

# The Experimentalist's Experience

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## ABSTRACT

I attempt to pose the following question in a framework which makes it meaningful: "What is the active operation in the evolution of knowledge?" The framework borrows from the theories of Michael Polanyi and the author's experiences in the enterprise of experimental particle physics. I suggest that the above question can be reduced to, "How do we learn to ask original questions?" and would like to think that I have thereby done so.

## INTRODUCTION

Any author knows enough to write from his own experience; attempts to trespass on unknown territory invariably lack much conviction and authority. However, any author also knows that a work is written *from* experience, *to* discovery. That is, the completion of any work leaves the author with new experience, new understanding, new knowledge, which was not present when he started.

I am no authority on epistemology; in fact I am the rankest of amateurs — I fancy myself, in fact, perhaps the least knowledgeable metaphysicist ever to attempt a piece of the intended gravity of this one, with sufficient arrogance take it seriously. I do, however, have a measure of experience in the realm of experimental physics, and some appreciation of the creative process in literature, both of which I believe to provide some poignant lessons for the epistemologist; and out of the pool of such experience I hope to crystallize several of those lessons.

There seem to be two diametrically opposed viewpoints of the nature of "reality" which enjoy popularity today: the first view holds that reality is bound up in the laws of physics as expressed in the motions of electrons, *etc.*, and that mental activity is simply a particularly complicated example; the second view holds that the "external" world we observe is not really external at all, but merely a projection of our mental structures upon our experience. Once upon a time, these views would have been labeled "Objectivist" and "Subjectivist," respectively, and I would have probably felt obligated to ridicule one in favor of the other. Times have changed since Newton and Descartes, however, and both views have been elevated to sufficient sophistication that neither deserves ridicule. Examples are Karl R. Popper's *Objective Knowledge* on the one hand, and David Chilton Pearce's *The Crack in the Cosmic Egg* or Carlos Castaneda's books

on the other. I feel that it is unfortunate that this battle continues on grounds which suffer so much from semantic inadequacy; surely the ultimate resolution of this apparent conflict can only come from a synthesis of “objective” and “subjective,” as for instance in Fritjof Capra’s book, *The Tao of Physics*.

I want to avoid this metapolitical hassle if possible; one however requires words with which to write, and behind the words are concepts one may regard as inadequate; so I’ll do what most people do at this point: try to redefine some words to my own liking. My “flag words” are going to be “**Reality**” and “**Existence**.”

**Existence** includes everything. Yep, that too. The *Tao*, the *Brahman*, the experimenter and the experiment, and all the mental processes that contributed to or benefit from those concepts. Also something else.

**Reality** is a subcategory of Existence which is intimately associated with mind, awareness, consciousness, or whatever you want to call it. I propose that the tree falling in the woods *exists* independently of any conscious awareness, but it cannot be *real* without someone for it to be real *to*.

**Experience** is the process by which the borders of Reality are extended into Existence.

In this context I think I have alleviated some of the unnecessary metapolitics; a naïve subjectivist viewpoint would be simply expressed as follows: Reality = Existence. A naïve objectivist viewpoint would read: Reality = 0. In this way I have contrived to make both seem rather silly, I hope.

I have also generated another entity, which is the part of Existence which is *outside* Reality. This region corresponds roughly to what is traditionally referred to as “objective reality” or the “external world” or other phrases which I find very misleading. I will call **The Unknown**, and entertain the presumption that it is not an empty category. Now a naïve objectivist viewpoint becomes: The Unknown = Existence, which makes it sound even sillier, so let’s not be naïve. The title of this paper refers to Experience in this sense as well as the usual dictionary sense; I suppose I could talk about the experience of Experience. This is the eventual focus of my analysis, since I feel strongly that I have good evidence for the all-important process

$$\text{The Unknown} \longrightarrow (\text{Experience}) \longrightarrow \text{Reality} \quad (1)$$

which is, obviously, the fun part.

But first I need to build up some background: if these “flag words” represent categories, what are they categories *of*? And what is the interaction of our individual and/or collective minds with the elements of Existence which make it Reality? For this I will borrow heavily from Michael Polanyi.

## REALITY

It should be clear that, using my definition, Reality is all we know about. Within this definition it also follows that Reality “is all in your mind;” *i.e.*, the subjectivist view is quite appropriate

when applied to Reality *alone*. Let me explain the reasoning behind this somewhat startling assertion.

Reality proper contains only that part of Existence which is *known*. That is, The Unknown passes through Experience into the awareness of minds, which, in order to *be* aware of it, are obliged to translate Experience into familiar terms, *i.e.*, theories, paradigms, languages, *etc.* Once Experience has been codified, it can be restructured and recombined according to the rules of mental modeling, more or less *ad infinitum*. I believe that our awareness of Reality (which by my definition *is* Reality unless we have some means of perceiving Existence directly, without models) consists entirely of fitting and refitting Experience (which, recall, is the transition *Process*) into models. Thus I have removed the familiar objections to such altogether model-dependent Reality by transferring them to the interface, Experience. I will come back to that later.

The above assertion can be stated, perhaps more clearly, as follows: *Reality consists only of models*. I have a concept in mind, “paper;” that concept is a complex theoretical entity structured after a *word* in my language, with all the richness of connotation and ambiguity. I also have in mind another concept, “this piece piece of paper,” the one I am writing on; this model is less, but still very, rich: it involves a number of interactions I have with the paper, one of which is my visual perception of it. That visual perception of this sheet of paper is in turn a model of nerve impulses, which are translated from physiochemical processes in my retina, which are the interpretation of the responses of rods and cones to absorbed photons, which I *assume* to have been reflected from “the actual physical paper surface” *whose very existence* is a theory. Whether “that which gave rise to these perceptions of the paper” is part of my Reality or part of The Unknown is not perfectly clear to me, but since I am able to name it I will assume that it is real, and therefore in my Reality. In fact, the further I drive this attempt to describe where The Unknown begins, the further The Unknown retreats before Reality, as I name new models of the Unknown. And of course “The Unknown” as defined here is in Reality by virtue of being defined; the real Unknown always retreats before our attempts to describe it. Let me desist with this chase for now.

I have been asked why The Unknown is needed at all in this model of Existence, especially considering its instant retreat from any attempt to conceptualize it. The principle reason is aesthetics, but I believe there are points where it is needed if we wish to discuss *Yin* and *Yang* as well as *Tao*. The most dramatic case is found in the instance of *two minds*. Mind A and mind B can coexist without knowing it (unless you postulate some sort of involuntary telepathy); thus Reality is immediately fragmented into Reality A (that which is known to mind A) and Reality B. In fact, Mind B is at that point in The Unknown of Mind A. A “nice” example would be if B belonged to an intelligent race of beings from Tau Ceti of which *Homo sapiens* had no previous knowledge. This makes all the (possibly false) dichotomies defined here extremely relativistic and complex, but it is in this complexity, I believe, that the richest meaning of my terms can be found, along with the possible justification for including The Unknown in the model.

Nevertheless, I will sidestep this rich complexity for the time being and speak of one Reality in a single mind, so as to be able to say more before language breaks down. I would like to call this subset of Reality “A Separate Reality,” but that’s been used. I’ll call it Isolated Reality.

In a strictly logical sense, Isolated Reality is the only kind there is. I can only be aware of my own models, hence my Reality is entirely inside my mind, and other minds are in The Unknown

with respect to mine (*i.e.*, in my Unknown) unless there is some direct bridge between my mind and other minds, in which case we are all just subsets of a larger mind (“We are all one in the Mind of God”). Not knowing whether this is the case or not, I will stick to the popular paradigm, which states that separate individuals’ minds communicate as follows:

$$\text{Mind A} \longleftrightarrow \text{Experience A} \longleftrightarrow \text{The Unknown} \longleftrightarrow \text{Experience B} \longleftrightarrow \text{Mind B} \quad (2)$$

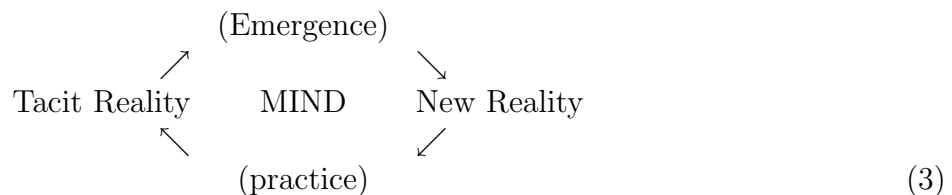
Here A and B explicitly share at least part of The Unknown. If we are indeed all part of one mind, then the need for an Unknown is considerably weakened, though its possible presence can never be eliminated logically. (Karl Popper would consider this feature to be the strongest argument against such a model.) In any case, if we do posit an Unknown, then it doesn’t really matter at what level Reality is Isolated, except in a personal sense.

## EMERGENCE

When an individual mind is born, its Isolated Reality starts to grow. This occurs (in my model) partially through Experience as an interface with The Unknown, but mainly through an intra-Reality process known as Emergence, whereby concepts are created out of concepts. To paraphrase Michael Polanyi, when we “practice” a model/paradigm long enough, it becomes “second nature” or “common sense”, or “tacit,” as he calls it. That is, it becomes so familiar that it recedes from our active, conscious awareness into our unconscious, where it acts as a building block or a “self-evident property” in terms of which we judge or describe and thus construct and enrich new, “higher-level” models/paradigms. I become adept at manipulating the extremely complex notion of “flat” and by the time it is common-sensical, I have used it to make models of milling machines, more general “curved” surfaces, and their  $n$ -dimensional extensions.

Thus Emergence, the process of making models of models, accounts for virtually all the growth of Reality, both in volume and In richness. The mathematician gives us the most easily perceived example of Emergence, since he carefully keeps archives of the many steps of hierarchical construction, striving to keep even the earliest and simplest from slipping into Polanyi’s Tacit Dimension. But the poet provides the most dramatic example, gathering as he does the entire richness of tacit understanding in his language and molding new language from it. Poetry moves faster than mathematics, but to follow it we have to accept the loss of any conscious understanding of its process, at least for now.

Mathematicians and poets are among the few groups of people who are aware that the whole point of their efforts is to *create Reality out of Reality*; yet no conscious mind can exist without making its own dramatic contribution to this enterprise. In fact, the vast majority of what we do with our minds can be expressed by the following diagrammatic representation of Emergence:



In fact, it is clearly feasible to assert that this is *all* we do with our minds, and that this is the exclusive process by which Reality grows. This assertion could be stated

$$\text{Reality} = \text{models}(\text{models}(\dots \text{models}(\text{models}) \dots)) \quad (4)$$

Thus, although this process certainly represents experience in the dictionary definition, it is distinct from Experience as I have defined it, namely the interface between Reality and The Unknown. Or is it? I would have been ill-advised to choose the word “Experience” to describe something which excludes almost all of what we subjectively regard as experience.

Let us ask the the following question: in what part of Existence (If any!) are conceptual relationships which the mind in question has not yet guessed at? If I have not yet even the vaguest unconscious suspicion of a model which will be (or may be) Emerged by next year at this time, is that model not in my Unknown right now? If so, is its Emergence not then a legitimate case of what I have defined as Experience? I think it is.

I hasten to point out that to permit Existence of models which have not yet been created by Emergence is neither deterministic nor suggestive of Platonism; at every juncture a vast, perhaps infinite variety of *choices* “preexist” in the Unknown for different ways in which the tacit components of existing Reality can be assembled to create new Reality, a new model. Like the superposed quantum state which contains the potentiality for several different final states following the interference of the observer, Reality is constantly bifurcating as the result of the specifically unpredictable acts of Emergence created by mind. In this way it is equally true that “potential” models are a part of Existence which is outside Reality, and that we *create Reality* constantly by the Experience of Emergence.

Here is an ironic example of the choice involved in Emergence: having hypothesized that Emergence is a true case of Experience in that potential knowledge is part of The Unknown, I am once again subjected to the temptation to simply forget about that other part of The Unknown, which is neither Reality nor potential patterns of models, but something new to be modeled. I will stick to this notion, however, because I have some strong intuitions about it. I will give it a name, “Experimental Experience,” the subprocess of Experience whereby we move the borders of our Reality into that special part of The Unknown which I will call the “Experimental Unknown.”

## EXPERIMENTAL EXPERIENCE

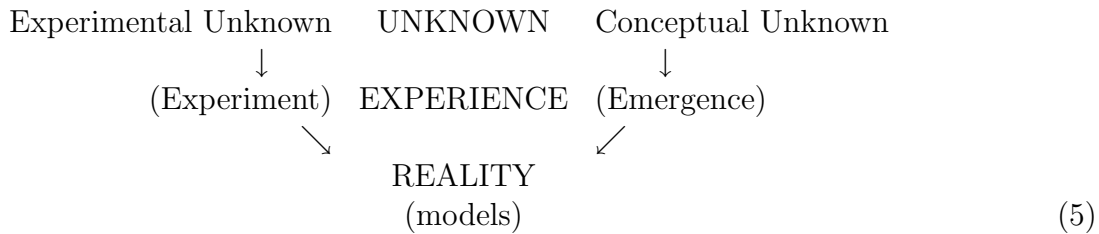
The evidence I offer for the Experimental Unknown is, like all evidence, inconclusive. But it is ubiquitous. It is this: many people go to a lot of trouble constructing elegant and richly self-consistent models, investing their own conviction and imagination in the Emergence of those models into Reality, only to have experiments flatly contradict the predictions of the models. And other people do experiments “just looking to see what’s there” and find, *independently of each other*, something consistent, dramatic, and repeatable, which they had not expected.

Now, I realize that an argument can be made that the only difference between these two cases is that the former thinkers lost sight of a serious inconsistency in the tacit building blocks from which they built their theoretical edifice, which caused it to cone tumbling down for purely

internal reasons, while the latter thinkers simply have extraordinary talent in their unconscious manipulation of tacit knowledge, and thus “discover” a new corner of Reality which they have already created. I consider this glib argument to be a sophism which tacitly maligns the ingenuity with which some people are able to ask unambiguous questions, or less ambiguous ones, in spite of the necessity to phrase any question in words representing existing paradigms.

A more serious argument with my interpretation of this evidence is that there is no Experimental Unknown, that “independent Experiments” do not exist because minds are not independent. If all minds are connected by a process more direct than (2), then there is logically only one mind, and any independence of one part of Reality from another is purely illusory. In this case, a sort of “majority rule” would be expected to govern the results of Experiment (Pearce takes this position, I believe) and once again we would have to deal with a theory in which the existence of an Experimental Unknown could be neither proved nor disproved. I will stay away from this hypothesis, if for no other reason than that there seems to be little left to talk about once we entertain that view. (This æsthetic is similar to Popper’s, I think.)

I therefore propose to continue with the following articulation of Existence:



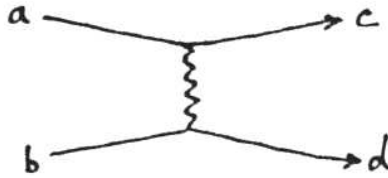
The arrows represent the direction of “motion” of *elements* of the various categories; as a result, the *size* or extent of the categories grows in the opposite sense: Reality grows at the expense of The Unknown. The whole driving “force” behind consciousness is simply a potential gradient, where “potential” here is in the sense of *potentialities* contained in The Unknown. “The idea, then, is” to become more skilled at facilitating this process. The first focus of my attempt to do so is in the realm of Experimental Experience, which I can best describe in terms of what I know best, *i.e.*, experimental particle physics.

There is something particularly strange (to make a double pun) about this field of endeavor: the “ultimate” subject of investigation is at a level of conceptual complexity somewhere near the top of Polanyi’s hierarchies; and yet the process of discovery has its roots very close to the bottom of the ladder, in the experimental art of localized physical detection. There are a string of modeling problems which go into an experiment in particle physics, which I can best enumerate by examples, starting with the most fundamental.

## 1. The Event

Particle physicists almost always talk about “events” as the universal units of Experimental Experience. This tradition probably has its origins in emulsion and cloud chamber techniques, where particles leave tracks which can be photographed and studied as processes in which the *time evolution* of an interaction is captured and displayed at a glance. I think this feature of taking, not a snapshot (which captures only the positions of things at *one* instant) nor a movie (which requires a subsequent time-ordering of successive snapshots to be viewed), but an *event*,

where the passage of time is encoded in space, created a unique conceptual approach in particle physics which is related to the models that appear in the theory. Take an example: Feynman graphs. These purely theoretical diagrams representing mathematical procedures bear a not accidental similarity to bubble-chamber photographs, each providing a satisfying image of an “event” to the observer.



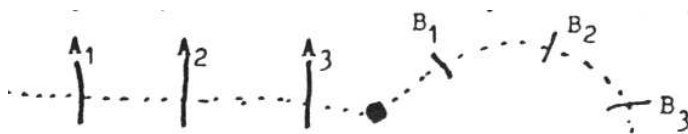
← Feynman Diagram (6)



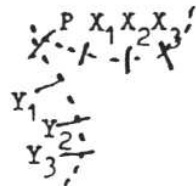
← Bubble Chamber Picture (7)  
(slightly idealized and embellished)

These cases of “events” are obviously at a very remote level of abstraction (until *practice* makes them so familiar that they become tacitly obvious); I would like to dip a little closer to the actual interface with the Unknown, where un-modeled Existence is first captured into Reality. I will fall to get very close, of course, using words, but I can point the direction.

Anyway, let me take a different example of “event” from “counter physics” — which is not an underground resistance movement, but an experimental technique using “particle counters”, devices which generate an on/off pulse billionths of a second long when charged particles pass through them. Several of these counters are placed in the path of a particle, and “coincidence circuits” are attached to them to indicate when they all fire in sequence, timed to an accuracy of a few nanoseconds.



$$\begin{aligned} A &= A_1 \cdot A_2 \cdot A_3 \\ B &= B_1 \cdot B_2 \cdot B_3 \\ X &= P \cdot X_1 \cdot X_2 \cdot X_3 \\ Y &= P \cdot Y_1 \cdot Y_2 \cdot Y_3 \end{aligned}$$



$$\text{EVENT} = A \cdot B \cdot X \cdot Y$$

(8)

Here “.” is the symbol for the electronic requirement of simultaneity.

Now, the “firing” of a single counter is a fairly basic process analogous to the stimulation of a single rod or cone our eye; it is the “doorway” through which The Unknown makes entry to

Reality, and in both cases it can only proceed by means of the absorption of photons. That is, according to quantum electrodynamics, or QED (the most spectacularly successful theory in the history of physics), electromagnetic interactions (which account for almost all our interactions with matter) proceed exclusively by the creation and destruction of photons. Photons have *no* interactions except those in which they are totally created or destroyed. Thus in the most literal sense (if you believe QED, which you had best do if you want to maintain any communication with modern science) the object of experiment is always destroyed by the act of observation. Any argument over the proper interpretation of the quantum mechanical principle of a lower limit to the disturbance created by observation is swept aside when we consider that our direct physical interaction is almost always with photons. We then can translate this back to the hypothetical object which *emitted* the photon (in this case, the particle), but this is exclusively a modeling process.

So I would say that the interface with The Unknown resides in the original absorption of photons. What does that look like to us? Nothing, yet. We need lots more modeling to get it to where we are even conscious of it, much less ready to attach any meaning to it.

The absorption of even one photon (in the right place) will sometimes be enough to produce a pulse out the end of the “counter”; knowing this, it is not surprising that such pulses are triggered by a huge variety of “background” processes, so that a typical counter fires many thousands of times per second even when there is nothing “interesting” going on. We therefore attach marginal significance to a single pulse from a counter. So much for the second level of interpretation.

However, these pulses are very short (a few nanoseconds) and the likelihood that two will fire accidentally *at the same time* (to a similar precision) is measurable and small. Typically this “random coincidence rate” is a few per second. Add a third counter with the same timing requirement, and the randoms virtually disappear. The quantitative details of this procedure can easily be calculated from the “on time” of the counters. At any rate, to drop another pun, the experimenter only perks up his ears when he starts seeing these coincidences, as for example the “**A**” coincidences in (8). At this point he knows he has an event.

He may not have the event he is looking for, of course. I will not pretend that particle physicists usually walk up to a beam of particles with an arbitrary stack of counters “just to see what they can see;” usually they have some specific type of event to look for which theory has predicted they should find. Sometimes they don’t find it. This is one interesting situation. The other interesting situation is when, on sore occasions, physicists carefully design their counters to detect events of as wide a variety as possible, with as little bias as possible, “just to see what’s there.” They have, of course, made some assumptions about what sort of things they might find, but they are occasionally able to be very open-minded about it. The entire picture of (8), which is designed to detect specifically the events of the type whose bubble-chamber track is shown in (7), is *not* an example of such an experiment; picture instead a huge array of counters positioned all around the “target,” and a logic system which stores all the information about which counters fired at any instant when a large number of them fired simultaneously.

This was the type of apparatus and technique used by two experimental groups under Sam Ting and Burt Richter, respectively, at different laboratories, who independently discovered an unexpected new particle in 1974, rocking the world of particle physics on its heels.

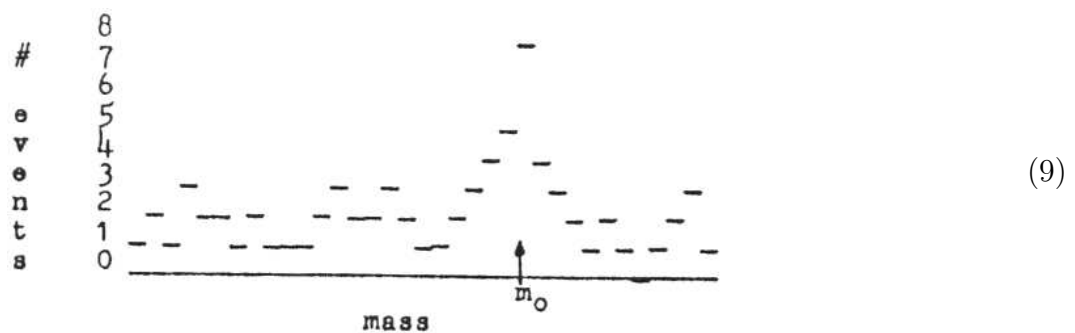


What was the role of a single event in these experiments? Not much! It is true that in bubble chamber pictures the wealth of information available from a single track can sometimes permit the identification of a new particle (the  $\Omega^-$  was found this way); but in counter experiments, like everyday experience, not much significance is attached to the individual event. You may catch a glimpse of a figure out of the corner of your eye; this pattern of simultaneous firings of rods and cones *in a familiar arrangement* is the analog of an event in particle physics. But your normal response is not to conclude that there really is a figure there and act accordingly, but to turn your head and take another, closer look. If the figure (*i.e.*, the familiar pattern on your retina) no longer appears, you simply shrug and disregard the event, storing it in tacit memory for a while in case further supporting evidence should arrive. The information about the event which you store is what I call the *data*. It is already heavily modeled.

What do we learn from a single event in particle physics? Data. That is, following the individual awareness that “something happened,” we make all sorts of restrictive decisions about what questions we are going to ask about any similar event which comes along. This is the first point at which conscious (or nearly conscious) modeling sets in. You turn your head to see if the pattern falls on a different part of your retina, betraying your expectation that the pattern came from the interception of photons emitted from a fixed physical object in normal space; the particle physicist tries to measure the *mass* of a hypothetical particle in an event, with the same degree of tacit expectation. Thus the very nature of the *measurement* process is to throw away all but a narrow range of interpretations of the event, and make a *measurement*, which is the same thing as formulating a question. Then he waits expectantly, with his mass-measuring equipment, for more events.

## 2. The Data

Sometimes you don't see any more events. This is dull. But sometimes you do. Then you accumulate data from many events, and usually you look for either distributions or correlations. Distributions are easier. In the case of Richter and Ting, for example, they measured the mass for lots of events, making as few restrictions as possible on the range of mass values their apparatus would measure with equal efficiency, and plotted up distributions of the answers.



The results looked something like (9), except the peak the distribution at mass =  $m_0$  was more dramatic. That they asked a certain class of events, “What is your mass?” and a large majority of those events said, “My mass is  $m_0$ , within the resolution of your question.” This is the data sample.

What do you make of it? As always, nothing — until you try to fit it into a model. Ting and Richter has a model in mind when they went asking about masses, of course; their model was that a group of events characterized by nearly the same mass are an indication of *a particle* if and only if there are a lot more events with that mass than can reasonably be accounted for in terms of pure accidents. That is, that the accidental “background” is normally *flat*, and *peaks* are significant. This theory is fairly well-founded in logic, but I demur attempting to explain why here. My main point is that Ting and Richter interpreted their data in terms of an extremely sophisticated model or models, which they were so familiar with that they had come to seem self-evident. That is, the data were meaningful only in the context of their tacit knowledge as physicists. Note also that the very notion of “a particle” in the context of a large number of events is explicitly an abstraction. Physicists mean two entirely different things when they talk about “*the* electron” and “electrons.” The latter are tacit building blocks from which conceptual models of atoms and galaxies are constructed, while the former is the original concept which was the first entry of “electron” into Reality.

### 3. The Interpretation

I hope it is obvious that anything so abstract as a particle comes into Reality strictly and only by the process of Emergence; that is, “the electron” arrived in Reality by the right-hand path of (5). So, in fact, did the data, and even the event. From the moment the photons are absorbed, the entire experimental process shifts over to the right-hand side of (5).

So where is the evidence for a left-hand side of (5)? Simple. *Richter and Ting saw the peak at the same  $m_0$ !* To explain this fact you have to posit mass hallucination, a common Mind, or else entertain the idea of The Experimental Unknown.

It is suggested that physicists may construct the “unexpected” new particle into their apparatus by virtue of tacit assumption of which they are not aware. I agree that a new particle could well be such a contrivance; but I do not believe that such self-generated discoveries can explain the remarkable frequency with which *independent* experimenters find their discoveries with *identical properties*. I admit that my disbelief in such coincidence is itself a model for which no Justification can be offered but that it seems to work so well in context; so these arguments do not constitute a proof, merely a demonstration that the concept of an Experimental Unknown is inextricable from a huge array of other conceptual frameworks on which we have built more of our cognitive complexity and which we would probably be reluctant to give up.

I will not attempt to show that the conceptual Reality of particle physics has all its foundations embedded in just such coincidences of simultaneous independent discovery of properties. I will simply say that physicists have a tradition of profound respect for these occurrences, and that theories which contradict them fall quickly into disrepute.

## THE ART OF EXPERIENCE

Whether or not you are convinced by my arguments in favor of the model displayed in (5), and even if you resolutely insist that my Unknown is an empty category, as long as you believe

that Reality is not an empty category you are faced with Emergence as the dominant process of Experience, whereby Reality is continuously created. Even if you would rather stay out of it altogether, this option is only available *via* death, if at all. And if you do find The Experimental Unknown plausible, you cannot help but be struck by the fact that Emergence pervades even Experimental Experience to the very edge of its penetration into the Unknown. The topology of my model is a bit sloppy, I admit, and what I have treated like surfaces may be more like lines, or even points, of intersection. In any case, one lesson appears: it behooves us to become as adept as possible at facilitating Emergence. How can we?

## Emergence as Creation

Polanyi makes an interesting point when describing Emergence: when pieces of the present Reality become well enough known (familiar) to be tacitly understood, we can put them together (usually in a problem-solving atmosphere) to form a meta model which gives them meaning as elements of a set rather than isolated entities. This process “ties up the loose ends” of the basis models into the context of a metamodel, which of course has its own loose ends (probably more per model, in fact, because of its higher dimensionality). After this process something (the metamodel) exists which was not Real before, even Implicitly, in any causal sense. The edifice may be made out of the bricks, but certainly something unique has been added to Reality by the arrangement of the bricks into the structure. *The building is not in the bricks.* The building may Exist prior to its conception, in the Conceptual Unknown, but only as one of an infinity of possible buildings; in any event the Emergence of the building in Reality involves Creation in an absolute sense.

How do we do it? Rather than adopt a mystical attitude toward Emergence, I would like to try to understand as much as possible of the mechanical steps in Emergence, so as to lighten the burden on “magic” or whatever you want to call it, through which the critical spark arrives. If I can eliminate the burden entirely, I don’t think I will have lost anything of great value.

Because of the crucial role played by choices of models in experimental physics, I have become aware of one important technique in the facilitation of Emergence: asking the right questions. Of disciplines in which a student seeks to understand a body of existing knowledge, it is truthfully said, “Ask the question clearly and you are 90% of the way to the answer.” I claim that this applies equally to cases where there is no “right answer,” yet. By formulating a question about The Unknown in terms of a judicious set of models, one can leave a direct and uncluttered path down which the desired potentialities can slide into Reality. We thus take full advantage of the “potential” whose gradient spontaneously forces elements of The Unknown into Reality.

Further development of these techniques is beyond the scope of this paper, and for the moment beyond me. However, I expect some to emerge soon.

## THE UNKNOWN

I have this to say about the Unknown: