Michael Polanyi and the History of Science

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ABSTRACT

This essay is a study of Polanyi's career as scientist and philosopher from the point of view of the history of science, starting with the first step in his academic career helped by an intervention of Albert Einstein. Polanyi's ideas are better understood if placed against the background of then-fashionable philosophical movements, including logical positivism, and his disagreement with Bukharin in 1935. The essay studies the sources and ambitions of Polanyi's notion of the tacit dimension, his attitude to evolution and "emergence," and his contribution to the search for the origins of Einstein's Relativity Theory. His success in the last of these is shown to be an exemplar of Polanyi's own philosophy.

Biographical Background

I have been asked to talk about Michael Polanyi's career as a scientist and philosopher from the point of view of history of science, and also his contribution to the history of science. But in order to arrive at my conclusions, I shall have to make some excursions also into other fields, such as the branches of politics and epistemology that were fashionable during his career. For it is fair to say that Polanyi, or as he was named at his birth in March l89l in Budapest, Mihaly Polanyi, was a unique person in the history of science, not least in the spectrum of his interests. The *Dictionary of Scientific Biography* lists his professional fields as chemistry, philosophy, and sociology.

The early family upbringing must have counted greatly in the eventual choice of his ideological direction. His parents' home was a place for "regularly held literary gatherings that attracted the leftist intelligentsia, some of them Marxists."[1] Moreover, the three children of the family joined left-wing youth movements at an early age. But as in the

case of so many central European intellectuals, the subsequent course of history radicalized Michael against authoritarian political movements.

He went on to study medicine at the University of Budapest, graduating just a year before World War I. Even before obtaining his diploma, he was publishing in chemistry, and although qualifying as a physician, he also earned a Ph.D. in chemistry with a thesis on thermodynamics. In the Albert Einstein Archives is a considerable amount of Einstein-Polanyi correspondence. It begins with a letter of January 30, l9l3 from Zürich, by Einstein to Professor Bredig in Karlsruhe, who had been unable to judge Polanyi's thesis on entropy at high pressures, and who had sought advice on it from Einstein. The latter responded, "The publications of your Herr Polanyi please me very much." Einstein had checked them and found them altogether useful and full of fortunate thoughts. (He only wished that it had been done at less length.) Then follows a series of handwritten letters to Polanyi, in which Einstein does find some points of disagreement on matters of thermodynamics. But they clearly speak as equals. M. Polanyi's son, John C. Polanyi, later noted that Polanyi's first scientific paper was published on Einstein's recommendation, adding, "it really marked the first step in my father's academic career."[2]

Polanyi's interest in the history of science was perhaps triggered by the personal experience of many historic episodes. When he presented his theory at a meeting in Berlin, at which Einstein was another participant, his theory was rejected, and it took more than a decade until his views began to gain acceptance. Eventually, Polanyi became a researcher at the Kaiser Wilhelm Institute for Physical Chemistry in Berlin, where he developed his best-known work on dislocation theory. Leaving Germany when the Nazi party seized power in l933, he became Professor of Physical Chemistry at the University of Manchester, where he continued a period of high achievements in physical chemistry. But perhaps under the pressure of contemporary history, his interest turned to the social sciences, and he resigned his professorship in l948 to move to a chair in social studies. After his retirement in l958, he continued his researches in the sociology and philosophy of science at Merton College, Oxford.

Two Sources of Polanyi's Approach

To understand the animus of his philosophical-sociological views, one must remember that throughout most of his career as a scientist, a main model for philosophy of science for the scientific community came from the writings of logical positivists or logical empiricists, who in their most extreme writings seemed to say that science is based only on sense data and that all questions that cannot be subjected to tests in the laboratory are meaningless. But Polanyi's own work had convinced him that while objective knowledge is the basis of science as transmitted within and by the scientific community as a whole, during the nascent period of the individual scientist, he or she draws on resources quite different from those that follow the logic of justification of proven achievements. Some prominent philosophers thought otherwise. Thus in a passage quoted by Polanyi, Hans Reichenbach, in the essay "The Philosophical Significance of the Theory of Relativity," had written that "the philosopher of science is not much interested in the thought processes which lead to scientific discovery; he looks for a logical analysis of the completed theory, including the relationships establishing its validity. That is, he is not interested in the context of discovery, but in the context of justification."[3] To be sure, Reichenbach at once modified this severe judgment by adding "but the critical attitude may make a man incapable of discovery; and as long as he is successful the creative physicist may very well prefer his creed to the logic of the analytic philosopher." Yet, one should also note that no sooner had he made this generous

gesture he followed it up by writing: "The philosopher has no objections to a physicist's beliefs so long as they are not advanced in the form of a philosophy."[4]

To all this, Polanyi opposed the value of what he called "tacit knowledge," the "personal notions and concepts" that are essential for progress and motivating, but that may be neither sanctioned by the scientific theories of the moment nor even always fully known to the creating scientist. I shall have much to say about this later, including the surprising test of the concept. But Polanyi went further by also opposing reductionism, the widely-held conviction that ultimately all biological and social phenomena will yield to the primacy of explanation in terms of mathematics, physics and chemistry--and one should add that since the triumph of quantum mechanics most physicists would say that chemistry itself is just that part of physics which really works.

Another, if I may say, radicalizing event in Polanyi's life appears to have been his visit to the Soviet Union in the mid-l930s, where, he later wrote, he first encountered questions of philosophy. During a discussion with Bukharin in Moscow in l935, Polanyi was especially appalled by the concept of "planning and guidance of scientific research,"[5] and returned from the trip eager to devote himself to work on behalf of the freedom of scientists to choose the content, subject and means of their work. Thereby he ran head-on into the opposition from the then strong movement in the United Kingdom, led in the opposite direction by such well-known scientists as J. D. Bernal, J. S. Haldane, and P. M. Blackett. The Society for the Freedom of Science, which Polanyi founded and which attracted many adherents in this country also (for example, P. W. Bridgman at Harvard), was no match.

In fact, with the explosion of research opportunities in the post-World War II era, the support system in most countries in the West showed itself capable of providing scientists with the necessary elbow room for the pursuit of their own ideas. But during the pre-World War II period in Britain, the prevalence and distinction of ideas expressed by scientists with Marxist leanings was reinforced by a famous conference on the history of science held in the early l930s, in which a number of Soviet scholars made presentations. The most impressive and memorable among them was Boris Mikhailovich Hessen, who published a work entitled "The Social and Economic Roots of Newton's *Principia*." In it, he followed the demand of Friedrich Engels, whose views on the history of science were the most commanding element in his whole approach. I should inject here that when I visited China a few years ago to give some lectures on the history of science under the auspices of the Chinese Academy of Sciences, I found that for most Chinese scholars the one basic work in the history and philosophy of science was still the set of notes Engels had prepared for himself in the period between l873 to l882, published in l927 under the title *Dialectics of Nature*. To Engels, in his words, "A single achievement of science like James Watts' steam engine has brought in more for the world in the first 50 years of its existence than the world has spent on the promotion of science since the beginning of time."[6] Science itself should thus be examined in the light of Marx's theory of historical materialism. As Engels had put it, "It is not the consciousness of men that determines their existence, but their social existence that determines their consciousness."[7] And Engels added, "From the very beginning the origin and development of the sciences has been determined by production."[8]

In this spirit, Hessen, on British soil, attacked the very icon of abstract science in the form of Sir Isaac Newton, and proclaimed, as he put it, "the complete coincidence of the physical thematics of the period, which arose out of the needs of economics and technique, with the main content of the *Principia*."[9]

Toward the Tacit Dimension

Opposition to such currents of thought, accepted in the l930s more widely in the West than we now may believe, surely determined Polanyi's motivation in large part. His visit to the Soviet Union, of which I spoke earlier, provided a force in the same direction. To document this, I can do no better than quote a part of Polanyi's introduction to his book, *The Tacit Dimension*, which he completed while a visitor at the Center for Advanced Studies at Wesleyan University in April l966. There he bared to us his soul in these words:

> I was struck [during the discussion with Bukharin] by the fact that this denial of the very existence of independent scientific thought came from a socialist theory which derived its tremendous persuasive power from its claim to scientific certainty. The scientific outlook appeared to have produced a mechanical conception of man and history in which there was no place for science itself. This conception denied altogether any intrinsic power to thought and thus denied also any grounds for claiming freedom of thought . . . .
>
> My search has led me to a novel idea of human knowledge from which a harmonious view of thought and existence, rooted in the universe, seems to emerge.
>
> I shall reconsider human knowledge by starting from the fact that *we can know more than we can tell*..[10]

You see here in the italicized phrase the head-on attack against the instrumentalism of the positivists who, since the time when Galileo made the division between primary and secondary qualities, declaring that we can know for certain only what can be rendered in quantifiable, shareable terms. And it is also a confrontation with the Wittgensteinian positivism which, in the last sentence of the *Tractatus* declares that whereof we cannot speak, thereof we must be silent--the implication being, of course, that such things are not worth talking about.

Perhaps I should be permitted here a brief digression of a personal nature. I came to know and like Michael Polanyi during the last two decades of his life, when he often visited the United States. He was of course always very gracious to younger colleagues; but we also shared a reaction against the more extreme form of positivism--although in those post-World-War-II decades, the Vienna Circle type of positivism had become ameliorated by taking interest in sociological, psychological, and historical components, and had moved away from the strict form that characterized its early phase. Although I was a doctoral thesis student of Bridgman who was often called the father of operationalism, and also was then a younger colleague and teaching assistant to Philipp Frank--the biographer of Einstein and one of the main movers of logical empiricism--I discovered through the study of the history of science that the model of science in terms of observable phenomena and the logic of analysis and mathematics alone by no means accounts for creation, discussion, acceptance, rejection, and ultimate fate of any scientific advance. There is a distinction between two meanings of science: science, let us call it S_1, which is the personal stage of science; and science S_2, that part of science which becomes the corpus that gets into textbooks as current, public science.

This distinction became particularly clear to me while assembling and studying the archives of Einstein at Princeton, from the mid-l960s on. Therefore in my experience I found myself also needing to go to a way of thinking about the growth of science which would add a dimension to the logical-analytic and the phenomenomic dimensions. In my case I opted for including a third dimension in the study of the origins of scientific thought, the thematic one.

That is not the subject of my talk; but it indicates why I had sympathy for Polanyi's wish to escape from a two-dimensional view of science.

But to return to Polanyi's presentation of *The Tacit Dimension.* Immediately after the passages which I quoted, ending with the point that "we can know more than we can tell," he adds, "This fact seems obvious enough; but it is not easy to say exactly what it means." And he gives the example of pattern recognition--for example, the recognition of somebody's face-- which, he might add nowadays, clearly is so idiosyncratic an activity that we can't teach it (yet) to a computer.

Polanyi tries to make it plausible that one can know and act on what one cannot tell by referring to Gestalt psychology. He refuses to think that Gestalt psychology can be reduced to the disposition of impressions on the retina or the brain. Rather, to him Gestalt is "the outcome of an active shaping of experience performed in the pursuit of knowledge. The shaping or integrating I hold to be the great and indispensable tacit power by which all knowledge is discovered, and once discovered is held to be true."[11] And it is not only perception which is an instance of tacit knowing. More generally, "our bodily processes participate in our perceptions";[12] and once we understand that this is the case one can "throw light on the bodily roots of all thought, including man's highest creative powers."[13]

This is analogous to Dilthey's and Lipp's teaching that there is an empathy or in-dwelling required for a proper knowledge of man and the humanities, an aesthetic appreciation that may not be possible to render directly in language. Polanyi believes the same to be the case for the natural sciences also.

> To rely on a theory for understanding nature is to interiorize it. For we are attending from the theory to things seen in its light and are aware of the theory, while thus using it, in terms of the spectacle that it serves to explain. This is why mathematical theory can be learned only by practicing its application: its true knowledge lies in our ability to use it.[14]

Formalizing all knowledge, "to the exclusion of any tacit knowing," which is the aim of those who hold to the model of "strictly detached objective knowledge...", is "self-defeating, for in order that we may formalize the relations that constitute a comprehensive entity, for example the relations that constitute a frog, this entity, i.e., the frog, must be first identified informally by tacit knowing."[15] And Polanyi adds that the most "striking concrete example of an experience that cannot possibly be represented by any exact theory" is simply "the experience of seeing a problem, as a scientist sees it in his pursuit of discovery."[16] What you need most at that stage is "the intimation of something hidden, which we may yet discover." It is this "tacit foreknowledge of yet undiscovered things"[17] which provides the sometimes passionate motivation to uphold a direction of work or a theory against heavy pressures from the outside.

Elaboration and Responses

This approach has two results. One is that he is in head-on conflict with Karl Popper, by severely disagreeing with Popper's doctrine that "The scientist is not only indifferent to the outcome of his surmises, but actually seeks their refutation."[18] Polanyi responds, "This is not only contrary to experience but logically inconceivable. The surmises of a working scientist are born of the imagination-seeking discovery. Such effort risks defeat, but never seeks it. It is in fact his craving for success that makes the scientist take the risk of failure. There is no other way."[19] Obviously, a working scientist is speaking here.

The second result is that Polanyi touches here, without saying so, on the very old problem of how major discovery is possible in the first place, given the obvious, severe limitations of the human mind, faced with the infinitude of natural phenomena and their connections. Einstein himself tried to answer it in l9l8 with the daring suggestion that our minds are guided by "what Leibniz termed happily `the preestablished harmony'."[20] You will recall that Gottfried Wilhelm Leibniz had postulated that our ability to discover the laws concerning material bodies is one aspect of the unity from which God created the two apparently separate entities of the universe, the spiritual and the material. Each of these obeys its own laws, but they can interact in sympathetic unison, somewhat in the way one string instrument goes into resonance and picks up the sounds made by a second one which is tuned to it. Or to use Leibniz's own words to explain this possibility of harmonious interaction, in which he uses an image that must have delighted Einstein, "the souls follow their laws and the bodies follow theirs, but nevertheless these two beings of entirely different kind meet together and correspond to each other like two clocks perfectly regulated at the same time. It is this that I call the theory of preestablished harmony."

In the early l9th century, the Danish physicist Hans Christian Oersted also struggled with this problem; in his way of reading Immanuel Kant, which was typical for the *Naturphilosophen*, Kant's insistence that phenomenal facts are not things in themselves but mere appearances, culminated in the warning that the study of these appearances and the connections between them are an interaction not with nature but with one's own mind. As Kant had put it in the *Critique of Pure Reason*,

> That nature should direct itself according to our subjective ground of apperception, and should indeed depend upon it in respect of its conformity to law, sounds very strange and absurd. But when we consider that this nature is not a thing in itself but is merely an aggregate of appearances, so many representations of the mind, we shall not be surprised that we can discover it only in the radical faculty of all our knowledge, namely in transcendental apperception, in that unity on account of which alone it can be entitled the object of all possible experience--that is, nature.[21]

Oersted, and I think Polanyi also, found this idealism uncongenial to a working scientist's mind, and Oersted therefore invented a modification, in his splendid conception of an "anticipating consonance"[22] existing between the mind of the scientist and the workings of nature. Polanyi comes very close to this notion. For example, he writes,

> When a discovery solves a problem it is itself fraught with further intimations of an indeterminate range, and ...when we accept the discovery as true, we commit ourselves to a belief in all these as yet undisclosed, perhaps as yet unthinkable, consequences. This is of course not explicit knowledge, and [he acknowledges] there is no explicit justification for the perception of a dawning truth.[23]

Still, Polanyi never quite admitted that these elements of tacit knowledge and of intimations of undisclosed consequences are, more often than not, simply wrong, although as a working scientist he must have observed this to be the case. But he would also have known that there is a certain pattern to these intimations, or anticipations. Almost by definition, a major scientist is one for whom this mechanism somehow works, at least often enough. At any rate, whether these anticipations are correct or turn out to be "a delusion"[24] (his words), Polanyi holds it futile to search for strictly impersonal criteria of its validity, "as positivistic philosophies of science have been trying to do for the past 80 years or so."[25]

In the climate of the decay of logical positivism after the mid-fifties, Polanyi's conception of tacit knowledge, or personal knowledge, did not remain a prominent target of attack. In any case it was never really a completely thought-through theory of scientific creativity. On the other hand, a concept which Polanyi thought to be directly related to the tacit dimension, namely "emergence," seems to me to have been then, and remains now, a focus of debate and opposition, particularly from among biologists. To rescue biology from reductionism, from being dissolved into mere physics and chemistry, Polanyi announced "the principle that the operations of a higher level can never be derived from the laws governing its isolated particulars,"[26] hence that "none of the biotic operations can be accounted for by the laws of physics and chemistry."[27]

Here we encounter a newer version of the old debate which so agitated scientists and philosophers in the l9th century, of mechanism versus vitalism. Of course Polanyi did not deny that there is "a great deal of truth in the mechanical explanation of life";[28] but he wanted to insist that living functions are "determined at all stages by a combination of a mechanism with organismic regulation."[29] At the very least, he said, "a principle not present in the inanimate must come into operation when it gives birth to living things."[30] Such views, coming from a prominent physical chemist, found probably a much more willing audience outside the laboratory than in it, and this may account in part for the fact that we are holding this meeting in recognition of the work of Michael Polanyi not in our Mallinckrodt Laboratory of Chemistry, but in the Sperry Room of the Harvard Divinity School.

Also, to Polanyi, the principal interest of evolution was the rise of man from "lower" beings. To him, the problem of evolution seems to boil down to understanding how we reached "our position as the highest form of life on earth, and our own advent by a process of evolution."[31] But we are now in the age of anti-specieism, in which even the Spotted Owl has still some political clout; so one cannot expect much resonance nowadays with Polanyi's call for a reshaping of "the problem of evolution deformed by the current theory of evolution."[32]

The origin of species was a preoccupation which he thought can only make us "lose sight" of that more fundamental question. Properly understood, evolution is an expression of the concept of the "stratified universe of living things,"[33] in which progress from one level to the other cannot be done via reduction, or even by the continuation of the logic of one level with respect to the logic of the second above it, but rather by emergence--"the first emergence by which life comes into existence being the prototype of all subsequent stages of evolution."[34] Polanyi is quite frank that such ideas connect with earlier versions encountered in the history of science, for example, that of Teilhard de Chardin.[35]

With such tools, Polanyi struggled with what he called the concept of the "potentiality for obedience to higher demands,"[36] and "the capacity to feel reverence for men greater than oneself,"[37] both of which he regarded as aspects of the process of evolution. The Harvard Biology Labs being, as it were, only a stone's throw away from this room, one must acknowledge that within a very different system of concepts than Polanyi's, sociobiologists such as E. O. Wilson are in fact struggling with very similar problems, summarized under the heading Altruism. I mention this only to indicate what to an historian of science is again and again so impressive: the continuity of preoccupations of the same sort within very different frameworks and worldviews, from the pre-Socratics to the end of the 20th century.

Consequences of Polanyi's Doctrines

As if by simple extrapolation, we can almost certainly guess where Polanyi's thought would land next. It is the modern base for moral belief. How, he asked, can

> intellectual powers, grounded in tacit knowing and descended from evolutionary emergence...exercise the kind of responsible judgment which we must claim if we are to attribute a moral sense to man. In a world where, it is widely held, scientific rationalism has impaired moral beliefs...by shattering their religious connections, where the Enlightenment weakened ecclesiastical authority, and modern positivism denied justification to all transcendent values;[38]

where, he asked, can one find a theory for reestablishing the justification of moral standards? Control through established ecclesiastical authority appealed to Michael Polanyi as little as the control of science itself. Thus he wrote,

> It was only when the philosophy of Enlightenment had weakened the intellectual authority of the Christian churches that Christian aspirations spilled over into man's secular thoughts and vastly intensified our moral demands on society. The shattering of ecclesiastical control may have been morally damaging in the long run, but its early effect was to raise the standards of social morality.39

What he feared most of all was the fusion of scientific skepticism and moral perfectionism. He saw that hybrid represented by modern existentialism and by what he called "an angry absolute individualism."[40] And the same hybrid also, by demanding a total transformation of society as a utopian project, expressed itself in Marxism as a political doctrine. In fact, it would be difficult to associate Polanyi's ideas with allegiance to any "ism;" for by putting centrally the concept of tacit thought as an indispensable element of all knowing, "The transmission of knowledge from one generation to the other must be predominantly tacit,"[41] and therefore cannot become concretized in a uniquely shareable ideology at a given time or through history.

And yet, apparently paradoxically, Polanyi sees a way of attempting total individual understanding with one's own mental faculties. That alternative is "entrusting oneself...to a teacher or leader."[42] St. Augustine observed this when he taught, "Unless you believe, you shall not understand." However, Polanyi does not hold out great hope that religion as now understood could fill this place for the need for tradition. "Modern man's critical incisiveness must be reconciled with his unlimited moral demands first of all on secular grounds. The enfeebled authority of revealed religion [as he called it] cannot achieve this reconciliation; it may rather hope to be *revived* by its achievement."[43]

Polanyi's final paragraph indicates his puzzled frame of mind on this point: "Perhaps this problem cannot be resolved on secular grounds alone. But its religious solution should become more feasible once religious faith is released from pressure by an absurd vision of the universe, and so there will open up instead a meaningful world which could resound to religion."[44] This view is connected, I believe, with Einstein's much better developed ideas on Cosmic Religion.

I don't see it as my task to provide a rebuttal to, or even a general assessment of Polanyi's thoughts. This has been done many times, for example, in the volume *Intellect and Hope*, edited by Langford and Poteat. But perhaps a few words are appropriate about the way comments on *The Tacit Dimension g*enerally run. Let me refer here to Robert S. Cohen's essay in the volume edited by Marjorie Grene, *Interpretations of Life and Mind*, an essay entitled "Tacit, Social and Hopeful." Cohen, both a physicist and a philosopher of science, acknowledges right away that the tacit dimension of knowing appears to him "acceptable and well-established."[45] Polanyi did not discover tacit knowledge, but he discovered at least how important it was in his own epistemology, and made more of it than many others. For Polanyi, "knowledge is situated within a background of clues, or a tacit background." That "means that there is a reality hidden behind the discovered objects. And so objects as we know them become clues to an as yet undiscovered and

deeper level of reality."[46] For philosophy, this poses an immense challenge owing to the whole series of progressively more hidden realities it implies.

But, Cohen asserts, there is in all this a hint that Polanyi has a novel and interesting though undeveloped view of how the history of science progresses. "Polanyi asserts that different epochs of science offer different cue-maps, different forms of in-dwelling."[47] Any working scientist who has passed through the development of his or her own fields over a couple of decades (and nowadays that is an immense distance), with the possibility of vast changes of mind and attitudes--is likely to assent to this picture.

The "Big Book" and "the Story of Relativity"

The work that most closely connects Polanyi with the field of the history of science as scholarship is of course chiefly what he called his "big book," *Personal Knowledge: Toward a Post-Critical Philosophy*, published in l958. As he says at the beginning of his Preface,

> This is primarily an inquiry into the nature and justification of scientific knowledge. But my reconsideration of scientific knowledge leads on to a wide range of questions outside science. I start by rejecting the ideal of scientific detachment. In the exact sciences this false ideal is perhaps harmless, for it is in fact disregarded there by scientists. But we shall see that it exercises a destructive influence in biology, psychology and sociology, and falsifies our whole outlook far beyond the domain of science. I want to establish an alternative ideal of knowledge, quite generally.
>
> Hence the wide scope of this book and hence also the coining of the new term I have used for my title: personal knowledge. The two words may seem to contradict each other: for true knowledge is deemed impersonal, universally established, objective. But the seeming contradiction is resolved by modifying the conception of knowing.[48]

That new conception is based on the view that the personal participation of the knower in acts of understanding does not make such understanding *subjective*. The act of comprehension is "a responsible act claiming universal validity. Such knowing is indeed *objective* in the sense of establishing contact with a hidden reality."[49]

The book was based on his Gifford Lectures, delivered in l95l-52 at the University of Aberdeen. But he confesses that he spent "nine years almost exclusively on the preparation of this book."[50] Nevertheless, as even his friends and followers admit, it is by no means an easy book to read or accept. In their introduction to the collection, *Intellect and Hope, Essays in the Thought of Michael Polanyi*, the editors, Thomas A. Langford and William A. Poteat, begin with the sentence: "*Personal Knowledge* is an exasperating book." They add,

> If one does not find it exasperating, one has not *really* read it....There can be no doubt that *Personal Knowledge* comes to us with its rhetoric all out of focus. It is a mixed bag....Philosophers by and large, at least English-speaking philosophers on both sides of the Atlantic, find *Personal Knowledge* annoying because it is dangerously loose, innocuous because it says what has been said elsewhere and better, or irrelevant because its preoccupations are no legitimate concern of philosophy or of philosophers....One never 'gets going.'[5l]

There is no doubt that the book is maddening in spots. For example, Polanyi writes, "The principal purpose of this book is to achieve a frame of mind in which I may hold firmly to what I believe to be true, even though I know that it might conceivably be false."[52] It has been suggested that it may be best to consider it an example of the confession literature, with such distinguished antecedents as Augustine and Rousseau.

Polanyi begins by going over a version of the development of the ideas of the solar system during the scientific revolution of the l7th century as a consequence of the Copernican model, and he draws on various well-known anecdotes to show how foolish it would be to hold that these early scientists forbade themselves to "go beyond experience by affirming anything that cannot be tested by experience."[53] Ecstatic passages from Kepler easily show the opposite to be the case. But Polanyi devotes only a few pages to these matters, for his main proof depends on what he calls "the story of Relativity." That theory was indeed taken by the positivists to show that through instrumentalist thinking Einstein had freed l9th-century physics from its metaphysical underpinnings, and thereby made the breakthrough to modern science. Polanyi correctly points out that every textbook of physics tried to present the rise of relativity as the necessary response to an experimental situation, namely the supposed null result of the Michelson-Morley experiment searching for an ether drift in l887--fully in accord with the sensationist or positivist view of how theories must proceed. (As well, we should add, the easiest *pedagogic* method of convincing students that they must take seriously what otherwise would be so counter-intuitive.) But, Polanyi declares, "the historical facts are different."[54] He noted that Einstein, in his publication, had not mentioned the Michelson-Morley experiment at all, and concludes from it that this theory was proposed "on the basis of pure speculation, rationally intuited by Einstein before he had ever heard about it."[55]

An Experimental Proof of Tacit Knowledge

Let us stop at this important point in Polanyi's book and consider what you, as an historian of science, would now do on the basis of such a personal hunch or presupposition. It is an interesting enough case to give it serious treatment. You would begin by searching the literature of the period around the publication of the theory, encompassing perhaps a decade to either side of it, and not only of Einstein but of his contemporaries, to see who says what, if anything, about the Michelson-Morley experiment but also about the others of the same sort which were available by l905. Then you would try to consult available documents in the archives of the main persons involved in the genesis and debates, pro and con, of the special theory of relativity, in the hope of finding contemporaneous exchanges or unpublished drafts and manuscripts from Einstein, but also from H. A. Lorentz, H. Poincaré, etc. You would also try to consult oral history interviews, autobiographical writings at a later stage, and so forth. If a promising Ph.D. candidate had come to me with such a project, I would have estimated it would take a year or two of research and quite a bit of travel to archives. In fact, as some of you may know, I published a long article on this case in *Isis* in l969, entitled "Einstein, Michelson, and the Crucial Experiment," and it did take me the better part of a year.

But Michael Polanyi did none of that. As he tells us in his book *Personal Knowledge*, he availed himself of a remarkable shortcut. After all, he had been in touch with Einstein since l9l3. Taking advantage of his entré, and in order "to make sure" of his hunch that Einstein's theory was based on "pure speculation, rationally intuited by Einstein before he had ever heard" of the Michelson-Morley experiment, Polanyi got in touch with the physicist N. Balazs who was working with Einstein in Princeton in the summer of l953, and asked his fellow former-countrymen to submit this speculation to Einstein himself.

In fact Balazs had an interview with Einstein on that subject, describing it to Polanyi in a letter of July 8, l953. He reported that Einstein concurred that (as Balazs wrote) "The Michelson-Morley experiment had no role in the foundation of the theory. He got acquainted with it while reading Lorentz's paper about the theory of this experiment (he of course does not remember exactly when, though prior to his papers), but it had no further influence on Einstein's considerations, and the theory of relativity was not founded to explain its outcome at all."[56] What did matter during the genesis, Einstein had told Balazs, was his concern with a series of more fundamental problems, such as the impression an observer, moving with the velocity of light, would have while viewing the light wave, and the lack of symmetry of action between coils and magnets when they are moved with respect to each other in producing the induction of currents in the coil.

Needless to say, this second-hand report of what Einstein may have said to Balazs, which Polanyi strangely chose to quote only in a footnote in his book, was not found convincing either by philosophers of science or by historians of science, the more so as the book as a whole was using this report as a tool in an otherwise quite idiosyncratic attempt at a new epistemology. Not until years later, when all the supporting work that I have mentioned above as necessary was done, would there be the kind of impact on the scholarly community which Polanyi had hoped to make by his shortcut. (And even then, I should add, to this day, long after all the supporting documents have been produced, there are still a few dedicated empiricists or experimenticists who will have none of this evidence, and they are holding on gloriously to their suspension of disbelief, which Samuel Taylor Coleridge thought was proper only for poets.)

And yet, and yet.... Polanyi *was* right. His hunch, of which he was so convinced that he tested it only in the most perfunctory way, through a third party rather than even taking the trouble to put the question to Einstein himself, was borne out later by a great deal of more laborious work by somebody else. To be sure, Polanyi overreached when he declared that Einstein's theory was framed "on the basis of pure speculation, rationally intuited," but it was evidently based chiefly both on the speculation about a thought experiment (that of traveling with the speed of light along a light beam) and some old, well-established l9th-century experiments long before Michelson's, those of Faraday, Fresnel, and of stellar aberration.

How could that be? Was it merely an accident that Polanyi's presupposition was borne out on the whole? Perhaps. But I prefer to think of it in Polanyi's own terms. After all, for decades he had been a very prominent and successful scientist himself, engaged both in experiment and theory. He had *internalized* how scientists think, and had observed how others do their work, in finished publications as well as in conversations, and in debates, for example during his time in Berlin, when Einstein was also there and Polanyi saw much of him. In short, if there is such a thing as *apperception*, personal or *tacit knowledge*, and *in-dwelling*, we must allow Polanyi to have had those capabilities as a scientist himself. Or to put it in Hans Christian Oersted's terms: Polanyi's prediction of how serious research in the entirely different profession of the history of science would illuminate the genesis of relativity was an act of anticipating consonance with the real state of affairs, one that would be made fully clear only later.

In short, I would like to hold open the possibility that it is precisely Polanyi's *lack* of having made a serious study and yet having reached the right sort of conclusion that constitutes, as it were, an experimental verification of his concept of personal and tacit knowledge. We all know that this sort of mechanism has worked in science, from the days of Kepler and Galileo who made advances to which their purely scientific knowledge of the time did not really entitle them. Polanyi is the first example I know where the same sort of thing happened in the pursuit of the history of science itself.[57]

Endnotes

(1)Ferenc Szabadvaary, *The Dictionary of Scientific Biography (DSB)* (New York: Scribner's, 1975), vol. XVIII, p. 718.

(2)Letter of 5 June 1964 from J.C. Polanyi to Helen Dukas (who had been Einstein's secretary).

(3) H. Reichenbach, in *Einstein: Philosopher-Scientist*, ed. Paul A. Schlipp (Evanston, Il.: Library of Living Philosophers, 1949), p. 289. This reference is given by Polanyi in *Personal Knowledge* (Chicago: U. of Chicago Press, 1958), p. 14, footnote 1 (along with a quote from H. Mehlberg expressing a similar point of view.)

(4) Similar passages can be found in many places, for example in Karl Popper's <F255P255MIC255>The Logic of Scientific Discovery (New York: Harper and Row, 1959), p. 31.

(5) See Ferenc Szabadvaary's summary of Polanyi's views in *DSB*, p. 719: "In the mid 1930's, Polanyi visited the Soviet Union. After his return, he wrote several articles and a book criticizing Soviet economic notions, and on planning and guidance of scientific research.... He was a supporter of complete freedom in scientific research, not only concerning its content but also in the choice of the subject."

(6) F. Engels, "Outlines of A Critique of Political Economy", in *Collected Works* (New York: International Publishing Co., 1975), vol. II, p. 428. Quoted and referenced by Robert S. Cohen in *DSB*, vol. XV, p. 136.

(7) F. Engels, *Preface to a Contribution to the Critique of Political Economy* (New York: 1970), pp. 20-21. Quoted by R.S. Cohen in *DSB*, vol. XV, p. 136.

(8) F. Engles, *Dialectics of Nature* (Moscow: 1954), p. 247. Quoted by R.S. Cohen in *DSB*, vol. XV, p. 136.

(9) B.M. Hessen, *The Social and Economic Roots of Newton's Principia*, introduction by Robert S. Cohen (New York: H. Fertig, 1971), p. 26.

(10) M. Polanyi, *The Tacit Dimension* (New York: Anchor book A540, Doubleday, 1967), pp. 3-4.

(11) *ibid*., p. 6.

(12) *ibid*., p. 7: "...bodily processes are prominent in the operations of perception." Similarly, Einstein reports that what he called "the elements of thought" were "in any case of visual and some muscular type." [Jacques Hadamard, *The Psychology of Invention in the Mathematical Field* (Princeton, N.J.: Princeton University Press, 1945), pp. 142-143.] See also Edmund Husserl, who writes: "Moving freely within the moment of experience which brings what is present into my intuitional grasp, I can follow up these connections of the reality which immediately surrounds me. I can shift my standpoint in space and time, look this way and that, turn myself forwards and backwards; I can provide for myself constantly new and more or less clear and meaningful perceptions and representations, and images also more or less clear, in which I make intuitable to myself whatever can possibly exist." [Edmund Husserl, *Ideas*, trans. W.R. Boyce Gibson (New York: Collier Books, 1962), chapter 3, section 27, p. 92.] See, further, Maurice Merleau-Ponty: "We grasp external space through our bodily situation. A `corporeal or postural schema' gives us at every moment a global, practical, and implicit notion of the relation between our body and things... A system of possible movements, or `motor projects', radiates from us to our environment. Our body is not in space like things; it inhabits or haunts space. It applies itself to space like a hand to an instrument..." ["An Unpublished Text by Maurice Merleau-Ponty", trans. Arleen B.

Dallery, in Maurice Merleau-Ponty, *The Primacy of Perception*, James M. Edie ed., (Evanston, Il.: Northwestern University Press, 1964), p. 5; first published as "Un inedit de Maurice Merleau-Ponty", in *Revue de metaphysique et de morale*, no. 4 (1962), 401-409.]

(13) M. Polanyi, *The Tacit Dimension*, p. 15.

(14) *ibid*., p. 17.

(15) *ibid*., p. 20.

(16) *ibid*., p. 21.

(17) *ibid*., p. 21: "For to see a problem is to see something that is hidden. It is to have an intimation of the coherence of hitherto not comprehended particulars." Again, compare with Husserl: "What is actually perceived ... is partly pervaded, partly girt about with a *dimly apprehended depth or fringe of indeterminate reality* ... Moreover, the zone of indeterminacy is infinite. The misty horizon that can never be outlined remains necessarily there." [E. Husserl, *Ideas*, p. 92.] See also Merleau-Ponty: "The characteristic property of the Visible is to have a layer of invisibility in the strict sense, which it makes present as a certain absence." ["Eye and Mind," trans. Carleton Dallery, in M. Merleau Ponty, *The Primacy of Perception*, p. 187; first published as "L'Oeil et l'Esprit" in *Art de France*, vol. 1, no. 1 (January, 1961).] For a discussion, see E. Wigner and R.A. Hodgkin, Bibliographical Memoirs of Fellows of the Royal society, vol. 23 (1977), p. 430, footnote.

(18) Polanyi, *The Tacit Dimension*, p. 78. Polanyi quotes Popper's words and gives the reference in footnote 10, p. 98: "This view has been persuasively expressed by K.R. Popper, e.g. in *The Logic of Scientific Discovery*, New York, 1959, p. 279."

(19)*ibid*., pp. 78-79.

(20) A. Einstein, in an address given at a celebration of Max Planck's sixtieth birthday before the Physical Society in Berlin. In *Ideas and Opinions* (New York: Bonanza Books, 1954), p. 226.

(21) I. Kant, *Critique of Pure Reason*, A 114.

(22) H.C. Oersted, "On the Spirit and Study of Universal Natural Philosophy" in *The Soul of Nature*, trans. Leonora and Joanna B. Horner (London, 1852; reprint London, 1966), p. 450.

(23) Polanyi, *The Tacit Dimension*, p. 23.

(24)*ibid*., p. 25: "The anticipation of discovery, like discovery itself, may turn out to be a delusion."

(25) *ibid*., p. 25.

(26) *ibid*., p. 36.

(27)*ibid*., p. 42: "Moreover, the conclusion that machines are defined by the fact that boundary conditions expressly left open by physics and chemistry are controlled by principles foreign to physics and chemistry, makes it clear that it is in respect of its characteristic boundary conditions that a mechanically functioning part of life is not explicable in terms of physics and chemistry."

(28) *ibid*., p. 42, immediately following the preceding quote.

(29) *ibid*., p. 43.

(30)*ibid*., p. 44. (The very definition of emergence.)

(31) *ibid*., p. 47.

(32)*ibid*., p. 46.

(33)*ibid*., p. 50.

(34)*ibid*., p. 49.

(35) See *ibid*., p. 46. See also *Personal Knowledge*, p. 388, where he associates his views with "noogenesis" and cites Teilhard in a footnote.

(36)*ibid*., p. 52.

(37)*ibid*., p. 52.
(38)*ibid*., p. 56.
(39) *ibid*., p. 57.
(40) *ibid*., p. 59.
(41) *ibid*., p. 61.
(42) *ibid*., p. 61.
(43) *ibid*., p. 62.
(44) *ibid*., p. 92.
(45) R.S. Cohen, "Tacit, Social and Helpful", in M. Grene, ed., *Interpretations of Life and Mind* (London: Routledge and Kegan Paul, 1971), p. 137.
(46) *ibid*., p. 138.
(47) *ibid*., p. 140.
(48) M. Polanyi, *Personal Knowledge*, Preface, p. vii.
(49) *ibid*., p. vii.
(50) *ibid*., p. ix.
(51) T. Langford and W. Poteat, eds., *Intellect and Hope. Essays in the Thought of Michael Polanyi* (Durham, N.C.: Duke University Press, 1968), p. 3 and pp. 6-7.
(52) M. Polanyi, *Personal Knowledge*, p. 214. T. Langford and W. Poteat quote this passage in their introduction to *Intellect and Hope*, p. 14, in the context of comparing *Personal Knowledge* to the *Confessions* of St. Augustine.
(53) The import of such passages is likely to be Polanyi's opposition to the teaching of scientist-philosophers such as Ernst Mach of who Polanyi says (p. 9) that "his book, *Die Mechanik*, published in 1883, founded the Vienna school of positivism."
(54) *ibid*., p. 10.
(55) *ibid*., p. 10.
(56) *ibid*., pp. 10-11, footnote 2.
(57) I gladly acknowledge the help of Anne Davenport in converting my address into an article.

Selected Bibliography

Cohen, Robert S. "Tacit, Social and Hopeful," in *Interpretations of Life and Mind. Essays around the Problem of Reduction*, Marjorie Grene, ed. (London: Routledge & Kegan Paul, l97l), 137-148.

Gelwick, Richard. *The Way of Discovery. An Introduction to the Thought of Michael Polanyi*. (New York: Oxford University Press, l977).

Holton, Gerald. "Einstein, Michelson and the `Crucial' Experiment," in *Thematic Origins of Scientific Thought: Kepler to Einstein* (Cambridge, MA: Harvard University Press, l988), chapter 8 and pp. 477-478.

Langford, Thomas A. and William H. Poteat, eds. *Intellect and Hope. Essays in the Thought of Michael Polanyi*. (Durham, NC: Duke University Press, l968).

Polanyi, Michael. "The Growth of Science in Society," *Minerva*, vol. 5, no. 4 (Summer l967), 533-546.

Polanyi, Michael. "Life's Irreducible Structure," *Science*, vol. l60 (2l June l968), l308-l312.

Polanyi, Michael. *Personal Knowledge. Towards a Post-Critical Philosophy* (Chicago, IL: University of

Chicago Press, l958).

Polanyi, Michael. "The Potential Theory of Adsorption," *Science*, vol. l4l (l3 September l963), l0l0-l0l3.

Polanyi, Michael. *Science, Faith and Society* (London: Oxford University Press, l946).

Polanyi, Michael. *The Tacit Dimension* (Garden City, NY: Doubleday & Co., Inc., l967).

Szabadvaary, Ferenc. "Mihaly (Michael) Polanyi," *Dictionary of Scientific Biography*, vol. 18 (New York, NY: Charles Scribner's Sons, l981), 7l8-7l9.

Wigner, Eugene and R. A. Hodgkin. Biographical entry for Michael Polanyi, in *Biographical Memoirs of Fellows of the Royal Society*, vol. 23 (l977).