Naturalized Philosophy of Science, History of Science, and the Internal/External Debate

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Philosophers have long stressed a distinction between theory justification and theory discovery based on a belief that justification and discovery are essentially different processes. What makes these two processes essentially different, it was assumed, is that the process of justification is guided by criteria which are expressable as rules, while the processes involved in discovery are not rule-guided. Moreover, and perhaps more importantly, it was assumed that the rules for justification are discoverable a priori by rationalistic logical analysis but an account of discovery, whatever it turns out to be like, will be describable only a posteriori. Philosophers who have assumed that rules for justification are discoverable a priori but that patterns of discovery are not, have also argued that the process of discovery may be historically and psychologically and sociologically interesting, but not philosophically interesting since it is not subject to a logical analysis which will yield a statement of necessary or even sufficient conditions for theory generation. An a priori, logical analysis of justified theory acceptance in science is possible because such conditions are free from the contextual factors which plague discovery.

The perceived failure of philosophers to provide an account of rules for rational theory choice and theory justification has paralleled an increased philosophical interest in the history of science. Why should this be so? The demand for a system of rules was a demand for criteria which would be unchanging, essential to the scientific enterprise, transcontextual, and discoverable a priori. The failure to provide adequate rules which had these properties and, at the same time, by arguments that there could be no such rules has encouraged many philosophers to conclude that there are no unchanging, essential, and transcontextual rules which are discoverable a priori (Kuhn 1970 and Shapere 1984).

One very strong and appealing argument against the possibility of a priori rules might be called "the argument from the naturalized turn". For the theoretician of science, the "naturalized turn" can be understood in the following way. Let us take as our example the problem of understanding the nature of theory change in science (though I assume that the discussion which follows can be generalized to the problem of understanding the nature of discovery, etc.) One can ask at least two

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sorts of questions about theory change in science. One, how ought theory change proceed in order for scientific goals to be achieved? Two, how has theory change proceeded in the past? I take it that the first question is a normative demand for ideal rules for theory change and that the second question is a demand for description. Of course we might also question whether theory change in the past (descriptive) has proceeded in the way it ought to have in order for scientific goals to be achieved (normative). According to the traditional philosophical view, the first question forms part of the proper domain for philosophy of science, and perhaps more importantly, the proper method for answering that question is a priori conceptual analysis. The second, descriptive question forms part of the proper subject for historians of science, and their methodology is historical description of what has been the case. Given this division of labor, projects, and methodology, no relation between their answers could be expected. Since the philosophical project is normative, while the historical project is descriptive, there is no reason to expect that theory change, for example, has proceeded in the way it ought to have proceeded, though in those particular cases where it has we will be able to judge that the goals of science have been furthered and that science is (has been) rational. But no relation is entailed. Given this division between history and philosophy of science, we may find, for example, that theory change has never proceeded in the way it ought to have proceeded.

The "naturalized turn" commits one to the rejection of the claim that the proper philosophical method is a priori conceptual analysis. One assumption of the naturalized turn is that philosophers do not and cannot have any presupposition free vantage point from which they can make a priori discoveries. Any discovery at all, of any kind, can come about only through empirical investigation and by using the best evidence and theories which the sciences have to offer. Then, since philosophers do not have privileged access to normative truths, any answer to the normative question is going to have to come through the only other available methodology, this sort of a posteriori methodology, specifically beginning with an historical analysis of particular cases. This conclusion amounts to the claim that the philosophical question cannot be answered independently of the descriptive, historical question. Now some relation between the philosophical project and the historical project is entailed, though it remains an open question as to the nature of this relationship. One option is that the normative project completely reduces to the descriptive project. Another option that I have argued for is that while both history and philosophy of science begin with case analysis, their projects and goals are different, with the result that history and philosophy of science operate at different though complementary levels of generality.

The breakdown of the demand for a priori rules for theory justification has precipitated a breakdown in the distinction between (the context of) justification and (the context of) discovery (Nickles 1984). Justification cannot be distinguished from discovery on the basis of amenability to a purely logical analysis. If so, then if historical, psychological, and sociological factors plague discovery, they very well might plague justification. But here we come to the core of the matter for this paper. What sort of analysis of discovery is possible?

Many demands of an account of theory justification and an account of discovery are the same. For this reason, there may be some profit in seeing discovery and justification as two phases in a more general process of theory development. What factors are (were) the important ones in the development of particular scientific ideas? Do we find any general patterns, if not rules, for theory development which appear after theorists of science examine particular cases? We recognize from the start that we may find patterns which are not rules, i.e., which are neither necessary nor sufficient for theory development.

Where does the historiography begin? As historian Robert Westman has remarked, successful history will be involved with "...finding out what the actors themselves took to be evidence, finding out what they believed and what traditions they were plugged into [and] reconstructing the temporal sequence of moves made in a scientific discovery..." (Nickles 1984, p. 43). Yet this account of the spirit of the theoretic enterprise, while certainly capturing the spirit of much current work, including this paper, is itself controversial for it allows that an agent's evidence in new theory development may consist of factors and reasons from observation and experimentation as well as from the social and political and psychological context.

For some time historians of science, and more recently philosophers of science, have placed the important factors in theory change and development either internal or external to science proper. An internal factor is one which involves the constraints of observation, the specifically theoretic content, or mathematical or experimental tools. A factor is external to science proper when it involves scientists' activities as members of a larger cultural setting, which might be, for example, social and economic conditions prevalent in the culture, or the psychology of the specific agents. Historians such as Rupert Hall and Alexander Koyre argue that only ideas and problems internal to science effect rational theory development (Basalla 1968). On the other hand, externalist historians such as Boris Hessen, Robert Merton, and Joseph Ben-David argue that economic, religious, and technological factors determine the rate and direction of theory development, though they would not argue that theoretic content is so determined (Basalla 1968). More recently, proponents of the "strong programme" of social constructivism argue that external factors influence the content of scientific theory, from its concepts to experimental results and interpretations thereof (see Mulkay 1979, for example)

Most philosophers since and including the logical positivists have sat squarely in the internalist camp. Imre Lakatos, for example, argues that "...philosophy of science provides normative methodologies in terms of which the historian reconstructs 'internal history' and thereby provides a rational explanation of the growth of objective knowledge." (Lakatos 1971, p. 107). And while Lakatos recognizes that a rational reconstruction of history needs to be supplemented by an external history, the "rational reconstruction or internal history is primary, external history only secondary, since the most important problems of external history are defined by internal history." (Lakatos 1971, p. 124). In addition, Lakatos argues that internal history is primary, external history only secondary, because the former exhausts the rational aspects of scientific growth. But internal history "cannot be comprehensive since human beings are not completely rational animals." (Lakatos 1971 p. 119). Thus external history is required in order to explain the irrational aspects of theory change.

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For Lakatos, the internal/external distinction is cashed out in terms of what is inside a research program and what is outside of the same. A research program, which consists of a hard core of articulated statements which describe theory and a positive heuristic, is autonomous from the subjective beliefs and personalities and social circumstances of which it is a product. This autonomy is what allows for a purely internal and objective history of theory change. The positive heuristic, which defines problems, outlines the "construction of a belt of auxiliary hypotheses foresees anomalies and turns them victoriously into examples..." is internal to the research program and therefore also part of what is rational in science. (Lakatos 1971, p. 116). So what we see in the Lakatosian account of scientific research programs is a way to slash broad philosophical distinctions between what is internal/external to science and, thereby, what is rational/irrational in theory change.

Philosophers of science who have rejected the Lakatosian project of finding an absolute internal/external distinction and an absolute and essentialistic characterization of rationality may still argue that, relative to specific contexts, it is possible to locate a viable internal/external distinction and, therefore, a notion of good reason... . Along these lines Shapere has argued that "...science attempts to become autonomous in its reasoning, to rest its arguments solely on 'internal' considerations, and this goal has been adopted because science has been able to achieve such autonomy to a considerable extent, and has found it possible to achieve great success by making its reasoning rest autonomously on considerations [relevant to its own domain]." (Shapere 1984, p. xxxviii). According to Shapere, there are no considerations or factors which are absolutely and irrevocably internal to science. As science develops, considerations or factors are discovered to be relevant, and these considerations are then internalized. "This process employed by science... I call... the internalization of considerations. It is in essence the development of the rationality of science, of what it is for an argument to constitute scientific reasoning." (Shapere 1984, p. xxiii). Thus, Shapere also equates internality with rationality. But for Shapere, contrary to Lakatos, the internal/external distinction is dynamic and changeable, though specifiable for any stage of scientific development. Internal factors are not determinable a priori, but are context free. "That process, which is essentially one of gradually distinguishing the scientifically relevant from the irrelevant and the unscientific, of gradually demarcating science from non-science, is an ideal we have learned to seek, but is far from fully achieved." (Shapere 1984, p. 340). Thus Shapere and Lakatos agree, though for different reasons, that the internal/external distinction enables us to slash broad philosophical distinctions between what is science and what is not, and between reasons which are good (internal) and those which are not (external). For both, and this I want to stress, external factors have no role in a description of a rational process of discovery.

Recently, historians of science B. J. T. Dobbs and R. Westfall have examined newly available manuscripts which throw Sir Isaac Newton's life and work into new relief. They have found that Newton's natural philosophy was of a piece with his Neo-platonism, Arianism, and his alchemical investigations. If we assume the sort of internal/external distinction suggested by Shapere, then this new material and new

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interpretation of Newton illustrates how the good reasons involved in theory development may include reasons which are both internal and external to natural theory. If a robust account of theory development requires an explication of the role of internal and external factors, then any purely internalist account will fail to provide an adequate understanding of theory change. In particular, according to an internal/external distinction such as Shapere's, any relevant factor which is necessarily external for a given period is also necessarily irrational for that period. As we shall see, since Newton appealed to alchemical and Neoplatonic reasons, which were external reasons given Shapere's division, Shapere would incorrectly conclude that these are irrational reasons. I want to argue that while Newton did appeal to external factors he would not be considered irrational for having done so. Therefore, contrary to Shapere's view and others like it, external factors cannot be equated with the introduction of irrational elements. If it can be convincingly argued that Newton's reasons from alchemy and neoplatonism are both external and rational, the external= irrational equation would be broken. Moreover, it will not do for Shapere to admit any reason we point to as a good reason, hence internal, for than the internal/external distinction he wishes to advance, would collapse.

Lastly, I suspect that the patterns of reasons and reasoning in theory development found upon examination of historical cases, as the Newton case will illustrate, will reveal a complex set of internal and external reasons operating conjointly. To argue that some of these reasons are irrational or rational merely because they are external or internal begins to sound exceedingly arbitrary.

There is no doubt that Newton's alchemical investigations have presented a problem for a reconstruction of the reasons that Newton's natural philosophy developed in the way that it did. The problem of whether to place Newton's alchemical beliefs internal or external to legitimate theory (science) presses traditional internalist theorists who have equated internal history with rational history. If understood as an activity external to science, Newton's alchemy presents an obstacle for the claim that reconstruction of the development of Newton's philosophy requires only internal history. Moreover, given the above equation of internal history with rational history, the influence of external factors on internal theory becomes tantamount to recognition of an irrational element in Sir Isaac.

If the confines of internal history are expanded so as to include whatever reasons Newton in fact had for his natural theory, then the alchemical investigations should be classed as part of internal history, since, as I will show, Newton's alchemical beliefs affected the content of his natural philosophy. But, if internal influences are interpreted to include whatever influences were historically present, then the internal/external distinction becomes a meaningless distinction having no illuminating bite for the problem of describing theory development. Being free of traditional attempts to draw an internal/external distinction would be no great loss, and would have some definite advantages. In particular, theorists of science once free of the internal/ external distinction might be less inclined to attempt to reconstruct theory change and development in terms of what has been rational or irrational. And philosophers may be less inclined to seek grand unified theories of rationality.

While at Cambridge in the early 1660's, Newton was trained as a mechanical philosopher. At that time that meant that Newton read Descartes as well as Gassendi, Hobbes, Digby and Boyle. These natural philosophers proposed that 1) all events could be explained by matter in motion, and that 2) motion is understandable in terms of bits of matter acting on each other by impact and pressure. Using these assumptions, the mechanical philosophy could explain not only gravity and cohesion of particles, but it could do so without positing occult forces acting at a distance. By 1668, when Newton wrote "De Gravitatione et equipendio fluidorium", he was clearly disenchanted with Cartesian mechanics. In "De Gravitatione" Newton argues for a Gassendist atomism (and against a Cartesian plenum) and for the claim that matter has active principles (and against the passivity of mechanical matter). This latter argument is especially interesting for the concerns of this paper.

Natural philosophers of the time were concerned to explain the fact that matter is able to move itself. According to Descartes, an explanation for the fact that matter can move must be given entirely in terms of bits of matter colliding with other bits of matter. But, Newton reasoned, if this were so, then matter would be the source of its own motion, i.e., no other agency would be required for motion and, in particular, God would not be required in order to explain motion. Perhaps the God of a mechanical universe would still be required in order to explain how matter was initially put into motion, but God would not be needed in order to explain matter's continued motion. Recognizing this implication of mechanical philosophy, Henry More quips that God would become analogous to an "absentee landlord". The implied atheism was unacceptable to Newton.

Matter is passive and cannot be the source of its own motion. Then how is continued motion possible? Newton came to believe that the universe is composed of passive matter which is informed by active principles. The posit of passive matter would have been acceptable to any of Newton's mechanical predecessors, but the notion of active principles which allow a mechanistically unexplainable process of action at a distance would not have been acceptable and marks Newton's break from mechanics.

The following brief history will trace the sources of Newton's concept of active principles and the role of active principles in his natural philosophy. I believe that the historical evidence shows that Newton's active principles represent a convergence of Neoplatonic, theological, and alchemical beliefs, and that it was from his concept of unquantifiable active principles that he developed his concept of quantifiable force.

Newton appears to have been introduced to alchemy at Cambridge in the late 1660's by a group of followers of the late Samuel Hartlib. Hartlib, as his followers, believed that alchemy could be used to yield up nature's secrets, and with this belief they engaged in alchemical investigations and circulated alchemical manuscripts. Newton came to believe that alchemy could be used to make discoveries about the natural world as, or more, strongly than those he followed. Dobbs claims that

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"Newton looked for no less than the structure of the world in alchemy-- a system of the small world to match his system of the greater." (Dobbs 1975, p. 88).

But why would Newton use alchemy as an investigative device? Both the Hartlibians and Newton assumed that God had revealed natural and theological secrets to a select few in antiquity, and that the holders of this natural and theological knowledge had encoded these truths in fables and mythical language as their legacy to the world. They believed that the mysterious and symbolic language of the alchemical tradition concealed theological truths (prisci theologi) and natural knowledge (prisca sapientia) from the vulgar and they also believed that these secrets would be revealed to the initiated who worked hard enough to get them. Not only did Newton hold these beliefs at the beginning of his Cambridge career, but he maintained these beliefs throughout his life. This is evidenced as late as the Opticks. (Newton 1704, pp. 405-406).

At the same time (late 1660's) Newton's initial interest in chemistry had given way to his sustained interest in alchemy. Newton expected that through alchemy he would find the forces which govern the motions of small bodies. He would then be able to unite the gravitational motion of large bodies with an account of small bodies and thereby preserve his assumption that causes operate in the same kind of way in all phenomena. But Newton also believed that an acceptable account of natural forces would unite natural philosophy and theology. If Newton could provide such an account he would thereby resolve the problem which was a major impetus for his rejection of Cartesian mechanical philosophy. Newton believed that his account of natural motion in large and small bodies should confirm God's presence in the natural world.

Newton expected that the forces which govern matter in general and small bodies in particular would have properties which would be acceptable to an alchemist. Newton was familiar with the work of Digby and Boyle (Dobbs 1975), and both claimed that there is one universal matter which is capable of transmutation, a process which results in changes in primary qualities. The process of transmutation, or vegetation, was believed to be present throughout nature, most obviously in plants and animals, but also in metal, and reveals a soul or active spirit in nature. When activated the vegetative or active spirit results in a process of growth (Westfall 1975). For metal, the final end of growth and transmutation is gold; all other metal properties occur as metal vegetates and grows toward that end. The alchemists believed that vegetation and transmutation were duplicable in the laboratory setting by freeing the active spirit.

In "De Gravitatione", a non-alchemical work mentioned above, Newton describes bodies as composed of active spirit and passive matter. Approximately one year later, in 1669, Newton wrote a sketch known as The Vegetation of Metals in which he uses "De Gravitatione's" central concepts of active spirit and passive matter, and has them appear in an explicitly Neoplatonic, alchemical guise. In the alchemical sketch, Newton describes not only how vegetation is the same in animals, plants, and metals, but also how vegetation is the effect of a Neoplatonic Universal Spirit. And like other Neoplatonists, Newton posits a cosmology in which the Universal Spirit is the soul of the world. The earth

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breathes in the Universal Spirit emitted by the Sun, uses it such as for vegetation, and exhales it. The exhaled vapors rise into the 'aire', to become aether, and by this rising, forces other aether to descend. The earth and its surroundings are thus seen almost as a living animal, breathing and circulating Universal active spirit (See Westfall 1980, pp. 304-305 and Newton 1687, p. 542).

Thus Newton, engaged in alchemical investigations, can be understood to be engaged in an attempt to reveal the vegetative powers of the Neoplatonic spirit. The current literature suggests that Newton believed that the Universal spirit which is active in vegetation and transmutation might be just the non-material active spirit which Descartes' mechanical philosophy needs in order to explain matter and motion. Newton would not be alone in this belief. Isaac Barrow, also at Cambridge and long-time friend of Newton's, also objected to Descartes' mechanical philosophy on the grounds that it was missing something immaterial to direct the motion of matter (Dobbs 1975, pp. 95-102). Barrow believed that the Neoplatonic Universal spirit was that immaterial and active something which passive matter required for motion. Thus Newton, and Barrow, seem to have derived their ideas about a Universal active spirit from Neo-Platonic alchemy, and then after some modifications, attached these ideas to mechanical natural philosophy.

In 1675 Newton wrote a letter to Oldenburg which came to be called "An Hypothesis Explaining the Properties of Light". This is Newton's first work to show a synthesis of the Neoplatonic Universal spirit, Boyle's alchemical universal matter, and mechanical philosophy (Dobbs 1975, pp. 204-205). The product of this synthesis is a mechanistically describable material aether which, Newton believed, could be used to explain vegetation and gravity, attraction and repulsion, among other natural phenomena. The material aether, like Neoplatonic 'aire', was the stuff which condensed to form material bodies and was the active spirit for transmutation, serving the needs of the living relationship between earth and the celestial bodies. For example, gravity was to be explained as the pressure which resulted from the descending aethereal shower.

But Newton soon found he had to reject the notion of a material aether for two physical reasons. First, suppose one grants that gravity is the result of the aether shower. But, if aether is itself composed of particulate matter, as supposed, then a cause is needed to push these particles downward. Newton had no solution and saw the regress. Second, Newton argued that if aether exists, it should offer more resistance to the internal parts of bodies than to their surfaces. But experiments conducted with pendulums showed that there was no resistance to internal parts. Newton was forced to abandon the material aether (Dobbs 1975, pp. 210-211).

By the time of the Principia in 1687, Newton is left with the quantifiable and mechanistically describable forces of gravity, attraction, and repulsion. These forces, like matter and motion, are ontologically respectable because they are quantifiable and explanatory. Gravity explains the cohesion between planets and stars; attractive forces bind particles, though the medium for these forces is now vapor, and not material aether. (Newton 1687, p. 542). Newton never rejected the active forces which he posits in the Principia.

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Even in the Opticks, Newton posits ultimate particles of matter, and space between them, which are attracted and repulsed by active principles.

Will these active principles explain the process of transmutation and vegetation? Newton continued to believe that all speciated matter is generated by condensation from some universal material. After rejecting the material aether, by the time of the Principia he attributed this function to the vapors produced by the sun, stars, and comets. (Newton (1687, p. 542). And by the writing of the Opticks, these functions performed by the vapors seem to have been replaced by light. (Newton 1704, qu. 31).

The Neoplatonic, alchemical concept of an active spirit which directs transmutation and growth would have been attractive to Newton for another reason. One of Newton's objections to mechanical philosophy, mentioned above, was that, if correct, the workings of the natural world would not require God as an active participant. This sort of atheism was not acceptable to Newton, who believed that the natural world could be investigated as a way of understanding God. Of course if God were not active in nature, then one could not do this. But how can God operate in a mechanically describable universe?

B. J. T. Dobbs (1982) makes the following suggestion: Newton believed that the Neoplatonic alchemical universal active spirit was the agent by which God acts. It has already been suggested that Newton saw alchemy as a means for investigating the behavior of forces acting on small bodies. But, if Dobbs is correct, alchemical investigation takes on an additional theological significance. If alchemical investigations could be used as a means for demonstrating the operations of the non-mechanical vegetative spirit, and if active spirit is God's agent, then one was thereby demonstrating God's action in the world.

Dobbs suggests that Newton believed that God's agency in the physical worlds is mediated through Christ. "Christ is the viceroy, the spiritual being that acts as God's agent in the world, a very unorthodox Christ indeed but one whose many duties keep him engaged with the world throughout time. A part of his function is to insure God's continued relationship with his creation; Newton's God is in no danger of becoming an absentee landlord, for he always has the Christ transmitting his will into action in the world." (Dobbs 1982, p. 527). God cannot directly interact with the natural world since he transcends all natural things. But Christ who is not of the same substance as God can serve the cosmic function of directing God's will into the passive matter of natural bodies. From an alchemical point of view, Christ is the active spirit which is required for transmutation and growth. From a Neoplatonic point of view, Christ is the Light.

Newton posited active forces not merely because of their experimental and explanatory success, though these are surely factors. His ideas developed in the way they did also because of his Neoplatonic and alchemical beliefs, and these beliefs in universal matter and universal spirit served as reasons for his natural philosophy.

Yet these reasons are not all reasons which have only to do with observations , experiment, and theoretic content... They include reasons available from the wider cognitive setting. Nonetheless, merely because these latter reasons are external does not by itself mark them as irrational. Nor do Newton's internal reasons, from the mere fact that they are internal, mark them as rational. We can surely imagine experimental results being used in a way which would not further the goals of science. So, in conclusion, it appears that theoreticians of science, historians and philosophers and sociologists alike, would benefit in their naturalized studies of science by rejecting the claim that only internal reasons mark rational science.

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