both our natural *and* our social environment in accordance with the deliverances of scientific wisdom' (pp.22-23). As such the 'most urgent task of reflection is to establish what it means to live in a world that has been shaped fundamentally by science and technology' (Bohme, p.21).

It is, however, a point of fact that the advance of science has been aided a great deal by speculative atomism. In fact, the state of art today in elementary particles (quarks) may not have been possible without speculative atomism. The notion of speculative atomism and quarks are intelligible within the domain of a reflective study – ontology. Ontology could be defined as the branch of metaphysics which deals with the study of the ultimate nature of things (Kattsoff, 1984, p.354).

Yet in the long history of relationships, certain uneasiness has always characterised the relationship between science and ontology. Common understanding is that since science deals with verifiable objects and ontology with assertions not yet verified that they are opposed to each other. Is this position correct? How can science, for instance, defend its own starting point given that its hypotheses are speculations waiting for verification? On this basis, it will be more profitable to approach science and ontology as representing two sides of one human concern that is invaluable to human progress even though they may differ in their procedure and orientation.

To this end, in this paper, I want to argue that: one, the logical relation that exists between science and ontology is far from being one of incompatibility as is often assumed; two, a balanced epistemology must acknowledge the ontological status of scientific knowledge.

Establishing the Ontological Nature of Scientific Knowledge

Science is usually taken to be empirical. Empiricism is the doctrine that it is only by experience that we can know anything. Science, therefore, deals with knowledge obtained through observable evidence. Its branches include: Mathematics, Physics, Chemistry, Astronomy, Geology, and Biology.

For the purpose of establishing the ontological nature of scientific knowledge this paper will examine: First, the methods by which science arrive at facts, and second, two branches of science, mathematics and physics, to ascertain if they are purely empirical. The interest in scientific method is to find a representative area for all branches of science. The choice of mathematics and physics is anchored on the fact that they are the leading subjects in purely formal or conceptual sciences and empirical or objective sciences, respectively.

Scientific Method

A problem-solving approach by which conclusions and discoveries are supposedly made in every science through the construction and testing of a scientific hypothesis is referred to as the scientific method. Typically, the scientific method involves the process whereby 'a researcher develops a hypothesis, tests it through various means, and then modifies the hypothesis on the basis of the outcome of the tests and experiments', and then 'the modified hypothesis is then retested, further modified, and tested again, until it becomes consistent with observed phenomena and testing outcomes. In this way, hypothesis serve as tools by which scientists gather data' (*Encyclopaedia Britannica*, 2020).

Here it is necessary to conduct some examination. In line with the above, hypothesis is a product of reflection which is not an empirical exercise. So while hypothesis is needed to birth and sustain scientific knowledge, it owes its existence to *meta*-scientific knowledge, to a family of axiomatic entities that derive their being from ontology. Besides, even when scientific experiment conforms with the hypothesis, it can never be based on 100 per cent accuracy. Copi (1978) insists that none of the important propositions of science are directly verifiable because for 'the most part they concern *unobservable* entities, such as molecules and atoms, electrons and protons and the like' (p.463). In accord with this reasoning, Bradford (2017) notes that although relativity has been tested may times and generally accepted as true, there could be an instance which has not been encountered, where it is not true. The point is that scientific knowledge is dependent on *sufficient* data and evidence, and not on *entire* or *total* data and evidence. Yet, its claim is supported not on the basis of sufficient data but on the basis of extra non-verified and, in some cases, non-verifiable data.

In addition, the assumption both implicit and explicit in the scientific method is that there is a necessary causal relation between the identification of a problem and the application. But what does it empirically mean to assert that there is a necessary causal relation between one event and another? Can such a relationship ever be observed? The Scottish philosopher, David Hume, argued that the assertion to the existence of some kind of necessary connection can never be justified. For him, all that can be observed in reality is that constant conjunction of events – a contingent but not a necessary connection.

> If two things or events A and B exist at separate times, then they are separable in thought. And that means that the existence of one can be conceived without supposing the existence of the other; in which case any assertion to the effect that the one is always accompanied by the other must be a contingent and not a necessary truth (as cited in Scruton, 1991, p.125).

Based on this, the scientific method of arriving at initial hypothesis from particular observation, induction, collapses. The assumption that there is a necessary inference from the past to future cannot be sustained since the relationship between things at different times is always contingent. Certainly, the inductive method of drawing inferences from singular or particular statements to universal statements cannot be justified empirically by science, although it remains an integral aspect of scientific method.

Popper (1992) endorsed Hume's rejection of induction. For him, 'it is far from obvious from a logical point of view, that we are justified in inferring universal statements from singular ones, no matter how numerous…' (p.27). He argued that the problem of induction is in principle unworkable. For him, hypotheses are defensible if formulated on the basis of their falsifiability. His justification is that the real role of observation and experiment is to refute theories. He argued that this provides a way out of the difficulty which the theory of scientific explanation has landed itself since refutation employs only deductive inferences.

But does this really resolve the impasse? How is a theory refuted? Popper acknowledged that a theory is falsified, refuted, only by experiments that are indefinitely repeatable. On what is the belief that an experiment is indefinitely repeatable, the belief needed to falsify a theory, anchored? Such a belief can only be the result of an inductive conclusion from evidence that it has been repeated some number of times. Popper's attempt to purge induction from science thus ends up re-establishing it.

Kant also tried to resolve the issue of induction. He stated that certain fundamental principles of science such as the principle that every event has a cause can be established *a priori*. What does it mean to assert that a principle based on experience is valid *a priori*? For Kant, although scientific knowledge arises from, and is based on actual experience 'it rests upon certain universal maxims and principles which because their truth is presupposed at the start of any empirical enquiry, cannot themselves be the outcome of such enquiry' (as cited in Scruton, 1991, p.139). Kant referred to these maxims as *a priori* and as such insists that science can be both synthetic and *a priori*, what he tagged 'synthetic *a priori*' knowledge.

How can synthetic *a priori* be justified: scientifically or reflectively? Science cannot establish what goes beyond it as Kant acknowledged by introducing the notion of *a priori*. To justify 'synthetic *a priori*' knowledge it has to be through reflection. It is within the purview of ontology as a reflective study to make assertions that may not be based on direct observation. Inductive inference properly located, therefore, belongs within the domain of ontology. The fact that it is employed satisfactorily in the scientific method is a demonstration of the ontological nature of scientific knowledge.

Indeed, Sellars (1962 [2012]) draws attention to the incompleteness of the 'scientific image'. He insists that there is complementarity, not just opposition, between the scientific image and its unquantifiable dual which he called the 'manifest image'. The manifest image consists of those experiences which do not yield to quantifiable evidence, precise documentation and causal fitted interpretation; those activities and interactions which explore the intangibles in human affairs. Our ability to exercise our free will, to make choices, to set priorities, to state intentions, to accept responsibilities, to respect obligations, to dive into the realm of the ought, are all within the ambit of the manifest image. The manifest image, then, 'concerns how we envision bringing about quality in all dimensions of life, including the science we pursue. So although this normative aspect of being human cannot be captured in scientific description, neither can scientific inquiry be conducted responsibly without it' (Lauer, 2017, p.546). Lauer (2017) sums up '[f]or formally organized knowledge to be successful in serving the human condition, clearly this prescriptive axis of our shared experience is a requisite component of the scientific endeavor. And it must be the ascendant component' (p.546).

Mathematics

Roman (1975) observed that 'since the days of Galileo it is commonly accepted that mathematics is the language of science' (p.xxiii). This notion is endorsed by Wolpert and Richards (1988) and Yadav (2017). Wolpert and Richards noted that mathematics 'is perhaps, the purest and most rigorous of intellectual activities, and is often thought of as queen of the sciences' (p.53); while Yadav sees it 'as the past, present and future of all sciences' (p.34). However, while these submissions position mathematics effectively in science, they fail to tell us anything of its component(s). To evaluate mathematics, we need to interrogate its components.

Traditionally, mathematics is defined as 'the scientific study of quantities, including their relationship, operations and measurements expressed by numbers and symbols' (Yadav, 2017, p.35), and Arithmetic which is the first branch of mathematics is 'the science of numbers' (*Chambers English Dictionary*, 1990, p.73; *Longman Dictionary of Contemporary English*, 2014, p.81). The implication is that numbers are the foundation of mathematics. But what are numbers? Are they physical in any way we can empirically verify or observe? Fuson (1984) defines a number as an idea that is used to refer to how many objects that is in a certain group (p.450[a]). The notion of 'idea' does not correspond to anything empirical whereas 'objects' do. It does appear as if numbers can exist independent of objects they represent. As such the number two, for example, will be the same in Nigeria as it is overseas. Lehman (1979) states as much when he asserts that: 'numbers are universals seems…clear. An object is a universal if it can be present in many different objects at the same time. Numbers can be present in different sets of objects at the same time' (p.6).

The notion of universal is ontological. To grant that numbers have an ontological status is consequently to grant the same to mathematics. Although numbers can be used to refer to observable entities, the number two surely is not a physical thing. Davis (1980) noted that 'mathematics which is supposed to be precise and reliable, turns out, ironically, to be based on words you can't define and assertions you can't prove' (p.23). Indeed, Yadav (2017) cites Albert Einstein as stating that 'as far as the laws of mathematics refer to reality, they are not certain, and as far as they are certain, they do not refer to reality' (p.35). This is not to say that mathematics is not applied. We can grasp such truths as that 2+2=4 in the course of experience. But that is, perhaps, the farthest experience can go. The notion that 2+2=4 is not an experimental truth as it is an experimental truth that if red ink pours on a white dress it stains. Paulsen (1992) asserts that, 'it is characteristic of mathematics that it makes no assertions concerning the existence and behavior of reality, but deals solely with deductions from notions' (480). For instance, the triangles, rectangles, lines and points of which the geometrician speaks can perhaps only be grasped through definition.

The fundamental concept in mathematics, therefore, remains outside the scope of observation. Wolpert and Richards (1988) summed this up in their interview with Christopher Zeeman, Director of the Mathematics Research Centre at Warwick University:

> To the outsider…it (Mathematics) seems like a private game, the manipulation of symbols to uncertain and unworldly ends. Many of the ideas in mathematics seem to lie beyond the bounds of common sense. It is obvious, for example, that the set of numbers 1, 2, 3…is infinite and there cannot be a highest number… (p.53).

To reduce human existence, then, to mathematically predictable arrangement cannot be substantiated even by mathematics. How can reality be completely grasped within the confines of scientifically structured, precise and predictable arrangement? Barrett (1957) warns that 'human life must be more than pure reason, and to attempt to reduce it to the latter is to destroy it, even if we make that reduction in the name of universal enlightenment' (p.148). It does appear that the profound concerns of human beings cannot be reduced to quantifiable data.

Physics

Physics could be defined as 'the science that deals with the structure of matter and the interactions between the fundamental constituents of the observable universe' (Weidner and Brown, 2020). As such an interest in physics is essentially a discussion on matter which invariably translates to a description of all the different substances in the universe. In fact, 'scientists use the term matter to describe all the different substances in the universe' (Basford, 1966, p.5).

The ancient Greeks tried to explain all the phenomena of nature in terms of four elements – water, fire, air and earth. If matter is one of these or all of these, what is it really made of? What is its basic entity? Whatever its form, all matter, according to Lapp (1974), is made up of the same basic entities called the atoms (p.9). The conception is that atoms are ultimately indivisible (Mark et al, 1970, p.33).

The atom, however, has been undergoing transformation. Modern science has been trying to simplify the basic building block still further. Wolpert and Richards (1988) observed that:

> The recognition of the existence of two more fundamental forces – the strong and weak nuclear forces – came with the discoveries about the structure of the atom in the first decades of the century. It became clear that an atom is not an indivisible sphere…, but consists of a small central region – the nucleus – surrounded by a cloud of particles called electrons. The nucleus is composed of particles called neutrons and protons, which are bound together by the strong nuclear force (p.13-14).

Do all these mean that we can demonstrate the existence of an atom in the same way we can point at a table? What is an electron for instance? According to the *Encyclopaedia Britannica* (2019) an electron is the 'lightest stable subatomic particle known'. This definition appears to be circular in view of the fact that what matter is in certifiable terms is yet uncertain. About five decades ago scientists agreed that 'no one to this day has actually seen an atom' (Mark et al, 1970, p.31).

This inability to empirically verify the atom has, however, not deterred scientists in their effort at revealing the mystery of matter. Trefil (1980) in his *From Atoms to Quarks* noted that: '[w]e are now at a point where there are tantalizing glimpses of possible resolutions to one of the oldest questions men have asked: the question of what the world is made of' (p.xi). In 1964 Murray Gell-Mann predicted the existence of quarks as the most elementary of all particles.

At this point it is necessary to ask on what basis is the scientific knowledge of quarks based? Is it derived through ontological channels or empirical data? Trefil conceded that 'the brutal fact of the matter is that there is not a single generally accepted shred of evidence that a quark has been isolated in a laboratory' (p.170). Eight years after Trefil made this assertion the *Chambers Science and Technology Dictionary* (1988) maintains that 'no quark has been observed in isolation' (p.730). Equally in the *New Scientist* of June 6, 1998, Davies reported that answers and questions surrounding quarks:

> May quite literally lie trapped in the bewildering mathematics of a theory called quantum chromo- dynamics (QCD), a theory born in the 1970s … to explain how quarks interact and come together to form more complicated objects. Physicists believe that QCD might

> be a staggeringly powerful and accurate theory – if only it wasn't so complicated that no one could solve its equations (p.33).

The solution to the problem, then, does not seem to be within range. How could QCD reveal the answer if no one could solve its equations? To overcome this, researchers turned their attention to super computers. Still the ride is not easy. They admitted according to Davies that: 'All that is holding us back is want of a larger, faster computer. There could be even stranger conglomerates of quarks … lurking out there. But we won't know until we managed to make the lattices churn at higher speeds' (p.35). Even the discovery of a new exotic particle, "tetraquark" in 2020 relied on supercomputers. Writing on the discovery, Capriotti and Cliff (2020) report that the 'strong force operating between quarks obeys very complicated rules – so complicated, in fact, that usually the only way to calculate its effects is to use approximations and supercomputers'.

What does it mean empirically to use approximations? How can physics which thrives on the ability to observe and to measure the world around us find it difficult (impossible?) to come up with the empirical evidence to authenticate not just the existence of quarks but also what quarks are really doing in those particles. It does appear that the theoretical entities appealed to in a successful explanation in science are not equally translatable into observational terms. Xavier Zubin's observation in reference to the progress of quantum physics contained in McInnes' (1972) account remains pertinent: 'Physics is again in crisis facing problems that cannot be solved by physicists, logicians, or epistemologists but only by ontologists'(p.382). Equally Lloyd Smith's view cited by Copi (1992) still reflects the dilemma of physics. In Smith's opinion, a 'physicist of this century interested in the basic structure of matter, deals with radiation he cannot see, forces he cannot feel, particles he cannot touch' (p.468). The physicists, therefore, do not have the world of very tiny things wrapped up. This failure of physics to have everything neatly wrapped and sealed is, however, not a bad thing. Barrett (1957) cautions that '[w]hen human life is so scientifically precise and predictable; nobody would want to live it' (p.148). This suggests that nothing that is really important about human beings can be reduced to quantifiable data.

Conclusion

From the foregoing, the following deductions appear cogent: There is more convergence and compatibility than is conventionally accepted, between characteristics associated with science on the one hand, and those attributes regarded as the preserve of ontology on the other hand. For instance the facts that science tries to establish are really attempts to provide solution to ontological issues: what is the nature of existence? What is the make-up of the world? How did it come into being and what accounts for the change we find in it? What is the true nature of a human being? What is the value of human knowledge and how long can it last? To what extent are human beings in control of the forces of nature? This way most scientific knowledge appears to be built on self-evident truths rather than observation and experiment.

Ontology is, however, incapable of making its reflective claims persuasive unless its cognitive claims are credible. Science provides that credence. It provides a certain reliability and predictability that is always so reassuring: There is an assurance in knowing that protease inhibitors is reducing the AIDS death rate; That there are vaccines to prevent and treat measles, polio, tetanus, whooping cough, tuberculosis, and, even, COVID-19 among others; That DNA and other scientific evidence made it possible to come to an irrefutable conclusion that the remains discovered near Yekaterinburg in the late 1970s were those of Tsar Nicholas II, his wife Alexandra and three of their children who were murdered in 1918. Indeed, Cohen and Nagel (1992) insist that 'scientific method is the only way to increase the general body of tested and verified truth and to eliminate arbitrary opinion' (p.494).

In all, it is necessary to recognise the limitation as well as the usefulness of science in furthering human knowledge. There is no way a dichotomy between science and ontology can be sustained without adverse effect to our epistemological quest. Knowledge deduced from pure thought need to be authenticated through experiment – empirically- in order for epistemology to be grounded, further extended and properly understood. Yet, while science demonstrates the usefulness of precision and gatherable data in resolving human problems, it is the mysteries and the un-gatherable data that are the stuff of life. Science and ontology must, therefore, feed off and spar with each other if a balanced epistemological progress is to be made in understanding a universe that thwarts human efforts to comprehend its total composition.

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