First Philosophy

The Theory of Everything

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Philosophy and Science

> Several years have now passed since I first realized how numerous were the false opinions that in my youth I had taken to be true, and thus how doubtful were all those that I had subsequently built upon them. And thus I realized that once in my life I had to raze everything to the ground and begin again from the original foundations, if I wanted to establish anything firm and lasting in the sciences.
>
> — RENÉ DESCARTES, *Meditations on First Philosophy (1641)*

> For the end proposed for this Science of ours is the discovery not of Arguments, but of Arts; not of what agrees with Principles, but of Principles themselves…
>
> Now my plan is to proceed regularly and gradually from one axiom to another, so that the most general are not reached till the last; but then when you do come to them you find them to be not empty notions, but well defined, and such that nature itself would really recognize as her first principles, and such as lie at the heart and marrow of things.
>
> — SIR FRANCIS BACON, *Instauratio Magna (1620)*

> I do not say that philosophy is an imperfect science; I say simply that it is not yet a science at all, that as science it has not yet begun.
>
> — EDMUND HUSSERL, *Philosophy as Rigorous Science (1911)*

> Philosophy as an exact theory should do to metaphysics as much as Newton did to physics…[I]t is perfectly possible that the development of such a philosophical theory will take place within the next hundred years or even shorter.
>
> — KURT GÖDEL, *From Mathematics to Philosophy (1974)*

> One of my most precious dreams…is to see one day scientific knowledge so clearly established as to allow a return of philosophy to its pre-Socratic sources, finding in science its own foundations or its most fitting mold.
>
> — ROLAND OMNÈS, *Quantum Philosophy (1999)*

First Principles

> The wise thing is a single thing – knowing the plan which steers all things through all things.
>
> — HERACLITUS, *Fragment (c. 500BC)*

> After all, when the first principle is unknown, and the conclusion and the steps in between are put together out of what is unknown, what mechanism could possibly turn any agreement reached in such cases into knowledge?
>
> — PLATO, *Republic (360BC)*

> …that of knowing all things must belong to him who has in the highest degree universal knowledge; for he knows in a sense all the instances that fall under the universal. And these things, the most universal, are on the whole the hardest for men to know; for they are farthest from the senses. And the most exact of the sciences are those which deal most with first principles; for those which involve fewer principles are more exact than those which involve additional principles…
>
> — ARISTOTLE, *Metaphysics (350BC)*

Physics and Progress

Physics is mathematical not because we know so much about the physical world, but because we know so little...

— BERTRAND RUSSELL*, *An Outline of Philosophy (1927)*

The next great era of awakening of human intellect may well produce a method of understanding the *qualitative* content of equations.

— RICHARD FEYNMAN*, *Feynman Lectures on Physics (1964)*

Still more uncommon, and still more needed today, is the outsider-generalist who, like Einstein, can lead the way surefootedly through the complex world of science and technology to goals that were overlooked or deemed impossible by most experts.

— JOHN WHEELER, *The Outsider (1979)*

Great physics does not automatically imply complicated mathematics!

— MARTINUS VELTMAN*, *Facts and Mysteries in Elementary Particle Physics (2003)*

The key breakthroughs in science have always been made by people of integrity who went their own way, defied authority, and paid a stiff price for doing so.

— ROBERT LAUGHLIN*, *A Different Physics (2005)*

…the lesson of the last thirty years is that the problems we're up against today cannot be solved by this pragmatic way of doing science. To continue the progress of science, we have to again confront deep questions about space and time, quantum theory, and cosmology. We again need the kinds of people who can invent new solutions to long-standing foundational problems.

— LEE SMOLIN, *The Trouble with Physics (2006)*

* Nobel laureate

Einstein

A physical theory can be satisfactory only if its structures are composed of elementary foundations.

— ALBERT EINSTEIN*, *Letter to Arnold Sommerfeld (1908)*

One should not pursue goals that are easily achieved. One must develop an instinct for what one can just barely achieve through one's greatest efforts.

— ALBERT EINSTEIN*, *Letter to Walter Dällenbach (1916)*

The supreme task of the physicist is to arrive at those universal laws from which the cosmos can be built up by pure deduction.

— ALBERT EINSTEIN*, *Principles of Research (1918)*

I want to know how God created this world. I am not interested in this or that phenomenon, in the spectrum of this or that element. I want to know His thoughts, the rest are details.

— ALBERT EINSTEIN*, *Said to Esther Salaman (c. 1920)*

The efforts of most human beings are consumed in the struggle for their daily bread, but most of those who are, either through fortune or some special gift, relieved of this struggle are largely absorbed in further improving their worldly lot.

— ALBERT EINSTEIN*, *New York Times (4 May, 1935)*

All physical theories, their mathematical expression notwithstanding, ought to lend themselves to so simple a description that even a child could understand.

— Attributed to EINSTEIN by LOUIS DE BROGLIE* (1962)

Einstein expressed over and over again the thought that one should not couple the quest for knowledge with a bread-and-butter profession, but that research should be done as a private spare-time occupation.

— MAX BORN*, *The Born-Einstein Letters (1971)*

* Nobel laureate

Contents

Preface

We live at a special time: our knowledge of the universe is at the crossroads. Science and philosophy have lost their direction. Science is unsure whether its primary focus should be reductionism (examining the parts) or holism (examining the whole). On the other hand, philosophy has found itself lost after, over the last century, blindly pursuing analytic (or bottom-up) philosophy rather than synthetic (or top-down) philosophy. The need for change is highlighted in the highly speculative character of many ideas, theories, stories and myths at the frontiers of science and philosophy today.

Standing at the crossroads, it is clear that there is a need for a synthesis of universal knowledge: both bottom-up scientific knowledge and top-down philosophic knowledge. This lofty goal is the purpose of this work, called First Philosophy: The Theory of Everything.

This book is written for scientists, philosophers and the general reader who is scientifically or philosophically inclined. It is a book of knowledge that contains no preconceived philosophy or philosophical system. Instead, the theory outlined herein is *logically* deduced from our *empirical* knowledge of the universe. Not only is the theory consistent with current scientific knowledge, but it also makes more than sixty testable scientific predictions. Some predictions, such as *non*-existence of Higgs particles, super-symmetric particles, Kaluza-Klein particles, and quark-gluon plasma, will each be tested once CERN's US$6 billion Large Hadron Collider is commissioned later this year.

Although this book is of scientific and philosophic interest, it has been written for the general reader for a number of reasons. Firstly, the deepest principles of the universe are expressible in a non-mathematical form – making an exposition such as this book possible. Secondly, the ideas in this book can be more quickly and widely disseminated in a user-friendly form. Thirdly, there is broad interest in the Theory of Everything – with a number of books for the general reader published over the last two decades.[1] And finally, the foundation for science and philosophy is logically the first subject that should be taught in high school science and philosophy classes. However, until now, the foundation for science and philosophy has been unknown and, therefore, "hidden under the carpet." If the ideas in this book become accepted, then it will now be possible to teach science and philosophy within an overarching foundational framework.

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[1] For example, Davies and Brown [1988], Peat [1988], Barrow [1991], Weinberg [1992], Kaku [1994], Kaku and Thompson [1995], Smolin [1997], Gribbin [1998], Greene [1999], Klein and Lachièze-Rey [1999], Smolin [2000], Hawking [2002], Falk [2002], Moring [2002], Greene [2004], Halpern [2004], Kaku [2005], Penrose [2005], Randall [2005], Woit [2006], and Smolin [2006]

Sir Isaac Newton famously wrote in a letter to polymath Robert Hooke: "If I have seen further it is by standing on ye sholders of Giants."[2] In this day and age, there are so many shoulders of so many Giants that one stands on. To give due recognition to the many contributions that have influenced this work, quotes and references are used liberally throughout the text. "Although quotations are sometimes considered as crutches for the intellectually imbecile,"[3] they provide the best method of recognizing these important contributions.

Lastly, but certainly not least, I dedicate this book to my children, Cameron and Sarah. Enjoy!

Spencer Scoular
April 2007

[2] Herbert Turnbull et al. [1959–1977], vol. I (1661-1675), p. 416
[3] Max Jammer [1957], p. vii

Part I

Unification

Chapter One

The Search for Unity

Overview

Man has always, more or less, sought a unified understanding of the world. This theme extends through theology, philosophy and science. In theology, this led to one supernatural being, God. In philosophy, this led to a constant search by philosophers for a coherent unifying philosophical framework or worldview. And in science this led to the aspiration for the ultimate theory of nature, which can be divided into the Theory of Everything (the basic building blocks of nature) and the Arrow of Time (how the building blocks created the complexity we see today).

The very early Greek philosophers believed in a world of one unifying substance.[1] Two hundred years later, however, at the time of Plato (428-348 BC), knowledge began to fracture from a unified principle into a number of parts – a problem that has not been resolved to this day. Plato was the first to address this problem when, in several of his later dialogues, he considered the relationship between the branches of science. For example, in *Timaeus*, he announced that there is unity in the universe and detailed a specific agenda to understand this unity.[2] However, after the fall of Greek culture, the world moved back to the comforting figure of God as the unifying framework for theology and Aristotelian science. This paradigm lasted over two thousand years until the rise of modern science.

At the beginning of modern science in the seventeenth century, God still cast a shadow: where the unifying paradigm of the mechanistic worldview failed, God provided the overarching framework. For philosopher René Descartes (1596-1650), God provided the unifying framework between the mechanical and mental components of Nature. Similarly, in a private communication in 1692, Sir Isaac Newton (1642-1727) ascribed the unexplained active organizing principle of Nature to a voluntary agent (i.e. God):[3]

> [All this] I do not think explicable by mere natural causes but am forced to ascribe it to ye counsel & contrivance of a voluntary Agent.

Similarly, German philosopher Immanuel Kant (1724-1804) suggested in his early work of 1755 that the universe might contain an organizing force that he ascribed to God:[4]

> …God has put a secret art into the forces of nature so as to enable it to fashion itself out of chaos into a perfect world system…

With the subsequent rejection by science of speculative metaphysics (and therefore God), science and philosophy began the search for a new unifying framework or worldview.

In 1965, philosopher Errol Harris (1908-) briefly outlined the search for unity:[5]

- The aim of science is and always has been to explain nature by a minimum of interrelated laws and, if possible, to derive these from a single principle;

- Scientific progress so far justifies scientists faith in this unified ideal;
- The findings of science indicate a unified world, diversified by many different phenomena that are related to one another through the principles of order and coordination.

All the great breakthroughs in science have been a result of the search for unity.[6] Theoretical physicist Albert Einstein (1879-1955) exemplified this search. Since his death in 1955, many physicists have taken up the challenge. Today, more than one thousand physicists search for the Theory of Everything.[7]

Types of Unity

Traditionally, there have been two interpretations of unity:[8]

- Unity of scientific method;
- Unity of nature, science and knowledge.

This book is concerned with the unity of nature, science and knowledge. However, the historical development of ideas associated with the unity of scientific method has impacted on the development of the unity of nature, science and knowledge. Lets, then, first consider the unity of scientific method.

Unity of Scientific Method

The unity of scientific method, as the name suggests, seeks to unify science through a common method. The most dedicated effort to unify science through method came from the Unity of Science Movement of the 1930s. This movement started out in the mid-1920s as the Vienna Circle. The philosophy of the Vienna Circle became known as logical positivism or logical empiricism, and had three components:

- The unity of scientific method;
- The application of a logical method based on a universal language; and
- The elimination of metaphysics.

One of the most important purposes of the Unity of Science Movement was to further all kinds of scientific synthesis.[9] According to leading advocate Otto Neurath (1882-1945):[10]

> The historical tendency of the Movement was toward a unified science departmentalised into special sciences, and not toward a speculative juxtaposition of an autonomous philosophy and a group of scientific disciplines.

The objective was to reduce all the terms used in the branches of science to a sort of universal language, which would serve as a sufficient reduction basis for the whole of the language of science.[11] The ultimate vision was that through a formalized language, the branches of science would all logically fit together. The movement was severely impacted by the Second World War and was slowly disbanded after the death of Otto Neurath in 1945.

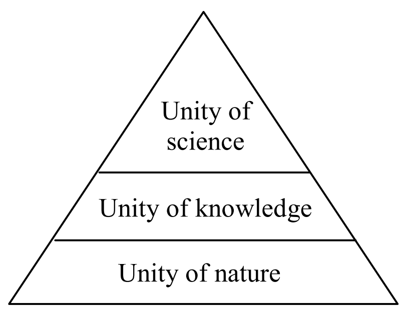
It appears in retrospect that the research programme was flawed from the outset. In 1953, Sir Karl Popper (1902-1994) stated that the task of constructing a scientific language that includes all of science but excludes all of metaphysics is not possible.[12] According to philosopher Peter Galison, the antipositivists of the 1950s and 1960s rightly concluded that no such "protocol language" could exist.[13] Although the Movement failed, it has left a lasting impression on philosophy: it encouraged the final transformation of philosophy into analytical philosophy, which is the mainstream philosophy of today. With the adoption of analytical philosophy, most philosophers now avoid or minimize the use of metaphysics and some no longer ascribe to the unity of science ideal.

Although the Unity of Science Movement did not succeed, and although the philosophy of science has had little success specifying a single scientific methodology,[14] the unity of scientific method still has a following.[15] If there is such a thing as a common scientific method, then, almost by definition, it is the logic required to develop an explicit, shared, well-defined, conceptual construct of the world. Clearly, this logic takes many forms depending on the circumstances and issues involved.

Unity of Nature, Science and Knowledge

While the unity of scientific method may be important for understanding the culture and philosophy of science, it dodges the real issue associated with the unity of science debate; in particular, whether there is a unity of nature. The unity of science and knowledge, on the other hand, is entirely linked to the hypothesis of a unity of nature. If one can show a unity of nature, then one can show a unity of knowledge and a unity of science.

The relation between these elements is best envisaged as a pyramid:



The unity of nature is the metaphysical belief that there is one universe, defined by one set of universal laws. Science and philosophy seek to understand nature, ultimately to understand its unity. Once science and philosophy discover this unity, there is a unity of knowledge and, therefore, a unified worldview.

After more than two thousand years, science and philosophy have been unable to find *the* principle unifying knowledge. As a result many philosophers and some scientists no longer believe in the unity of knowledge. This has resulted in three broadly held views in relation to the unity of knowledge:

- There is a unity of knowledge, and it will be discovered in time;
- There is no unity of knowledge;
- There is a unity of knowledge, but it is beyond the abilities of man to discover.

These views are reviewed in turn.

Undiscovered Unity

Scientists, mostly natural scientists, typically hold the belief in the undiscovered unity of knowledge. The classical theological-philosophical formulation of the unity of knowledge is due to Italian philosopher and scholar Giovanni Mirandola (1463-1494). Simply put, true knowledge is all in some sense knowledge of God. Knowledge is therefore one, its unity guaranteed by the unity of God.[16] Sir Isaac Newton, René Descartes and many others of their era believed this argument. Others, such as astronomer Johannes Kepler (1571-1630)[17] and Albert Einstein[18], simply believed that nature is harmonious, simple and unified. And still others, such as philosopher Herbert Spencer (1820-1903), argued that if it is reasonable to assume each branch of science conforms to laws, then it is also reasonable to assume that their co-operation conforms to laws.[19] Philosopher Ian Hacking (1936-) summarized the outlook by suggesting the metaphysical sentiment that bears on the unity of science is, "There is one scientific world, reality, truth."[20] These sentiments, however, are not provable and do not establish whether science will ever discover the unity of knowledge.

Scientists, therefore, usually make the argument by projecting historical progress into the future. The argument has been expressed a number of times, for example in 1938 by Nobel laureate Niels Bohr (1885-1962),[21] in 1952 by scientist Ludwig von Bertalanffy (1901-1972),[22] and in 1998 by biologist Edward Wilson (1929-).[23] The basic structure of the argument is:

- Empirical science shows an overlapping web of causes-and-effects running from particle physics all the way through to social science;
- Theoretical science has historically produced more and more general explanations of these overlapping causes-and-effects;
- This trend toward greater interdisciplinary synthesis will continue, ultimately leading to the unity of knowledge.

Whilst the argument may be simple, it is also controversial. Edward Wilson, when he published this idea in 1998, said he was frankly surprised that the idea, prophecy or projection met with so much resistance.[24] The resistance is partly explained by an observation in 1972 by philosopher of science and theorist Ervin László (1932-). He noted that whilst the presupposition that the world is ordered as a whole is of an equivalent type to the presupposition that the world is ordered in special domains, there is an illogical tendency for modern scientists and philosophers to automatically assume that the world is ordered in special domains and require demonstration that the world is ordered as a whole (but not vice versa).[25] Albeit the case, until the unification of science is discovered, the undiscovered unity argument will always remain intuitive and philosophical in nature; and, ironically, should unification be achieved the argument will become redundant.

No Unity

Given the failure of science and philosophy to discover the ultimate universal theory, some scientists and philosophers – such as philosopher Nancy Cartwright (1943-)[26] – have come to believe there is no unity of knowledge. For example, philosopher Steven Horst noted that philosophers of science have, since the 1970's, been more inclined to favour the autonomy of each "special" science over assumptions about how they fit together into a unified whole.[27] Philosopher John Dupré suggested that in recent years perhaps a majority of philosophers have become sceptical of strong doctrines of scientific unity.[28] Similarly, philosopher Stephen Burwood has observed a general twentieth century trend away from a unifying metaphor: he suggests that many scientists no longer believe in the unity of science.[29]

The irony is that, in effect, these philosophers have used the analytic approach to criticize the metaphysics of scientists who believe in a unity of knowledge. That is, whilst at the turn of the twentieth century scientists criticized philosophers' use of metaphysics, the tables have turned, and at the end of the twentieth century philosophers are criticizing scientists use of metaphysics (i.e. their metaphysical belief in unity).

To resist the unity of knowledge argument means accepting pluralistic knowledge (i.e. many non-unified branches of knowledge). However, accepting pluralistic knowledge is not a simple position to hold. For example, it is contrary to another trend in philosophy whereby most philosophers have come to accept that mind and body are not dualistic – they are one. These notions of a unified mind and body but multiple branches of knowledge are not entirely consistent, certainly not within a simple framework.

Some philosophers have attempted to overcome these difficulties. In 1974, philosopher Jerry Fodor (1935-) proposed a pluralistic framework based on the idea that a higher science supervenes on the lower science, but does not reduce to the lower science.[30] In 1978, philosopher Patrick Suppes (1922-) argued that, because of Gödel's incompleteness theorem,[31] science could never be complete and, instead, would forever remain pluralistic.[32] In 1983, philosopher John Dupré argued that most events are irreducibly unique: the world exists in disunity.[33] In 1994 philosopher Nancy Cartwright suggested that nature might consist of a patchwork of universal laws, each with limited scope, that are not necessarily related to each other in any systematic or uniform way.[34] The general belief in the disunity of science became apparent when, in 1996, philosophers Peter Galison and David Stump edited a collection of seventeen papers on the disunity of science.[35] In 1998, theoretical physicist Stephen Hawking (1942-) suggested that the ultimate theory might not be one theory, but rather a series of overlapping theories analogous to the maps of the Earth.[36] The same year, philosopher Steve Clarke (1964-) argued that the metaphysical position of science should not be based on the unity of science, although that may be an appropriate goal.[37]

Although these ideas give some comfort to the possibility of pluralistic knowledge, conceptual, empirical, philosophic and logical discomfort has led a number of scientists and philosophers to believe in a third option: the unity of knowledge is beyond man.

Beyond Man

The idea of a unity of knowledge that is beyond man to discover can be traced at least back to French philosopher Auguste Comte (1798-1857), the father of sociology. He believed in the harmony of science with "each science…being itself only a part of a great whole."[38] Nevertheless, he believed the task of unifying science into the ultimate theory was beyond man:[39]

> There is something so chimerical in attempts at universal explanation by a single law…Our intellectual resources are too narrow, and the universe is too complex, to leave any hope that it will ever be within our power to carry scientific perfection to its last degree of simplicity.

Other historical figures to hold this view included German physiologist Emil DuBois-Reymond (1818-1896), British philosopher Herbert Spencer, and British naturalist Thomas Huxley (1825-1895).[40] More recently, in 1980, American mathematician and computer scientist Richard Hamming (1915-1998) expressed the idea as follows:[41]

> Just as there are odors that dogs can smell and we cannot, as well as sounds that dogs can hear and we cannot, so too there are wavelengths of light we cannot see and flavors we cannot taste. Why then, given our brains wired the way they are, does the remark, "Perhaps there are thoughts we cannot think," surprise you? Evolution, so far, may possibly have blocked us from being able to think in some directions; there could be unthinkable thoughts.

The modern version of the argument argues that mere humans will never be able to discover the unity of science since they do not have the cognitive capacities to do so (i.e. the mind is cognitively closed in relation to the problem). Cognitive closure was put forward in its current form by philosopher Colin McGinn (1950-) in 1989 (in relation to the mind-body problem)[42] and was later extended to a wider set of philosophical problems.[43] Given the mind-body problem is a subset of the unity of knowledge problem, it can be inferred that if the mind is cognitively closed to the mind-body problem, then it must also be cognitively closed to the unity of knowledge problem. There is a slightly modified form of this argument that doesn't rely on cognitive closure. It simply says that whilst there is unity of knowledge, it is not accessible to anyone within the universe.

Like the no unity argument, the principal argument in favour of the 'beyond man' thesis is that empirical evidence to date shows that man has been unable to solve the unity of knowledge problem. However, whatever its merits, many philosophers and scientists find the 'beyond man' argument self-defeating and shy away from its mystical elements.

In 2000, philosopher Margaret Morrison (1954-) pointed out that there is insufficient evidence to decide between the unity and disunity hypotheses.[44] There appears to be little point speculating. Instead, the only sure-fire way to resolve the question is to discover the unified theory of the universe.

Summary

For all of recorded history, man has sought a unified understanding of the world. There have traditionally been two interpretations of unity: (i) unity of scientific method; and (ii) unity of nature, knowledge and science. In this work, we are concerned with discovering the unity of nature, knowledge and science. There are three views on the unity of nature, knowledge, and science: (i) there is unity and it will be discovered in time; (ii) there is no unity; and (iii) there is unity but it is beyond man to discover. In this book we hold the first view that there is unity of nature, knowledge and science that we seek to discover.

Before we unify knowledge, we need to understand science: what it is and how it searches for unity bottom-up. This we consider in the next chapter.

Notes and References

[1] Only at the time of the early Greek philosophers did philosophy (the rational view) and art (the emotive view) become distinguished subjects. Prior to this time, they were combined in mythology (see Ervin László [1972], p. 220)
[2] Étienne Klein and Marc Lachièze-Rey [1999], pp. x-xi
[3] Isaac Newton [1692], "Newton to Bentley, December 10, 1692" in Herbert Turnbull et al. (eds.)[1959-1977], vol. III, p. 234
[4] Immanuel Kant [1969], p. 27
[5] Errol Harris [1965], p. 144
[6] Étienne Klein and Marc Lachièze-Rey [1999], book jacket
[7] Brian Greene [1999], p. xii. Lee Smolin [2000], p. 209
[8]A third category, "sociological unity of science" is not considered; it has been dealt with elsewhere, see John Dupré [1993], pp. 221-224
[9] Otto Neurath [1938], p. 1
[10] Otto Neurath [1938], p. 20
[11] Margaret Morrison [2000], p. 22
[12] Karl Popper [1953], p. 209
[13] Peter Galison [1998], p. 782
[14] Ian Hacking [1996], pp. 43, 51
[15] For example, Jan Faye [2002]. For a rebuttal, see Claus Emmeche [2001]
[16] Betty Dobbs [1991], p. 6
[17] Margaret Morrison [2000], pp. 7-11
[18] Albert Einstein [1935b], pp. 136, 141
[19] Herbert Spencer [1910], p. 220
[20] Ian Hacking [1996], pp. 44-45
[21] Niels Bohr [1954], p. 28
[22] Ludwig von Bertalanffy [1952], p. 157
[23] Edward Wilson [1998]
[24] "Divisive ideas on unification", Los Angeles Times, 9 July 1998
[25] Ervin László [1972], pp. 8-9
[26] Nancy Cartwright [1999], p. 1
[27] Steven Horst [2003]
[28] John Dupré [1993], p. 7
[29] Stephen Burwood [2003], p. 256
[30] Jerry Fodor [1974]. Reproduced in Jerry Fodor [1975], pp. 9-25. For a rebuttal, see Jaegwon Kim [1993], pp. 309-357
[31] Kurt Gödel [1931] showed, in his incompleteness theorem, that any precise mathematical system of axioms and rules of procedure whatever, provided that it is broad enough to contain descriptions of simple arithmetical propositions and provided that it is free from contradiction, must contain some statements which are neither provable nor disprovable by the means allowed within the system
[32] Patrick Suppes [1978], pp. 50-54. Others have argued that Gödel's incompleteness theorem undermines the very notion of a complete theory of nature (e.g. Sir Roger Penrose, Freeman Dyson and Hans Moravec in John Horgan [1996], pp. 175, 250, 254)
[33] John Dupré [1983]. See also John Dupré [1993] and John Dupré [1996]. For a rebuttal, see David Davies [1996]
[34] Nancy Cartwright [1994]. See also Nancy Cartwright [1999, 2000]. For rebuttals, see Philip Anderson [2001], Carl Hoefer [2002], Stéphanie Ruphy [2003] and Lawrence Sklar [2003]
[35] Peter Galison and David Stump [1996]
[36] Stephen Hawking [1998]
[37] Steve Clarke [1998]
[38] Auguste Comte [1974], p. 31
[39] Auguste Comte [1974], p. 37
[40] Andrew Reynolds [2002], pp. 7-8
[41] Richard Hamming [1980], p. 89
[42] Colin McGinn [1989]. Reproduced in Colin McGinn [1991], ch. 1
[43] Colin McGinn [1993]. See also Colin McGinn [1999]
[44] Margaret Morrison [2000], p. 235

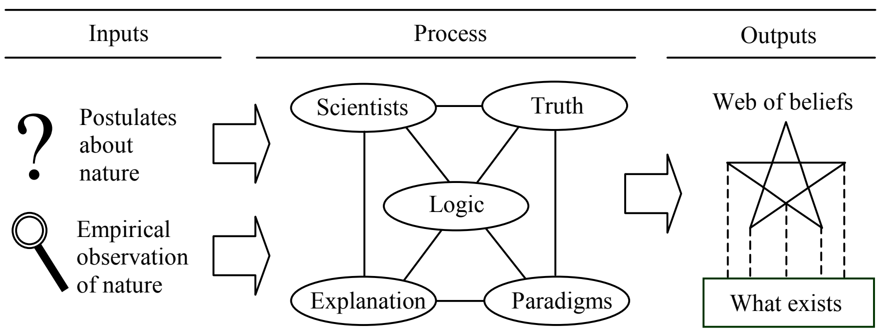
Chapter Two

The Scientific Search

Overview

Science seeks to explain *how* nature works. Other types of questions, such as why and what, may only be answered (if at all) after first understanding *how* nature works. For example, questions such as "Why does the universe exist?" and "What is the universe ultimately made of?" are theological or philosophical questions beyond the scope of quantitative science.

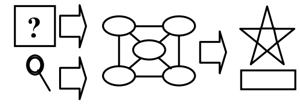
To understand the scientific process, consider the following framework that includes the inputs to the scientific process, the structure of the process, and its outputs.[1]



When a person perceives the world, they perceive it relative to their evolving mental constructs of the world. For example, a mental construct of a tree may enable a person to identify a tree in their sensory input. Compared to the implicit constructs within a person (e.g. of a tree), science builds an explicit, shared, well-defined, conceptual construct of the world. The output of science (i.e. what exists, and the web of beliefs) is this shared construct. Just as a person uses internal constructs developed during their lifetime from experience to perceive the world, mankind is able to use the explicit external construct of science developed over many generations to "better" perceive the world. In this way, a person can leverage the scientific construct of mankind to develop a more thorough internal construct of the world. The process of science, therefore, is all about building this shared, external, conceptual construct of the world.[2]

In the rest of this chapter, each element of the scientific process is considered in turn, beginning with the inputs to the scientific process, then the structure of the process, and finally its outputs.

Postulates about Nature



To begin, lets consider the postulates science makes about nature. There are two groups of postulates: those associated with the:

- Physical world (that may be physically observed by many); and
- Mental world (that may be mentally experienced by each conscious individual).

Science makes five interrelated postulates about the physical world:[3]

- The physical world exists (independent of the mind);
- The physical world is ordered (i.e. open to rational inquiry);
- Science has non-trivial access to the knowledge of (part or all of) this physical world, without destroying its essential structure;
- Within this accessible physical world, there is distinctive subject matter (in whole or part), that can be described and classified;
- Underlying the subject matter are uniformities, regularities, and causal (or relational) structure that science seeks to discover.

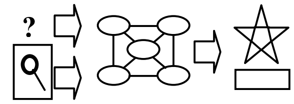
One of the most important postulates underlying the "uniformities and regularities" of the subject matter is the principle that what has happened in the past will (under the same conditions) recur in the future. Another important postulate underlying the "uniformities and regularities" of the subject matter is the principle of general relativity; which states that the general laws of nature apply equally from any local point of reference.[4] Without this principle, every observation of the real world may be unique[5], undermining this postulate.

The postulate of "uniformities and regularities" of the subject matter is used to infer our explanations from observable phenomena to unobserved phenomena; for example, to infer a law of nature founded on observations here on Earth to the entire universe. This is achieved by assuming the laws of nature are *uniform* across the universe. In the same way, a law of nature founded on historical observations may be inferred into the future. This is achieved by assuming the laws of nature are *uniform* across time.

The postulates for the mental world are much the same, with the first postulate replaced by "the mental world exists in conscious animals such as humans" (i.e. you are not the only conscious individual, and you are not the only conscious individual to perceive mental events). The mental world is assumed to exist only for conscious animals since they are the only known living entities that can observe mental events.[6] The different postulates for the physical and mental worlds do not imply duality: instead, they reflect the different methods of observing the subject matter. That is, evidence for the physical world rests on external observation of (or interaction with) physical events whereas evidence for the mental world rests on introspection.

Scientists sometimes introduce additional postulates when the problems are so difficult that it does not appear possible to solve them otherwise. Such postulates include the existence of multiple universes, and the existence of more than four spacetime dimensions. Again, all else being equal, theories that do not require these additional postulates (or extra degrees of freedom) are preferable.

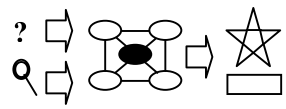
Empirical Observation of Nature



Historically, science emerged from historical philosophy. What distinguishes science from historical philosophy is empirical observation (i.e. experience, experiment or observation, as distinct from theory). Science is the effort to solve problems lying within the scope of empirical, scientific inquiry: whereas historical philosophy is the effort to solve problems lying beyond the scope of empirical, scientific inquiry.

The role of the scientist is to use observation to actively discover how nature works. The scientist is in an active dialogue with nature, *a priori* determining the entities (e.g. "things" or events) to be observed and *a posteriori* updating scientific models and theories based on these observations.[7]

Logic



At the centre of the scientific process is logic (i.e. how to reason). This is not surprising, since science emerged from philosophy and at the heart of the philosophical process is logic. The logic process manifests itself in many ways, for example:

- The logic of abduction
- The logic of the evolving scientific method

Let us consider these in turn.

Logic of abduction

When scientists put forward an explanation of their observations, they do it in a logical manner. The challenge scientists face is that they can only observe the past[8] and present, but not the future. Therefore, whilst their theories may explain the past and present observations, there's no logical deductive method of being sure they predict the future. For example, just because the Sun rose this morning doesn't deductively mean that it will rise tomorrow morning. Therefore, science needs to use induction to foretell the future. The way they do this is to adopt the input assumptions of regularity, uniformity and causal (or relational) structure of the subject matter. Therefore, based on these assumptions, they can inductively assume that what has occurred in the past and present will also occur (in the same manner) in the future.

However, there may be many explanations of the past and present observations. To choose between the explanations, scientists use abduction. Abduction is the deductive method of choosing, among other things, the *simplest* and *least miraculous (inductive) explanation* that *matches* with our *observations*.

The principle of accepting the simplest explanation is called Occam's razor and is named after the British philosopher William of Occam (1285-1349). He argued that the best explanation of our observations is generally the simplest, the one with the fewest assumptions. The principle assumes the universe and nature have an underlying simplicity. Unfortunately, however, it is generally not possible to know when the simplest explanation has been found, the one that represents the most compact possible explanation of the observations.[9] Furthermore, according to

Swiss mathematician John Bernoulli (1667-1748), the explanation needs to be simpler than the phenomena being explained: “In physical science one should banish the practice of explaining phenomena by chimerical principles more obscure than those presented for investigation.”[10]

The principle of accepting the least miraculous explanation is called the doctrine of the lesser miracle. The doctrine was invented by notable Scottish philosopher David Hume (1711-1776) and states that when you have two or more competing hypotheses for a phenomena you should always choose the least miraculous option even it if turns out to be very unlikely. For example, if there are two hypotheses – one of which is based on God and the other on causes – then the causal explanation should be chosen, since it is less miraculous. The doctrine is particularly important when there are more theories than there are observations, in which case, not all theories can be falsified by observation.

Underlying abduction is the deductive method. This method eliminates all the simpler and less miraculous hypotheses (that we find *don’t* match the observations) until we’re left with the simplest and least miraculous explanation that *does* match the observations.

Sometimes it is *not* possible to differentiate between two theories based on Occam’s razor, the doctrine of the lesser miracle and data fit. In this case, scientists resort to aesthetics: the general view of the scientific community on which theory is more “beautiful.” The criterion for “beauty” is typically based on what theoretical attributes have been successful in the past.[11] This creates an in-built conservatism in theory choice, which works well for normal science although it can inhibit revolutionary theories from being readily accepted.

Logic of the evolving scientific method

Since many people let science provide them with their beliefs of the world, science is perceived to be a rigid, objective and methodical process. And, in general, that is the case. However, the scientific method also logically evolves over time, as new thinking is developed.

One of the reasons the scientific method logically evolves is that science (like mathematics[12]) is not self-defining[13] and, therefore, there is no exact answer to what the scientific method should be. Further, at the beginning of science, *all* the foundations, postulates and rules were not known. For example, in 1687 Sir Isaac Newton listed only four “rules of reasoning in philosophy” in his infamous publication, *Philosophiae Naturalis Principia Mathematica* (Newton’s Principia).[14]

Since the time of Sir Isaac Newton science has logically evolved, passing through many eras (or “-isms”): classical empiricism, classical rationalism, idealism, classical positivism, classical realism, pragmatism, logical positivism, logical empiricism, falsificationism, historical relativism, historical empiricism, scientific realism and reliabilism! In many cases, these ideas have been developed by philosophers and have had less impact on scientists – who, unaware of the philosophical issues, continue on in a logical manner “doing” science.