

# THE POLANYI – WIGNER DIALOG ON TACIT KNOWING<sup>1</sup>

STEFANIA RUZSITS JHA

Independent Scholar  
San Francisco, USA  
E-mail: stefania1@jha.net

## ABSTRACT

The article focuses on the ten year Wigner-Polanyi correspondence on epistemology and analyzes their debate. Michael Polanyi was Eugene Wigner's mentor in the 1920s in his laboratory in the Kaiser Wilhelm Institute for Physical Chemistry and Electrochemistry in Germany. He advised a small group of young expatriate Hungarian scientists, and wrote joint articles with some, Wigner amongst them. Polanyi thought of the group at the Institute as an ideal scientific community – sharing knowledge, skills, and interests outside science – humanities in general, epistemology in particular. Polanyi was convinced that explicit descriptions and definitions do not capture one's knowledge of phenomena, that the foundation of all knowledge is tacit knowing. He explored this by investigating the process of scientific discovery. For him, epistemology had a wide meaning: a combination of informal logic, psychology and background knowledge. Wigner's notion of epistemology was tied closer to the question 'how do we know A is real' a more pressing question for physics than Polanyi's notion. The ten-year correspondence between them explored their understanding of epistemology. Wigner was looking for something he could use to solve the measurement problem in Quantum Mechanics, and he was willing to look to the future for a 'new science' for an explanation, a combination of quantum physics and psychology. Polanyi thought he has found a way to explain tacit knowledge by way of analogy with art. This did not satisfy Wigner as a solution to his problem, so the dialog was inconclusive. The correspondence points to further possibilities to explore the epistemology of science.

**Keywords:** epistemology, tacit knowing, scientific discovery, Polanyi, Wigner, measurement problem.

## 1. INTRODUCTION

Eugene Wigner was on a search for a new science to solve the measurement problem – something between physics and psychology. In his 1959 paper, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," Wigner expressed his debt to Michael Polanyi saying that many years ago Polanyi deeply influenced his thinking on problems of epistemology. (Wigner 1967:237)

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Not only did Polanyi mentor young physical chemists as a laboratory director and instill in them openness to inquiry, with his philosophical bent he investigated the phenomena of invention and discovery which he knew so well. In this essay Wigner mused: "...it is not at all natural that 'laws of nature' exist, much less that man is able to discover them." (Wigner 1967:227)

By 1959 Polanyi published several papers and two books on his new epistemology, "personal knowledge," knowledge with a knowing subject which is still objective. (It is on a continuum from personal to objective, the knower's personal participation makes it objective.) As their correspondence shows, this new epistemology gave Wigner hope that the paradox of the "measurement problem" of quantum physics (that the observation changes what is observed) could be solved. As Wigner noted at the end of the above mentioned paper, if no coherent theory of the phenomenon of consciousness would be formulated similar to extant coherent theories of the physical world, scientists' faith in the reality of their concepts would be strained. (Wigner 1967:236) Or as Fritz Rohrlich expressed this, playing on Wigner's title, in the "Unreasonable Effectiveness of Physical Intuition: Success While Ignoring Objections:

[T]he problems that were ignored turned out to be considerably more difficult than the problems that were actually solved; typically, their solution required a much deeper level of theory than the level on which progress was made. [...] One wonders whether the measurement problem of Quantum Mechanics is of this nature. Seventy years of effort... ha[s] not resulted in a definite solution. (Rohrlich 1996:1625)

The search has been on for some time for a coherent theory, a famous version of which was John von Neumann's logical theory of automata paper read in 1948 at the Hixon symposium at the California Institute of Technology. (von Neumann 1951) Wigner referred to it in his Festschrift paper for Polanyi, "The probability of the existence of a self-reproducing unit." (Festschrift 1961) Von Neumann's proposal of self-replicating machines was based on the Turing model, but von Neumann understood that his model does not apply to living systems. Wigner pointed out that his own speculative model differs from this.<sup>2</sup> He said, the present laws of physics do not incorporate the influence of consciousness on matter, and the present concepts of the laws of nature do not include the mutual influence of living matter and consciousness. He suggested that the influence of consciousness on matter is analogous to the direct influence of light on matter as described in the Compton effect. (Ibid. 232)

Wigner's speculative analogy assumes that "the 'living state' is completely given

<sup>2</sup> Von Neumann's model in The Hixon Symposium paper assumes a discreet set of states, while in Wigner's all variables are continuous, and he also assumes that the model is not realistic and does not allow a final state. (Festschrift 1961:236)

in the quantum mechanical sense” and a calculation can be carried out to support this argument. (Ibid. 233) However, the organism is not completely determined in this sense, as there are many states representing a living organism.

## 2. THE POLANYI – WIGNER DIALOG CONCERNING THE MIND-BODY PROBLEM.

This was a topic of disagreement never resolved between Polanyi and Wigner. The discussion started after Wigner’s contribution “Self-reproducing unit” to Polanyi’s *Festschrift*. In his letter of April 3 1961 Polanyi states emphatically, that Wigner’s position amounts to reductionism, and that no reduction of mental to physical is possible. Polanyi’s analogy is a machine as defined by its function, not its parts.<sup>3</sup> But this is only a partial analogy illustrating a hierarchy of levels – and as it turned out, a misleading analogy suggesting insentience as far as Wigner was concerned – machines are constructed for a purpose, while the purpose of living things is intrinsic to themselves. They both agreed that an explanation of living things as machines completely defined by their physico-chemical properties is false. Explaining living organisms by the properties of ‘communication,’ is also false. Polanyi said in this letter:

A set of objects may be said to carry the same message if each member of the set has the same meaning. Communications work by embodying their own peculiar operational principles; no physical-chemical analysis of an object conveying a communication will reveal its meaning. In fact, no object has a meaning. It can mean something only to a person who means something by it.

Polanyi goes on to say in this letter, that if Wigner would test his hypothesis, he would find that his claim that his hypothesis is set in opposition to von Neumann’s is misleading.

For, if I am right [Polanyi said] in the interpretation of your argument, it should exclude the possibility of machines or communications being formed according to laws of quantum mechanics from inanimate matter not already embodying communications or operational principles of machines.

Polanyi admitted that Wigner’s mathematical proof in the article was “over his head,” and that he was only arguing about the reasonableness of the hypothesis. – Wigner in his reply a week later explained that the mathematical proof of his speculative model

<sup>3</sup> Eugene P. Wigner Papers, Special Collections, Princeton University Library. Box 66, Folder 1 (66:1). Hereafter EW Papers (box # : folder #).

claims that it is infinitely unlikely that there are systems which are self-reproducing. This is a statement similar to statements used in thermodynamics, where we always assume that it is infinitely unlikely...<sup>4</sup> In the present case the infinitely unlikely relates to results of the calculations which cannot be carried out in practice. (EW Papers 66:1)

Wigner believed von Neumann was firmly convinced of this conclusion with regard to living beings, i.e. the unlikelihood that self-reproducing units of the type of living beings could arise, even though he did not publish his thought on this. (EW Papers 66:1)<sup>5</sup>

In the same year in 1961, Wigner took another tack at the problem of how to deal with the quantum mechanical theory of observation, but this time from the angle of the concept of the real. In his article “Two kinds of reality” he offered a dualist position. (Wigner 1967) The first kind of reality is consciousness, an obvious fact which is often disregarded when focusing on the content of consciousness (i.e. on everything other than one’s consciousness), and the content of consciousness is the second kind of reality. Normally one is not aware of the operations of the mind, except in the process of learning something.<sup>6</sup> Wigner considered this first reality absolute, or possibly considering the absolute a limiting case of consciousness. He also called it “personal reality”. The second reality – that of objects – is sharply divided from the first, and is of various degrees of probability, although we accept them as “real” for our picture of the world. Wigner considered the consciousness of others as well as (spiritual) values to be the same degree and type of reality as that of objects. This, he states, “is the only known point of view which is consistent with quantum mechanics.” This second type of reality is the universal or impersonal one, and the concept cannot be made meaningful without accounting for the phenomenon of mind and integrating it into our understanding of physical phenomena. (Wigner 1967)<sup>7</sup>

The two kinds of reality, consciousness and its content, are related in such a way that not only is absolute reality not independent of the constructs of the universal reality, but contrary to naïve beliefs, both share the property of impermanence.

<sup>4</sup> I.e. “it is infinitely unlikely that the system occupy one of the periodic orbits if there is only a finite number of such orbits.” (11<sup>th</sup> April 1961, EW Papers 66:1)

<sup>5</sup> von Neumann’s last speculations on natural and artificial memory were written for the Yale Silliman Lectures published posthumously as *The Computer and the Brain* (Yale University Press 1958)

<sup>6</sup> Wigner’s favored source of explanation of conscious and unconscious processes is J. Hadamard’s clear but general description of mathematical invention, according to which the unconscious is a manifold (it can combine and synthesize ideas). There is a range of consciousness from fringe-consciousness, the ‘ante-chamber’, to full consciousness. Then the mind chooses from the combinations by an “aesthetic sieve”, an essential means. In this process, the will of finding a solution is crucial. (Hadamard [1945] 1949, chapters 2 & 3)

<sup>7</sup> In this article Wigner refers (on p. 187, n. 3) to an important 1939 monograph by London & Bauer, *The Theory of Observation*, which says “the measurement is not completed until its results enter our consciousness.” (Thanks to Abner Shimony for bringing this reference to my attention.)

Scientific thinking before quantum mechanics considered consciousness to have no influence on scientific explanation. After quantum mechanics explanation should give an account not only of the phenomenon, but its circumstances and related phenomena. (Wigner 1967:193) In terms of the “paradox of measurement”, it means that measurement (“reading”) cannot be interpreted if the properties of the measuring apparatus are not known or taken into consideration, i.e. correlation between the “object” and the measuring apparatus must be taken into account. This has not been done satisfactorily, and will require the study of concept-forming abilities and what we call intelligence (a fully “awake” consciousness – Wigner’s example was the mind of von Neumann).

Wigner was puzzling through the “mind-body problem”. A traditionally difficult problem he made seemingly even more so by slicing the world into two kinds of reality instead of the notion of continuum from personal to objective as Polanyi has done. (See section 7 below) Wigner’s two kinds of reality now need an explanation for their relation.

In his October 6 1961 letter he expressed high interest in Polanyi’s (pre-publication) article “Clues to the understanding of Mind and Body”, which was stated in the context of Polanyi’s theory of tacit knowing. (in Good 1962:71-8; in Grene 1969b: 159-80) In this letter Wigner has shown agreement with Polanyi’s conclusion, but was not convinced of his argument. (EW Papers 66:1)

Polanyi’s conclusion in this article states that entities are made up of hierarchies of levels of existence, each level relying for its workings on the laws of the level below it, but a more complex higher level’s operation cannot be accounted for by laws of lower levels, i.e. in terms of its particulars. (Ibid. 175) The relationship between levels can be described thus: the boundary condition is defined such that the principles of each level operate under the control of the next higher level. The possibility of the extent of explicit description of particulars varies with levels, and their connection that forms the comprehensive entity varies with systems (objects, living entities, skills such as skillful knowing-and-doing, and responsible judgment). – Thus, Polanyi’s conception of reality is hierarchical, where more complex entities seem to be “more real”, i.e. the mind is more real than a stone.

Polanyi’s argument to support this claim is rather involved, but the general idea is that the higher the level, the more difficult it is to state explicitly and fully all the connections of the particulars which make the entity function as a whole. (The entity’s description is underdetermined). He goes further, to state that one could not identify particulars except by previously attending to the entity as a whole. Specifically, workings of the mind cannot be explained by particular behaviors, or by equating the mind with its workings. The workings of the mind and the observations it makes cannot be focused on at the same time. (The foci are mutually exclusive – one cannot pay attention to the object of the action and the action at the same time.)

To explain his partial analogy of machine-like hierarchical levels, he noted that machines and living systems are alike in that in both the system is unspecifiable

in its particulars. (Polanyi [1958] 1962, Ch. 13, esp. 401) He remarked that if causal explanation is sought, one must say with regard to machines that initial conditions (controlled by the laws of technology which cannot be accounted for by the laws of physics and chemistry) must be taken into account before one can rely on the machine's operation to make predictions. (in Good 1962:75) By analogy, (taking the living body as a "machine") the parameters of the living body are left just as undetermined [sic] by physics and chemistry as that of the machine. Consciousness must be recognized as acting as a "first cause" for the machine – human intelligence created the machine. The emergence of higher levels is an innovation initiated by a "first cause".<sup>8</sup> For the sake of continuity, and by analogy, one would have to postulate a sentient first cause of organic evolution. (in Good 1962:77)

Speculation on how living beings evolved from inanimate matter has not been lacking. Mechanistic conception of the universe would lead one either to hypothesize that entities were "preformed" by suitable patterns of parameters, in which case there would be nothing new, and the notion of randomness would have to be abandoned – or, human beings would have to be represented as insentient automata.<sup>9</sup> A clue has been offered by living organisms, by the process of repair and adjustment in embryonic development and beyond. Gestalt psychologists likened these primitive integrations to the ability of animals to reorganize their field of experience, and the ability of people to innovate (a faster process than evolutionary changes). However, the scope of causes at the highest level are restricted by time and place, and directed toward the possibilities of innovations. For this idea Polanyi was accused of "entelechy" – but it is simply the teleological process, the "vector".<sup>10</sup>

Polanyi's conception of the relation of epistemology and ontology is somewhat peculiar, and can be misleading for those who are looking for clear delineations. He said:

<sup>8</sup> But see Polanyi ([1958] 1962:384) "The Rise of Man". Where he said: evolution like life itself can be said to have originated by the action of an ordering principle sustained by environmental conditions. The "ordering principle" is not explained well. The schema seems to be parallel to "tacit integration" in his epistemology.

<sup>9</sup> For Polanyi, randomness is an example of emergence to higher ontological levels, in the sense that an increase in randomness increases entropy and increases the possibility for new combinations. Degrees of randomness can happen by occasional fluctuations caused by internal or external forces, a decrease in randomness means the system would "sort itself out" and become more predictable. (Polanyi [1958] 1962:391)

<sup>10</sup> When Polanyi speculated on the evolution of man, he said: "The rise of man includes a continuous intensification of individuality, similar to that which normally takes place in the formation of a human person from a parental zygote. No new creative agent, therefore, need be said to enter an emergent system at consecutive new stages of being. Novel forms of existence take control of the system by a *process* of maturation." (Polanyi [1958] 1962:395) His notion of "maturation" in his ontology is analogous to "meaning making" in his epistemology. His epistemology and ontology are isomorphic. See Polanyi (1966:33,55) and see section 9.4 below. Also see Jha (2002, Chapter 9), "Polanyi's problematic architectonic – a critique," esp. p. 225 n. 4.

Strictly speaking, it is not the *emerged* higher form of being, *but our knowledge* of it that is unspecifiable in terms of its lower level particulars. We cannot speak of emergence, therefore, except in conjunction with corresponding progression from a lower to a higher *conceptual* level. And we realize then that conceptual progression may not always be existential, but that it becomes so by degrees. (Polanyi [1958] 1962:393-94)

That is, Polanyi's ontology is generated out of and is isomorphic with his epistemology. Wigner was not convinced by Polanyi's arguments. He said in this same letter (October 6, 1961. EW Papers 66:1):

If we had a state of very low entropy, the subsequent increase of entropy may lead through stages of surprising regularities [e.g. the development of the solar system]. I do not believe that the case which you consider is comparable with this example but the fact of surprising regularities remains. [... I] realize that no argument on this question can be 'rigorous'.

### *2.1. Polanyi's most direct answer to Wigner's puzzle: making sense – "indwelling" and observation*

The next substantive exchange between Polanyi and Wigner occurs after Polanyi sent Wigner his 1962 article "Tacit knowing: its bearing on some problems of philosophy," (in Grene 1969b) which was a published version of one of his Yale Terry Lectures. Here Polanyi explored his notion, that all understanding is grounded in tacit knowing and all understanding is achieved by the act of indwelling: "When exercising a skill we literally dwell in innumerable muscular acts which contribute to its purpose, a purpose which constitutes their joint meaning."<sup>11</sup> It is a mistake to distinguish indwelling from observation as practiced in the natural sciences – it is a matter of degree, a continuum: indwelling is less deep when observing an object, than when understanding a work of art or a person. Indwelling bridges the gap between the two by rooting the person in the awareness of his body.

[W]e are able to make sense of clues or particulars to which we are not attending at the moment, by relying on our awareness of them for attending to something else – so that the appearance of that which we are attending may be said to be the meaning of these clues or particulars. Once we had grasped this way of making sense, we also realized that the position at which the meaning of the clues appeared to be situated did not coincide with the position of the clues themselves and could lie in some cases nearer to, in others further away from them. (Grene 1969b:161)

<sup>11</sup> In one of his notes dated 29/8/1960 on perception he says on 'indwelling': 'invade, move in, occupy, come to reside. Indwelling – moving into residence.' Indwelling is active. (Michael Polanyi Papers, Regenstein Library Special Collections, University of Chicago, Box 22, Folder 3 (22:3). Hereafter MP Papers box # : folder #)

*This can be taken as Polanyi's explanation to Wigner's puzzle, and is the most direct reference to Wigner's measurement problem in terms of tacit knowing – it is the observer's act of "making sense".*

Studies in neurology, motion studies in skill acquisition, analysis of language, all attempt to understand tacit knowing, in which we attend to something by relying on clues, elements, and particulars we are not attending to at the time. The phenomenon studied may be called "intuitive", which these studies attempt to formalize, to capture fully by specifying the elements and stating the rules of integration into "wholes" explicitly. But since focusing on the elements destroys the meaning of the whole (whether the whole is a piece of art, a physiognomy or a skill) no formalization in this manner is possible – one has to limit oneself in the effort of "specifying" to discovering maxims that can be applied artfully. The original tacit act will largely remain tacit. -- It is an interesting point, that tacit knowing can integrate conflicting clues in various ways (in Grene 1969b:167) and can resolve a contradiction by revealing a joint meaning of these clues in terms of a new quality (e.g. stereo sound).

The theory of phenomenism teaches one to consider sense data as ultimate information about the outside world,

and to regard our knowledge of the objects to which sense data refer, as based on inference from these data. This gives rise to the insoluble problem of the manner in which such inference can be carried out. [It seems Polanyi thought this may be Wigner's problem]. The school of linguistic analysis disposed of this problem by affirming that we never perceive sense data as such, but are aware of them only as qualities of objects, which are what we actually do perceive. (Grene 1969b:169-70).

Polanyi adds that we do see sense data until we make an intelligent effort to see the "objects" of which these are the qualities. This intelligent effort is tacit integration by which the object is recognized as the "meaning" of the sense data. It is not an explicit process (such as Wigner's calculations) – trying to make it explicit makes the problem into an insoluble one. In his work the scientist focuses on the meaning of the clues, while he is "groping" towards new ideas and evidence following his hunch.

How does one deal in this context with the problem of how primary qualities give rise to secondary qualities? Primary qualities today mean the parameters of statistical functions as determined by quantum physics. How do these give rise to qualities such as color, sound, etc. by means of configuration of these parameters? "[P]rimary qualities representing the objective reality of all things and secondary qualities deemed to be subjective." (Grene 1969b:173) The puzzle is, how do we answer questions of experience (of color, sound, etc.) which are not directly derivable from the conceptual framework of physics, how do we "explain" things with the "bottom-up" method? The theory of hierarchies of laws would affirm that we cannot,

as Polanyi illustrated it with the example of the machine's levels of structure and function – the operational principles of the machine, the function for a purpose, defines and explains the machine, not its primary qualities. Another illustration was the example of a map: elements of a map are meaningless by themselves – only when the elements are integrated into a whole which we recognize as having the meaning “map” (a figure that functions as a map). The elements were integrated by the process of tacit knowing, “making sense”, described above. Polanyi's answer only alluded to the process Wigner attempted to understand in a more specific (scientific?) way.

### 3. POLANYI'S ANALYSIS OF KNOWING

The process of knowing is in two stages: subsidiary attention and focal attention. The second relies on the first – when it becomes transparent to us that we are looking at a map of X, i.e. the map is in our focal awareness, it is by relying on the various clues, the elements which are in our subsidiary awareness, and which our tacit knowing integrates, that we are able to understand what we are looking at. The map is defined by the meaning we give it, by its function, not by the lines and their position in space which compose it. This process cannot be dismissed as a purely ‘psychological’ process. Since the result of the process of integration can be fallible, the process is one of logical inference – a tacit logical inference. It is personal judgment and it is used in scientific inquiry.

Wigner's reaction in his letter of December 17, 1962 to Polanyi's rather thick description of tacit knowing and its various illustrations and analogies was confusion about the details, but agreement with the general idea that there is tacit knowing:

I am not sure that the distinction you make between tacit knowledge and subconscious knowledge is equally clear. [...] There is only one sharp distinction that may exist between the two, [...] we can not consciously recall the time of a subconscious thought. [This is the puzzle of the measurement problem in quantum physics Wigner has been struggling with for some time, and for which he looked to Polanyi's notion of tacit knowledge for help. He continues:] Your point of the absurdness of disregarding what you call tacit has often occurred to me. First, actually, when analyzing the epistemology of quantum mechanics. This purports to give probability connections between subsequent observations. However, by observations they mean conscious impressions. If one tries to think this through, one soon realizes the absurdity of the position. How do we know the properties of the apparatus which we use for our ‘measurements’ (observations)? Evidently, from having observed the apparatus. This preliminary observation tells us whether we have a grating or a microscope at hand. However, this evidently involves us into an endless process and we must, rather admit that we have some knowledge

which developed in our unconscious, as your tacit knowledge, without conscious observations. (MP Papers 6:2)<sup>12</sup>

Wigner may be correct in his complaint about Polanyi's article "Tacit Knowing: its bearing on some problems of philosophy". However, in a previous 1961 article in *Mind*, "Knowing and Being", Polanyi gave a detailed explanation of tacit knowing as constituted of various levels of consciousness. (Grene 1969b:123) Similarly he did so in the volume *The Scientist Speculates* to which both contributed. (Good 1962)

One more topic Wigner finds lacking in Polanyi's writing, as he said in this letter – a discussions of innate knowledge, inherited knowledge in animal instinct, inherited capabilities, an so on, all of which constitute a much larger part than our learned conscious knowledge. When we speak about ourselves, we speak of this small conscious part, and we speak of it as a possession. – It seems, at this point he has not yet read Polanyi's book *Personal Knowledge*.

There is a two year gap in the correspondence, during which both wrote on related topics: Wigner wrote "Remarks on the mind-body question" (interference of the observer in measurement), "Two kinds of reality" (consciousness and objects) and the "Problem of measurement", (the orthodox view and its critique) – while Polanyi wrote "My time with X-ray crystals" (on discovery), and "The unaccountable elements in science" (on intuitive surmise and informal decision making, "mother-wit" and gestalt perception).<sup>13</sup> All of these papers explore how the mind inter-acts with or understands physical reality. If they were discussing or otherwise following each other's efforts on this topic, we will have to glean this from these essays viewed as a conversation between them. (See section 10)

#### 4. WIGNER'S 'POLANYIAN' EPISTEMOLOGY.

The correspondence resumes in 1965. During the years 1965-1966 Polanyi came to the USA at least twice, during which time the two met. Polanyi organized a study group on the Unity of Knowledge, which held meetings in the USA during two consecutive summers in Maine.<sup>14</sup> Wigner participated in these meetings with the paper "Epistemology of quantum mechanics – its appraisal and demands" and Polanyi contributed "The structure of consciousness." The correspondence includes

<sup>12</sup> Typed extract from Wigner's letter. No full copy of the original exists in the Wigner Papers.

<sup>13</sup> See References at the end for these articles.

<sup>14</sup> Papers were collected and edited by Marjorie Grene in *The Anatomy of Knowledge: papers presented to the Study Group on Foundations of Cultural Unity, Bowdoin College, 1965-1966*. (see Grene 1969a) Articles of Wigner: pp. 31-46, Polanyi: pp. 318-330. In the Polanyi archives this group is identified as the Unity of Knowledge Group, the name change occurred after the conference. Reprinted in a collection of various essays by the same group a *Toward a Unity of Knowledge*. (Grene 1969a)

two letters from Wigner, with substantive comments on the mind-body problem that continued to trouble him. Prior to the 1965 summer conference, on February 19, 1965 he writes to Polanyi in anticipation of discussing the question in person: he was just reading Polanyi's book *Personal Knowledge*, and wanted to bring up a point of difference between their thinking:

We both feel that materialism is absurd, and in this we entirely agree. However, your principal reason is based on Gestalt theory. I agree with the very important and interesting points which this theory makes, but my own reason for disagreeing with materialistic philosophy lies on a lower level already. I think it is about as incorrect as to pretend that mechanics gives the answer to all physics and that electric phenomena follow from classical mechanics. I have two reasons for believing this. One is entirely ontological, the other one is based on modern quantum mechanics. This may not give the full picture, but, on the other hand, there is no reason to believe that an earlier and less complete theory does give the full picture. (EW Papers 66:1)<sup>15</sup>

There is no record of Polanyi's reply. One should note however, that although Polanyi's philosophy cannot be categorized as idealist, he does assign "more reality" to ideas than to material objects, as mentioned above. Wigner's ontology, as we saw above in "Two kinds of reality", also gives more weight to one's thought as real. Therefore, for both, man is not explained by materialist philosophy. Also, as Wigner said in his 1965 conference paper on the epistemology of Quantum Mechanics, and in a paper "Are we Machines?" (Wigner 1997:483) Quantum Mechanics is not a "materialist" theory. On this last point Polanyi did not agree: as he said "a change from classical mechanics to quantum mechanics makes no difference to the 'mechanistic' outlook." (Polanyi [1958] 1962:390) (See his comment on Wigner's reductionism in section 7).

Following the conference Wigner writes on 14 Sept. 1965:

I have been giving a bit of thought to our attitudes toward the question of life and perhaps I do understand a little better what I find not fully satisfactory in your thinking. It seems to me that you make the same difference between living and inanimate objects as between a machine and its constituents. In other words, your emphasis is on the purpose of the machine and also the purposefulness of the arrangement of objects in living beings. I cannot quite believe that this does full justice to life and, even emotionally, I do not feel that it is desirable to equate machines and living beings. From an unemotional point of view I would argue that almost all new sets of phenomena such as electricity, nuclear forces, heat, light, have required either entirely new concepts for their description, or at least a new and striking re-interpretation in terms of phenomena. I do not see

<sup>15</sup> Apparently Wigner did not find Polanyi's comments on the measurement problem on pp. 392-3 of *Personal Knowledge*. See these comments in section 9 below.

anything like this in the present discussion of life, [...] I feel that the phenomena of desire and emotions are at least as new to present physics as was electricity to Mechanics and that it won't be possible to describe it in the same terms, not only on the low level on which machines can be described adequately. In other words, I consider the difference between life and machines enormously great because the machines do not show the phenomena of volition and emotion. I am sure I grossly misrepresent and probably misunderstand your views. However, I would like to know in which way. (EW Papers 66:1)<sup>16</sup>

It is obvious that Wigner found Polanyi's partial "machine-like" analogy wrong for stratified structures of comprehensive entities, and the term "boundary conditions" borrowed from physics not quite clear. (See section 7 below). He did not see the relationship Polanyi wanted to select for the analogy: the hierarchy of levels of innovation. Wigner did find Polanyi's notion of re-framing and re-conceptualizing to understand new phenomena to his liking. This second aspect was where they found their common ground.

This letter was followed by a planned personal meeting and discussion in Princeton in 1966, of which there are no written records. A two year hiatus follows, Wigner initiating correspondence, followed by sending Polanyi a paper which Polanyi calls "on men and machines" – this seems to be the 1968 paper "A physicist looks at the soul" (Wigner 2001:41) discussing three points of view: a Laplacian purely mechanistic view, the "translation of physical laws" view (translation of laws of physics into recordable evidence), and the "laws of physics as the limiting case" (if life plays no role) view. Wigner subscribes to the third view:

It is true that matter influences my consciousness, but I believe it is also true that the atoms in my brain do not follow the laws of present-day physics. The next major change in physics will be, I hope, an incorporation of the phenomena of life and consciousness into this discipline. (Wigner 2001, Vol. 7B, 43)

As the years pass, letters are becoming sparser, though Wigner still approaches Polanyi in a letter for discussion and general thoughts on his puzzle as he is struggling with the epistemology of quantum mechanics. (September 20, 1969, MP Papers 7:16) He was re-reading Polanyi's 1959 *The Study of Man*, a concise form of his earlier magnum opus, picking up on

the points you make about the language and its reliance on tacit knowledge. We speak about measurements in quantum mechanics but we do not tell how we know the properties of the measuring instrument, how we were informed that a particular apparatus is to be used and to what purpose.

<sup>16</sup> For Polanyi's explanations, see "The structure of consciousness."

Polanyi's proposed visit to Princeton to meet Wigner did not materialize. To continue the discussion however, Wigner commented in his letter of 4 February 1971 on Polanyi's (pre-publication) paper "Genius in Science" which he received earlier.<sup>17</sup> (*MP Papers 9:7*) This paper is a clarified short presentation of Polanyi's book *Personal Knowledge* on tacit knowing, this time with the emphasis on scientific creativity as a process of insight driven by the imagination and anticipation based on hunches of a scientist. Scientific creativity, Polanyi insists, is not a process of refutation of earlier theories, nor theory construction from collections of data. What can be observed depends on the theory. Polanyi makes the same analogy between gestalt perception and creative scientific insight as he did in his *Personal Knowledge*, but adds, different branches of science are based on different ways of seeing (i.e. ways of seeing are framed by one's theory). Polanyi's notion of the driving force of imagination and the pull of anticipation is reminiscent of Poincaré and Hadamard, as well as Polya, and analogous to Merleau-Ponty's theory of bodily actions. His shorthand explanation for meaning making is "personal judgment", the scientist's participation in and evaluation of his act of the scientific process.

Although Wigner agrees with the overall tacit knowing thesis, he disagrees with the summary on which he focuses in this letter:

I do not fully agree with what you say... that natural science is an extension of perception. I think you are making this point in relation to gestalts-theories, while I mean it epistemologically. [...] It is very unclear how we have learned [things which we learned in babyhood]. I still do not understand how our children guessed that there is a meaning in the sounds which come out of our mouths and how they ever guessed their significance. (*MP Papers 9:7*)

It seems Wigner missed Polanyi's point on the passivity of gestalt theory, that this theory is only an initial analogy on which he built a layer of active participation and a layer of meaning-making, also by analogy. The whole structure and function explained in much greater detail in his various books and articles.<sup>18</sup> It could be said that Polanyi's epistemology incorporates psychology. – Wigner mentions that he learned from Hadamard that there are two stages of mathematical invention – intuitive knowledge, followed its formulation (these would correspond in Polanyi's theory to the tacit-explicit aspects, but written in a clearer prose with less complex structure). Wigner's comment is perhaps fair, if "Genius in Science" is taken in isolation, but not if the corpus leading up to it is known, as it was presumably by Wigner. This leaves the possibility, that Wigner understood Polanyi's theory as a

<sup>17</sup> Appeared in *Encounter* 38 (Jan 1973) 43-50. Reprinted in R. T. Allen ed. (1997) *Society, Economics and Philosophy: selected papers of Michael Polanyi*.

<sup>18</sup> For an analysis of Polanyi's schema of tacit knowing with its various layers and their functions, see Jha 2002:51-69, 123-48.

psychological one, and his own search as one for an epistemological explanation. We may note again that the meaning of epistemology for Polanyi was a combination of informal logic, psychology and background knowledge culminating in meaning making, a combination he considered to be a general, broader epistemology. The meaning of epistemology for Wigner, according to the considerations above, would have been meaning-making grounded in quantum phenomena – and yet, as he said in his 1969 paper “The Epistemology of Quantum Mechanics”, we see that what he means by epistemology is answering *how do we know*, show, prove what we “know” is “real” (i.e., that in quantum mechanical measurement the state vector *represents* reality).<sup>19</sup> Since observation changes what is observed (it is not continuous over time) and can be represented only by probability laws, the problem becomes for him the double one of epistemology and ontology. He is not willing to accept as a solution the explanation that the state vector is only a tool for calculating the probabilities, only a tool for predictions. He would also not agree that classical physics (macrophysics) and quantum physics are discontinuous – both follow causal laws. He would most likely not accept the following repair of the standard Copenhagen view.<sup>20</sup>

## 5. CRITICISM AND DEFENSE OF WIGNER’S “POLANYIAN” EPISTEMOLOGY

### 5.1. Criticism

In “On the quantum theory of measurement” Feyerabend suggests that the theory of measurement under discussion is incomplete, and a theory can be developed

[w]hich depends, just as its classical counterpart does, on nothing but equations of motion and the special conditions (macroscopically distinguishable states; macro-observers) under which those equations are applied. [...] [Then it could be shown, that this has the consequence (a) that] there are no quantum-jumps and (b) that the idea that there are quantum-jumps has its origin in an incomplete theory of measurement. [...] What is omitted is the fact that M [measuring apparatus] is a macroscopic system and that B [pointer] cannot discern the finer properties of M. [...] Now the transition from the level of QM to the level of classical mechanics involves certain approximations. Within a theory of measurement which omits reference to the macroscopic character of both M and B those approximations cannot be justified. Hence, within such an incomplete theory the transition to the classical level will have to be treated as an

<sup>19</sup> “However, it is dangerous to attribute physical reality to this vector, first, because it is not quite clear what physical reality means, and second, because it changes as a result of observation in a way not given by its equations of motion [collapse of the wave function].” (Grene 1969a:31-45; reprinted in Wigner 2001 6B p. 49-53).

<sup>20</sup> See his critique in “The problem of measurement” in *Symmetries and Reflections* (1967:153-170, as noted in section 3 above).

independent element which cannot be further analysed and which cannot be explained in terms of the equation of motion. We suggest that a complete theory which contains a reference to the macroscopic character of both B and M will allow for such an explanation.” (Feyerabend 1981:213-6)<sup>21</sup>

He also noted, that observation can be made without an observer (by a camera), to simplify the argument.

Putnam, addressing both physicists and philosophers discussing the issues, expressed the opinion that there is something wrong with the conventional theory. (Putnam [1975] 1979:81)<sup>22</sup> Superposition, something being in a state both A and B at the same time, a particle behaving as if it is going through both slit 1 and 2 at the same time, is called the measurement paradox. But conditions in the macro-world are different – in the macro world, a cat being both alive and dead at the same time does not happen, the conditions cannot be super-imposed. Therefore, Putnam says, these assumptions of conventional quantum mechanics constitute a contradiction. [See his definition of state vector on p. 80 *ibid.*] He notes, that Wigner and Margenau defend the adequacy of the received view (of quantum-jumps/collapse of the state vector) along a somewhat different line:

According to them quantum mechanics presupposes a cut between the observer and the object. Any system can be taken as the object; however the observer himself cannot be included. [...] The observer always treats himself as possessing definite states which are known to him. Here Margenau and Wigner deviate slightly from the Copenhagen Interpretation. According to Bohr and Heisenberg, the observer must treat himself as a *classical* object, i.e. everything on the observer side of the ‘cut’ (including the measuring apparatus) is treated as obeying the laws of *classical* physics. Margenau and Wigner do not mention this. What they rather say is that the observer must include ‘consciousness’. Thus they deviate from the Copenhagen Interpretation in a *subjectivistic* direction. Whereas the fact that we do not get superposition on the observer side of the ‘cut’ is explained on the Bohr-Heisenberg story by the fact that we use *classical* physics on this side, it is explained on the Margenau-Wigner story by the fact that we have a faculty of ‘introspection’ (cf. London and Bauer (1939) for the source of this interpretation) which enables us to perform ‘reduction of the wave packet’ upon ourselves. (Putnam [1975] 1979:81)

<sup>21</sup> Wigner disagrees: “at present there is no clear evidence that quantum mechanics is valid only in the limiting case of microscopic systems, whereas the view here represented assumes it to be valid for all inanimate objects.” (“Remarks on the Mind-Body question.” In Good 1962:300, fn. 11)

<sup>22</sup> In “Philosophy of Physics – the problem of ‘measurement’ in quantum mechanics.” First published in Franklin H. Donnell Jr. (ed.) *Aspects of contemporary American Philosophy* (1965), Wurzburg, Physica-Verlag, Rudolf Liebing K. G. Reprinted in Hilary Putnam 1979.

### 5.2. Defense

To these charges Wigner and Margenau respond, that Putnam challenges them to restate the theory without mathematical formalism and that Putnam's argument is faulty:

According to von Neumann and London & Bauer every measurement is an interaction between an object and an observer. [...] The object obeys the laws of motion, [...] as long as it is ...separated from the rest of the world. [...] this is the case during time intervals *between* measurements. [...] [and not true during measurement] [...] The chain of transmission of information from the object to the consciousness of the observer may consist of several steps... . One cannot follow the transmission of information to the very end, i.e., into the consciousness of the observer, because present-day physics is not applicable to the consciousness [of the observer] [...] [as] has been clearly recognized by both John von Neumann and by London & Bauer. As they express it, one must introduce a cut between object and observer and assume that the observer has a 'direct knowledge' of what is on his side of the cut. [...] We must also reject the suggestion that quantum mechanics treats the universe as consisting of two qualitatively different kinds of things, "classical" objects and micro-objects. [...] [C]lassical objects are included as proper limiting concerns of a probabilistic theory which, in this limit, reduces to classical physics. (Margenau and Wigner 1962:292-3)<sup>23</sup>

## 6. WIGNER'S ATTEMPT TO CLARIFY "POLANYIAN" TACIT KNOWLEDGE

Although Wigner satisfied himself that his explanation to Putnam will stand, he was still looking for an epistemological explanation to reconcile or integrate the incompatible elements in tacit knowledge. Polanyi sent him his lecture on "Visionary Art" which contained his views on the integration of incompatibles.<sup>24</sup> By this time the two were "talking past each other", and Wigner was polite and respectful about Polanyi's "helpful" analogies. In the postscript of the above mentioned letter of February 4, 1971 Wigner said: "I enjoyed many parts of it, but do not feel its meaning. Perhaps, as I often say, wisdom cannot be taught except to those who already possess it 'tacitly.'" (MP Papers 9:7)

<sup>23</sup> Margenau and Wigner, "Comments on Professor Putnam's Comments." In *Philosophy of Science* 29 (1962) 292-93. Reprinted in Wigner (1995) pp. 31-2. For Putnam's reply see "Discussion: Comments on Comments on Comments: a reply to Margenau and Wigner." *Philosophy of Science* 31:1-4. (1964) Reprinted in *Philosophical Papers* Vol. 1, pp. 159-65. For Polanyi's notion on direct and indirect knowledge, see end of section 7 below.)

<sup>24</sup> The Meaning Project, University of Chicago Lecture 3, "Visionary Art," May 27, 1969. MP Papers 39:10)

Apparently Polanyi sent the manuscript of this 1969 lecture to Wigner as part of their conversation on Wigner's puzzle about the measurement problem that observation changes the observed.<sup>25</sup> The lecture is an illustration of the way the mind integrates incompatible elements and interprets them in a [new] coherent framework. Polanyi thought this is also done in the natural sciences:

The creation of hitherto inconceivable conceptions by the combination of hitherto incompatible features is a commonplace in mathematics and modern physics and, here too, these innovations are usually fraught with indeterminate implications. (Ibid. 23)<sup>26</sup>

The detailed illustrations explaining the mental process are from surrealist painting, poetry of Baudelaire, Rimbaud, Eliot, etc. (he called these poems of symbolism, intuitionism and formalism by the collective term 'visionary art'), as well as from the structure of myth as analyzed by Eliade. The artist's interpretation of experience must make a break from our usual perception – it views its subject suspended in one moment, timeless. The form and content of the poem or the painting are deliberately incompatible; the acceptance of such art by the viewer is done

by sustaining the belief that art is meaningful, and discovering thereby the joint meaning of its focally incompatible elements. (Ibid. 3) [He goes on to say:] [T]he powerful act of the imagination ...comprehends all details in one... its disparate elements have a joint meaning, [...] which will be strikingly novel...the more incompatible were its unintegrated elements. (Ibid. 7) [...] [W]e find their visionary form unintelligible until we realize that we must not try to understand them as representing a sequence of events that hang together in the way real events do. [...] [and quoting Robbe-Griller he continues:] 'In the modern novel time has ceased to exist. Or rather it is a time without temporality, it is an instantaneous time which never creates a past [...] never accumulating to form either a memory or things past to which one can refer one day; it is a present that has no value save in the present. (Ibid. 9)

Polanyi means by this, that this non-temporal instant (in myth it is the "beginning of time") is to be differentiated from normally perceived time, which is perceived as continuous and irreversible. (Ibid. 9)

Art creates facts of our imagination, which guide our thoughts. The artificiality of form enables it "to act as a framework detaching the events to which they apply, and endow these with tangible and lasting quality by luminous imaginative powers [insight]. (Ibid. 15)

<sup>25</sup> Observation in two senses: the act of observation and the data.

<sup>26</sup> "Visionary Art" Ibid. 23.

Although Polanyi thought that his exploration in this lecture – of how incompatible elements can be given meaning by a new framework – would be a key piece in the epistemology of quantum measurement Wigner was looking for, Wigner’s comment to him was, that he did not understand Polanyi’s meaning, that perhaps “wisdom cannot be taught except to those who already possess it ‘tacitly.’” Wigner seemed to be frustrated by Polanyi’s examples and analogies – they seemed too vague and mystical, and did not capture what Wigner was looking for. Perhaps the meaning of “incompatible” was so different for the two, that they could not envision “integration in tacit knowing” in the same way. Was Polanyi saying, the incompatible elements (behavior as either particle when observed, or wave when not observed) can be integrated somehow by the power of the imagination, but then does not say how? Was he saying one needs to believe that science is meaningful, that the scientist’s interpretation of the event is not like interpretation of ordinary events? But earlier Polanyi used the analogy that scientific understanding, insight, is similar to gestalt perception, an analogy Wigner objected to, because he was looking for an epistemological explanation, and took Polanyi’s analogy as a psychological one. Was his comment about ‘tacit wisdom’ a way of saying to his aging teacher and friend “you are not explaining, you are retreating into poetic descriptions which do not apply”?<sup>27</sup>

## 7. POLANYI’S “DEFINITIONS” OF ASPECTS OF TACIT KNOWING

Although both Polanyi and Wigner refined their working definitions of epistemology, it would be useful to see how these were related over the ten-year period when they were corresponding about this topic.

First, Polanyi’s view on how he sees the relation between epistemology and psychology, since this was one of the aspects Wigner found frustrating in Polanyi’s explanations.

He said on knowledge interpreted from behavior:

Epistemology reflects on knowledge which we ourselves believe we possess; the psychologist studies knowledge which he believes to have been acquired by another individual and studies also the shortcomings of such knowledge. No knowledge, whether our own or that of a rat, is fully specifiable; but the fact that we must rely on recognizing the rat’s knowledge, or ignorance, from our knowledge of the rat’s behaviour, involves an additional enquiry and an additional unspecifiability. (Polanyi [1958] 1962:365)

<sup>27</sup> Wigner was famous for his courtesy. After this exchange there is one more letter the following month about an upcoming conference, but no discussion. Correspondence continues sporadically until 1974, but there are no further substantive exchanges on epistemology.

In *Personal Knowledge* Polanyi “defined” his new epistemology this way:

I start by rejecting the ideal of scientific detachment. ...[I]t falsifies our whole outlook far beyond the domain of science. I want to establish an alternative ideal of knowledge, quite generally... Personal Knowledge. The two words may seem to contradict each other ... But the seeming contradiction is resolved by modifying the conception of knowing. [...] I regard knowing as an active comprehension of the things known, an action that requires skill. Skilful knowing as doing is performed by subordinating a set of particulars, as clues or tools, to the shaping of a skilful achievement, whether practical or theoretical. We may then be said to become ‘subsidiarily aware’ of these particulars within our ‘focal awareness’ of the coherent entity that we achieve. Clues and tools are things used as such and not observed in themselves [subsidiary knowledge can function as instrumental knowledge]. They are made to function as extensions of our bodily equipment and this involves a certain change of our being. Acts of comprehension are to this extent irreversible, and also non-critical. For we cannot possess any fixed framework within which the re-shaping of our hitherto fixed framework could be critically tested. [...] Personal knowledge is an intellectual commitment, and as such inherently hazardous. (Polanyi [1958] 1962 vii-viii.)

In redefining knowledge, Polanyi combined “ineffable” knowledge of skills and knowledge acquired by education.

This ineffable domain of skilful knowing is continuous in its inarticulateness with the knowledge possessed by animals and infants, who [...] also possess the capacity for reorganizing their inarticulate knowledge and using it as an interpretive framework. [...] We may say in general that by acquiring a skill, whether muscular or intellectual, we achieve an understanding which we cannot put into words and which is continuous with the inarticulate faculties of animals. [...] [understanding in this manner has an existential meaning, understanding of language has a denotative meaning which is a special case of existential meaning]. To assert that I have knowledge which is inaffable is not to deny that I can speak of it, but only that I can speak of it adequately, the assertion itself being an appraisal of this inadequacy. [...] We acknowledge our own capacity to distinguish what we know from what we may be saying about it... (Polanyi [1958] 1962:90-1)

Polanyi also redefined the use of the word “true”:

We have re-defined the word ‘true’ as expressing the asseveration of the sentence to which it refers. This is closely akin to Tarski’s definition of ‘true’ which implies, for example: “snow is white” is true if and only if snow is white.’ But Tarski’s definition now appears to equate a sentence with an action. This anomaly may be eliminated by revising the definition as follows: ‘I shall *say* that “snow is white” is true if and only if I *believe* that snow is white.’ [...] Earlier on [...] I have denied the possibility of expressing the act

of placing my confidence in a statement of a fact by a statement of the probability of this fact. [Suggested that Frege's prefix, assertion sign, should be read as 'I believe' as an endorsement of the statement.] Such a prefix should not function as a verb, but as a symbol determining the modality of the sentence. The transposition of an assertion sign [...] would correctly reflect the fact that such an assertion is necessarily attributable to a definite person at a particular place and time...We might have a better chance of achieving the purpose of epistemological reflection if we asked ourselves instead [of the quality of sentence of being true or false by impersonal criteria] why we do believe certain statements of fact, or why we believe certain classes of statements, such as those of science. [The antecedent beliefs justifying these statements are the self-set standards of science.] (Polanyi [1958] 1962:256)

It should also be mentioned again, that for Polanyi, logic did not mean only formal logic, but the whole range of informal logic the rational mind uses – including, and especially tacit inference, which is the power of the mind to make connections, to see the relation of part and whole.

His whole personal epistemology was a campaign against reductionism. In his opinion, Laplacean ideas were continued in the notion that DNA, its chemistry and physics, will be the ultimate explanation of living organisms. (According to Polanyi, DNA, rather, functions as a boundary condition irreducible to chemistry and physics) He described the hierarchy of organization of living organisms not only by analogy to the structure and function of the machine (to which Wigner objected), but also, he explained this organization (organismic principles) in his 1965 “The Structure of Consciousness”:

Living beings consist in a hierarchy of levels, each level having its own structural and organismic principles. On the mental level, explicit inferences represent the operations of fixed mental structures, while in tacit knowing we meet the integrating powers of the mind. In all our conscious thoughts these two modes mutually rely on each other, and it is plausible to assume that explicit mental operations are based on fixed neural networks, while tacit integrations are grounded mainly in organizing fields. I shall assume also that these two principles are interwoven in the body, as their counterparts are in thought. (In Grene 1969b:219)

For Polanyi, principles of this control are organizing fields, organizing principles, illustrated by how (according to C. H. Waddington) the development of the embryo is controlled by the gradient of potential shapes<sup>28</sup>. He also called the organizing principle organismic principle.<sup>29</sup> Polanyi's 1968 article, “Life's irreducible structure” (in Grene

<sup>28</sup> This analogy is controversial.

<sup>29</sup> This principle is not explained, but seems to be postulated as a parallel to his epistemology's “active element” added to the passive Gestalt. (See Jha (2002) Ch. 2.)

1969b:225) reiterates that organismic processes, as a level of explanation for living organisms, are irreducible. The progression is upward, with boundary conditions specifying the relations, from inanimate to life, each with a deeper level of significance.<sup>30</sup> – He also uses this organization as an explanation of (what in standard talk is called) the “objective” and “subjective” mode of seeing and to highlight the mind-body problem, as well as direct and indirect knowledge, which is of great importance assessing knowledge resulting from scientific experiments. In this article he noted:

I have said that the analytic descent from higher levels to their subsidiaries is usually feasible to some degree, while the integration of items of a lower level so as to predict their possible meaning in a higher context may be beyond the range of our integrative powers. I may add now, that the same things may be seen to have joint meaning when viewed from one point but to be lacking this connection when seen from another point [as seeing patterns on the ground from an airplane, but not from the ground]. The relation of mind to body has a similar structure. The mind-body problem arises from the disparity between the experience of a person observing an external object, e.g., a cat, and a neurophysiologist observing the bodily mechanism by use of which the person sees the cat. The difference arises from the fact that a person placed inside his body has a *from-knowledge* of the bodily responses evoked by the light of his sensory organs, and this from-knowledge integrates the joint meaning of these responses to form the sight of the cat [from-knowledge, or from-to knowledge is direct, it functions from the body to what is in focal awareness]; whereas the neurophysiologist looking at these responses from outside has but an *at-knowledge* of them which, as such, is not integrated to the sight of the cat. [from-at knowledge is indirect, by looking at and interpreting data from an instrument – the neurophysiologist does not perceive the same thing as the cat does] This is the same duality that exists between the airman and the pedestrian in interpreting the same traces... [Similarly, in reading a sentence, the difference between a person familiar with a language and one not – the first understands the meaning, the second sees only letters]. Mind is the meaning of certain bodily mechanisms; it is lost from view when we look *at* them focally. [...]. Owing to the existence of two kinds of awareness – the focal and the subsidiary – we can distinguish sharply between the mind as a from-to experience and the subsidiaries of this experience, when seen focally, as a bodily mechanism. [...] though rooted in the body, the mind is free in its actions – exactly as our common sense knows it to be free. (in Grene 1969b:237-8)

For Polanyi, epistemological inquiries mean questions of “how do we know, and what do we rely on to know”, rather than “is this statement logically true or false in a deductive process”. There is a continuum between psychology and epistemology, and his re-definitions have bridged whatever gap standard interpretations saw.

<sup>30</sup> The isomorphism with epistemology is clear here, i.e., evolution as “achievement”. (Polanyi [1958] 1962:388)

## 8. EXPLANATORY GAPS

Wigner, in his 1965 paper for the Unity of Knowledge Conference, “Epistemology of quantum mechanics – its appraisal and demands”, was understood to say that the present (1965) state of the sciences hold that there is a gap between psychology and the physical sciences. (in Grene 1969a:22) Psychologists want to warn physicists, that their findings may be influenced by subjective considerations, and affirm that psychology aims to explain the processes of the mind by the laws of chemistry and physics. Wigner considered this direction doomed. Physicists warn that “the laws of physics give only probability connections between the outcomes of subsequent observations or contents of consciousness.” (Ibid. 24) Wigner thought that the direction of quantum physics has more promise, although quantum mechanics will be a “limiting case of something more general”. The body and mind form a unit, and a dualistic conception is problematic.

How does one understand the “gap” between the natural sciences and psychology? The natural sciences look for regularities of behavior of bodies (provide explanations, explore circumstances and conditions), the descriptive sciences including psychology, look for characteristics of these bodies (the older sciences, e.g. astronomy, have discovered a larger number of regularities, and transformed themselves into other disciplines). Seeking regularities, making progressively more encompassing theories, is a way to deal with the limit of the human mind to absorb particulars. These newer sciences also make discoveries, innovate (create new phenomena). – Psychology has begun to seek regularities such as theories of the subconscious, and Polanyi developed a theory of tacit knowledge, which can be examined before exploring the epistemology of physics.

## 9. SORTING OUT THE POLANYI - WIGNER DIALOG

Looking over the approximately ten year substantive correspondence on tacit knowing regarding the measurement problem in quantum physics, one can see the following:

### *9.1. Wigner's side:*

Wigner is trying to find an explanation for the quantum mechanical phenomenon that observation changes what is observed. (Note that observation has two meanings, not clearly differentiated here: observation as the act of observing by a person, and observation as a result of that act, data). Wigner's hunch is that the mind's action, taken on the quantum level, influences the path of the observed quantum entity (in analogy with light influencing matter in the Compton effect), and that there is a potential explanation for this by a future hybrid science of physics-psychology.

He does think that the theory is incomplete; it is a puzzle to be solved in the future by such a new science.

### 9.2. Polanyi's side:

Polanyi thought this line of speculation is not fruitful. He considered this explanation, as all naturalized epistemological explanations, reductionist. According to him, there is no ontological difference between the “stuff” of classical physics and the “stuff” of quantum physics as explained by probabilistic quantum physics:

For the laws of quantum mechanics coincide with those of mechanics for reasonably heavy particles. However, to be precise, the classical predictions of positions and velocities would have to be replaced by predictions of the probability distribution of positions and velocities. [footnote:] My argument will reveal my dissent from [...] [a] widely held opinion of great importance. In quantum mechanics any attempt at specifying the position and velocity of an electron must be defined in terms of the electron's interaction with a definite measuring instrument. The result will depend on the instrument chosen and will again be a statement of probability. [...] [T]he outcome of the observation does not depend here on the participation of the *observer*, but on the action of a *measuring instrument*, the result being the same for any observer. This contradicts on the one hand the view that the relation between the macroscopic and microscopic descriptions of an atomistic system is an instance of complementarity; and it shows also on the other hand that (contrary to a widespread opinion) the indeterminacy principle of quantum mechanics establishes no effect of the observer on the observed object. The supposed effect vanishes if we include the ‘measuring instrument’ in the ‘observed object’. The latter becomes then ‘the observed phenomenon’ in the sense now accepted by Bohr's school of interpretation. (Polanyi [1958] 1962:392-3)

In essence, Polanyi is saying that Wigner's problem is one of interpretation – that this formulation of the question leads to unfruitful directions for an answer, to a physical, causal link as an explanation to the quantum mechanical measurement problem.

### 9.3. Their epistemologies:

It may be said that both Polanyi and Wigner constructed their ontologies in *parallel* to their epistemologies. Wigner's epistemology expressed in the measurement problem as knowing a quantum entity only when effected by the knower (unobserved entities whereabouts can be predicted but not “known”) has a Kantian echo of “*ding an sich*”.

It is not the Kantian flavor to which Polanyi objected, neither did he object to Wigner's attempt to try to apply the notion of tacit knowing to the process. He objected to transfiguring tacit knowing into what he considered to be still a “physical” process, a reduction. To Polanyi, the tacit is a vector – in epistemology, it takes the form of integration, and in ontology it takes the form of emergence. (Polanyi 1966)

To him, the mind-body connection was not a question of causal explanation, but a question of “achievement”, an emergence or innovation, a teleologically indicated vector. His notion of tacit is one “pulled by the goal” of the vector, not “pushed” by causes. If causal explanations require definitions and entities being specified, Polanyi’s ontology cannot accommodate it. What he calls his comprehensive entities of the higher levels, although they rely on the lower physical levels in the hierarchy, are unspecifiable (the more complex an entity is, the more unspecifiable it is – our knowledge of it is unspecifiable by its elements).

#### 9.4. *Their ontologies:*

Since their epistemologies are parallel to their ontologies, and for Polanyi, a template for his ontology, the following can be said: For Polanyi, the higher levels in the hierarchy of emergence are more real than the lower levels (thoughts are more real than physical objects). For Wigner, there are two kinds of reality: thoughts, and everything else. It is the primacy of thought in their ontology, and admitting the importance of non-explicit (tacit) thought in their epistemology of science, that they share. This may be the basis of Wigner’s claim for his “Polanyian” epistemology.

However, Wigner was not satisfied with Polanyi’s analogical descriptions of the mind-body connection, he found them vague. Wigner took Polanyi’s analogy of the machine to describe levels of emergence as not applicable to living organisms. Wigner found puzzling, mystifying and non-explanatory Polanyi’s analogy of synthesis of incompatible elements (described in the context of art and eastern religions) as providing a possibility for emergence of the mind and higher conceptual levels in innovation. So the decade long dialog about tacit knowing and the measurement problem was inconclusive – Polanyi was not convinced by Wigner that quantum mechanics had a different ontology than classical physics and therefore tacit knowing can be incorporated, and Wigner was not convinced that Polanyi found a satisfactory explanation for the body-mind connection. The dialog ended as the aging Polanyi’s responses to Wigner grew less fresh and focused.

In a sense, both were looking for a bridge between *Naturwissenschaften* and *Geisteswissenschaften* to answer the mind-body problem. *Geisteswissenschaften*, in its old meaning would provide at least some of the three integrated elements they were looking for: reason (soft sciences), “feeling as” (art), and “feeling that” (religion), which could be looked at experimentally. For Polanyi, science and art exemplified “vision”, as in insight, or Kant’s “mother-wit” – and religion exemplified “awe”. His extensive explorations were in the phenomenon of insight, although he made less successful forays into “awe”. Wigner did not use art as an analogical resource, but on occasion he treated “*Geist*” as “soul”, as an alternative to finding a Quantum Mechanical explanation the mind-body problem.<sup>31</sup>

<sup>31</sup> “A physicist looks at the soul.” (1968), in Wigner (2001) 7B, pp. 41-3. Wigner was shifting between use of “consciousness” and “soul” according to the occasion and the audience.

## 10. A SUMMING UP AND SOME QUESTIONS REMAINING

A summing up and some questions remaining after this study on the influence of consciousness: How “polanyian” was Wigner’s epistemology of physics? And remarks on extrapolating the Polanyi-Wigner discussion on epistemology through their essays. Current investigations.

We must note that most of the Wigner essays that fall in the ten-year period under discussion here, give the impression that Wigner was committed to the hypothesis that the reduction of a superposition is the work of consciousness. This is the function of the selective attention in this paper on the Polanyi-Wigner discussion on tacit knowledge. The larger question of the quantum theory of measurement cannot be explored here. For that study, and to investigate a trace the “element of consciousness” (Wigner’s “Polanyian” epistemology) in this regard, see the works of A. Shimony (2002; in Wigner’s *Collected Works*, vol. 3). Shimony as well as L. Diosi in “His Function and its Environmental Decoherence” (2004) pointed to the influence of D. Zeh on Wigner (along the lines of London & Bauer and von Neumann): consciousness is the phenomenon that could violate the linear laws of quantum mechanics. (d’Espagnat (1976: 263) Zeh (2000, 5) noted that a “concept of observation must ultimately be based on an observing subject.” Diosi (2004:29-34) also pointed out that Wigner was an early supporter of what later was called “environmental decoherence”. In this article Diosi said that Wigner was also impressed by Zeh’s claim (d’Espagnat 1971:263) that a macroscopic body’s inner structure (wave function) is influenced by its environment (it cannot be a closed system). A. Shimony referred to the same claim by Zeh as an influence on Wigner. (Wigner in d’Espagnat 1971:16-7)

Shimony stated (personal communication 3/29/2007) that Wigner considered hypotheses other than the hypothesis discussed in this article (i.e. the reduction of the superposition is the work of consciousness), but did not choose among them.<sup>32</sup> Shimony noted (Shimony 2002) that one of the proposed tentative solutions (“Wigner’s solution”) to the various problems in the quantum theory of measurement was that consciousness may play a role in the reduction of the wave packet, but, Wigner while evaluating Zeh’s observation that the macroscopic system of the measuring apparatus is not a closed system, was skeptical of this observation’s use to solve the reduction of superpositions.

Further remarks on the “dialog” through their essays: Between 1961 and 1963 both Wigner and Polanyi wrote rich and productive essays on the problem of the knower and the act of knowing. Wigner’s were published in the collection *Symmetries and Reflections*. Three are relevant here. His 1961 “Two kinds of reality”

<sup>32</sup> A. Shimony offered the following references on this point, among others: Wigner (in Good 1962) “Remarks on the Mind Body Question.” Endnote 11; d’Espagnat (1971). See also A. Shimony (2002) “Wigner’s Contributions to the Quantum Theory of Measurement.” Also, Shimony “Wigner on Foundations of Quantum Mechanics.” In Wigner, *C.W.* vol. 3A, pp. 401-414.

was already mentioned above. This essay was of a dualist, idealist flavor. The person's consciousness is "absolute reality", and it is not permanent. All else, including objects, are "universal reality", with various degrees of probability, and it is useful to think of them as permanent. The two kinds of reality are not independent. As mentioned above, the greater reality of mind than of objects and the interlinking of the "two realities" echoes Polanyi's conception, although Polanyi has no category of "absolute".

Wigner followed this piece with a 1962 essay "Remarks on the mind-body problem", in which he discussed the "measurement problem", saying that to measure quantum motion, the sentient being's entrance changes linear equations to grossly non-linear ones. That is, consciousness influences the "observed" via the physical world (instruments) (Wigner 1967:182). He seems to give his own answer here, but is not satisfied with it. In this essay he gives a speculative solution (thesis?) to the mind-body problem: simple substrates give rise to simple sensations, while complex substrates give rise to complex consciousness. The mind is a "complexification". His thesis is that there is a correlation between the physical substrate and consciousness via the structure in which it exists. This correlation can be discovered only by two avenues: observation of human development, and the discovery phenomena in which consciousness modifies the usual laws of physics. (Ibid. 182) Is it possible that the question/thesis is put wrong – looking at the structure instead of functional relationships and properties – therefore it points towards no solution? Polanyi's "answer" to this is stated in "The Logic of Achievement" at the end of his *Personal Knowledge*. (Polanyi [1958] 1962, chapters 11-13)

Wigner's next essay was his 1963 "The Problem of Measurement," in which he presented the orthodox view and its critique. According to the orthodox view, possible states of a system, its state vectors, change in two ways: (1) continuously as a result of the passage of time, according to the equation of motion of quantum mechanics; and (2) discontinuously, according to probability laws, if measured (reduction of the wave function). This aspect is opposite to expectations in ordinary experience. The system consists of the object and the apparatus (observation on the apparatus). Wigner's criticism is that a full description of the observation is impossible: quantum mechanical equations of motion are causal and contain no statistical element – the measurement does.

These three essays look at the problem of measurement from various angles. However, Wigner did not seem to have made progress during this decade toward the "new science" he envisioned as the instrument for the solution of the problem.

In the same period of time Polanyi wrote several pieces that were collected in *Knowing and Being* – two of them discussed above ("Tacit Knowing" and "Knowing and Being"), as well as a reflection on his years of discovery "My time with X-ray crystals". In this 1962 essay he notes that discoveries bring forth some intrinsic potentiality of the intellectual situation of the field – it only *seems* to be a "flash of discovery", this essay, as some of his others, show the social "gestation" of a discovery.

His next 1962 essay “The unaccountable elements in science”, speaks more directly to Wigner’s puzzle. He reiterates here, that personal judgment cannot be replaced by the operations of explicit reasoning – tacit operations play a decisive role in discovery and in holding scientific knowledge. Pointing to Kant’s reference to “mother-wit” when no rules of reason could be determined for application of rules, Polanyi holds that the ultimate agency for decision-making in a particular instance is personal judgment. – To solve a scientific problem is to see if there is anything to an anomaly. One must pick out a significant regularity, a pattern. The gift of seeing this marks a ‘scientific genius’ – mathematical analysis of patterns only formalizes the phenomenon, its significance is in the intuitive informal decision. Polanyi holds that a scientist attributes meaning to a sequence of events, to randomness in relation to potential order – e.g. noise in relation to true signal – to elements in certain configurations. The clues a scientist sees from which he integrates the meaningful whole, have to ‘leap a logical gap’ to integrate into a whole. It is a process of embodied knowing, a power of intelligence guided toward a solution, toward the achievement of a coherence. (Note, that for the mind to achieve an integration, a *simple partial* analogy is a gestalt perception). For a researcher, “a good problem is half a discovery”. “A problem is something that is puzzling and promising...” a gift of sensing the direction toward a surprising solution. (Ibid. 117) It is interesting that Polanyi gave a new definition of external reality woven into this above description of a “good problem”. He said: external reality is

something that attracts our attention by clues which harass and beguile our minds into getting ever closer to it, and which, since it owes this attractive power to its independent existence, can always manifest itself in still unexpected ways. (Ibid. 119)

One might conclude that Polanyi, in one sense, is telling Wigner that perhaps his “problem” is not a good problem. He said that much in his comment on the measurement problem in *Personal Knowledge* (section 9.2 above). He also believed that Wigner’s attempt to formalize the measurement problem and make it explicit in the way he did, missed the point, that Wigner’s understanding of tacit knowledge as the last few steps of observation which creates the measurement problem in the observer’s consciousness, was not the kind of tacit knowledge he has been describing, that Wigner’s epistemology of quantum mechanics is not “Polanyian” (although he agreed that in human development, learning and understanding have a tacit component).

At the beginning I quoted Rohrlich’s comment about seventy years of effort to solve this puzzle. It is to be seen whether the solution to the puzzle will eventually be provided in line with Wigner’s hopes, by a combination of quantum mechanics and psychology/neurology by a notion similar to that of Penrose’s micro-tubules within neurons within which occurrences of “quantum-coherent activity” constitute

consciousness<sup>33</sup> – or in line with Polanyi’s speculations of informal logic and meaning-making couched in metaphors and analogies, a basically irreducible and emergent property of experience. Ultimately the “solution to the puzzle” will depend on what level of explanation we are looking for.

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<sup>33</sup> Penrose (1997), also see recent papers of Stuart Hameroff in *Quantum Consciousness* and *Journal of Biological Physics*.

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