

# Knowing One from the Other

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## Abstract

The question may be more subtle than “It from Bit, or Bit from It?” as determining whether information creates form or form creates information is sometimes a matter of knowing which entity is playing which role, or seeing what part a given component of reality is playing at any moment. Indeed; a single entity can play the role of “It” with respect to what came before, and “Bit” with respect to what comes after, or the reverse. Determining unambiguously whether a system is creating information or is created by information is thus virtually impossible – as the two modes are so deeply intertwined. The creative flow moves from possibilities to actualities, but the objects and conditions present then give rise to new possibilities. When observation leads to exploration, however, any action taken to explore and measure reality also has a creative role in helping to determine the state of things, or the outcome of events – thus changing how they appear. In this sense; the real challenge is to understand what plays the role of object, and what takes on the role of information, at a given point in the process. Ergo; this paper is devoted to sorting this matter out.

## Introduction

In an ancient tale (as once told to me); Spirit takes on the myriad forms to learn by becoming, and being, and doing, what it is to live in the world of form. Then after immersing itself in the universe of form and its living inhabitants, it begins the upward journey back to oneness, rising above the world of separate forms as it has learned all there is to know in that manner, and becomes unified again – so the cycle can repeat. Though told in this way it is an epic saga, at each step and every stage there is an exquisite interplay – a dance of information and form, where they take turns being creator and observer. Does life descend to play in or with form, bestowing consciousness and creativity? Or does form rise and evolve to acquire these attributes, so it may play in the heavens? Science favors the latter view, and relegates the former to Religion, but because “It from Bit” makes information more primal than form, this changes things profoundly. In the ancient tale; Spirit is both the consciousness of the observer and the active or creative principle at work, so it portrays or resembles ‘Bit,’ or information, and form is clearly ‘It.’ In the “It from Bit” metaphor, ‘It’ plainly refers to

substantial material things like objects or entities, having a particular or unique nature independent of other things, while 'Bit' refers to the information which defines a particular thing, describes it so it may be observed or perceived, or transforms it into something else. This is useful insight, but much of the story remains unclear.

In considering the question "It from Bit, or Bit from It?" one must always ask 'With respect to what?' The question is undecidable otherwise, as it is essential to understand that entities or systems can have a dual role, and can in fact be a blend of It/Bit flavors – at any moment – where the face manifested depends on where and how the observer is situated, and whether the observer is taking action as well. This is similar to the wave/particle duality, a concept which Quantum Physics people are greatly more familiar with. In that case, even units of light, as photons, have a particle-like nature, and dense particles like electrons are wave-like simultaneously. What we detect with a physical apparatus tends to show one or the other, though, as there are constraints on measuring both set of properties simultaneously. There is a similar ambiguity, when asking questions like "Is what we are examining 'It' at a given moment, or is it 'Bit' instead?" This greatly complicates issues of procedural flow, and foundational questions like "It from Bit, or Bit from It?" – when studying interactions, systems, or processes. With respect to system A, an entity B may start out as an 'It', be 'Bit' while in transit, and again become 'It' to observer C. However; we know what is actually detected by an observer is only information – 'Bit' and not 'It'. So if an object is what is seen, there is a hidden assumption made by our observer (that detection = object). Though we imagine there must always be an 'It' if information about an object or 'Bit' is detected, this is actually a learned behavior – but it is one acquired very early in our development.

The acquisition of object constancy, which takes place in early childhood, is a gateway skill for further learning, and it is how we first form a concept of 'It.' Briefly stated; an infant must learn that even when they are not in sight, a parent or other caregiver is not gone, and that objects such as toys persist even when they are put away. It appears that the constancy of objects as a part of one's surroundings or environment becomes a comfort of regularity that allows the organization of thoughts to develop further. But this threshold is crossed much earlier than the development allowing symbolic reasoning to first be grasped, at around 2½ years of age. This makes the perception there is an 'It' for every 'Bit' a part of our deepest metaprograms, and a bias of which we are consciously unaware – because it is a portion of our wiring that formed long before verbal reasoning was possible. That is, with respect to our human development; some of what we believe about objects and the object/information relationship resides in impressions formed at a pre-literate stage when no explanation was possible, and we had to figure things out for ourselves. This is not so bad, as it turns out, because according to experts in early childhood Cognition, like Alison Gopnik, very young children behave like 'little scientists,' if given the opportunity. When allowed to play and observed, little ones carefully vary one thing at a time, to isolate variables *while* figuring things out, just like adult researchers in the laboratory. So we obviously had a capacity for making subtle distinctions, even at such an early age.

To revisit these questions as adults, however, we must consciously set aside our preconceptions, and look upon the basic issues with child-like eyes again. If neither “It from Bit” nor “Bit from It” is simply and exclusively true; perhaps we need a different perspective. What if the rule of dialectic applies here, and we need a synthesis of the apparent opposites – a third dimension? Maybe there is something unifying ‘It’ and ‘Bit’ we need to examine. Perhaps to catch the universe as form and information at play, we need to see reality *as* a play. Information as author, forces as director, and objects as actors may be the metaphor we seek. A case can be made, that information is a template for substantial forms, and that objects are a collection of forms (sub-atomic particles, atoms...) comprised mainly of information and energy – as the *prima materia* – without which there would be no substance. This does not change the fact that much of the knowledge we now possess about the universe has also been obtained through channels of energy and information. Of course; our survival has depended on gathering information from every channel available and smelling or tasting lets one take a bit of substance in – to discern whether it is palatable – so the energetic component of reality is not the only important carrier of information. And indeed; a day may come when we can learn by eating, or by taking an injection, information about things other than the nature of what we consume, and knowledge to understand it. But much scientific knowledge has come from electromagnetic radiation, and observations or measurements thereof.

In light of the above; one can see it would be easy enough to show that “It from Bit” or “Bit from It” is *the* essential reality to consider. Indeed; it is accurate, in some measure, to say that they are *both* true and both apparent, or even equally true, apparent, and real. But this fails to capture the deeper and foundational reality, that form and information are engaged in a dance within a play, or a play within a dance, such that there is an assumption of both observational and creative roles by every entity or system, as it evolves within the greater reality of the cosmos. This means there is often an exchange between alternating phases, or phrases, of “It from Bit” and “Bit from It” over time – when considering the role an entity or individual takes on. And this suggests an analogy in the dance between matter and information in Physics with the ancient tale of Lila Rasa, the ‘Cosmic Dance,’ which I recounted earlier. This notion is deeply woven into Eastern culture, but the idea that objects are things, apart from action or subject, is as deeply woven into Western culture, as it is into our languages. Nonetheless; it is reasonable to observe that an ongoing interplay between “It from Bit” and “Bit from It” is an essential part of the natural order, and that this exchange of modalities is more fundamental than either view is on its own. The remainder of this paper will focus on how and why this is true.

### **The Dancers or the Dance?**

Patterns of form and formation dance on the stage of the universe, and the dance unfolds for all to behold, but there are always choices of what to focus upon. Do we follow the dancers or the dance? Should we pay attention to the characters, or the action? The dance

and the story unfold the meaning, but this takes place on many levels at once. Sometimes the attributes of a character are all-important to the meaning of the story. But in other cases; the action and the interplay that take center stage, or demand the most attention. In a play or a movie, we can watch the same scene unfold multiple times, to see the action one time and understand the characters the next. However, the real world shows us each scene only once. So over time, our choices of observational focus add up – and are a major determiner of perceptions. When considering the question “It from Bit or Bit from It?” there is a significant influence on our perceptions from habits of mind, apart from the nature of the universe itself. And similarly; choices of action taken, involving how we explore the universe of form around us, accumulate to determine what face of the universe we are shown, or can measure. But a surprisingly large part of such mental habituation takes place in early childhood, during the pre-literate phase of our development. When we first learn that many of the things around us are persistent, and do not cease to exist when out of sight, this insight is called object-constancy. This perceptual landmark is a gateway to further learning, and a step toward putting things in perspective.

Because the sense of what constitutes ‘It’ is something we learned well before we acquired the tools for symbolic thinking and language, the tangible reality of material objects is a very deeply embedded belief. But Western culture and language also emphasize the distinction – casting objects as independent units of form, and subject as the active principle at work. The dancers are seen as separate from the dance and dancing. However; the traditional beliefs and languages of other cultures do not make this distinction, but instead represent the process-like aspect of objects and the interrelatedness of things. In Chinese pictographs, especially original calligraphic forms, the characters tell a story – with the more complex characters comprised of strokes from simpler ones, and thus telling the tale of how that character comes to represent what it does. So in Chinese language and culture, we see that objects are treated in a more process-like way, rather than being separate from the action or ‘subject’, as in Western languages and culture. But many Native American languages are also more process-like in their depiction of reality, instead of having a strict subject/object distinction, so it is not strictly an Oriental mindset. However these are traditional languages and cultures, which are dying out, where Chinese is a living modern language – but it still contains an outlook where all is treated as subject, to some degree. This informs us that the way we define ‘It’ and ‘Bit’ is largely cultural.

Rising above all of this conditioning, to think for ourselves about how “It from Bit” relates to the universe, is a very difficult matter. And what is revealed is a sensibility where the dance is all there is, but without the dancers there would be no dance. This is still a conundrum, especially to Westerners. On some level; the dance gives the dancers a reason to be there on stage, but what does this mean to Physics? The “It from Bit” metaphor, as originally formulated by John Archibald Wheeler, used the ‘Bit’ as one of many either/or choices made by either nature, or a human experimenter, on the way to some observable. Wheeler’s assertion was that all objects, and the universe itself, comprise the realm of ‘It’

which is uniquely determined by a sequence or collection of ‘Bit’ elements, or information. The key observation here is that information is more real or fundamental than substance, which is much like saying that things are comprised of mind-stuff – on a deeper level than the physical. Using this metaphor gives “It from Bit” a rather Buddhist flavor or character, but accurately depicts this perspective. Since Wheeler’s time, the notion of ‘Bit’ has been generalized to include a broader spectrum of information types, and I think this is wise – because information does not always fit into conveniently-sized packages. People already think in either/or terms overmuch, in my opinion, and not all of the choices faced by nature or humans are reducible to binary choices. This statement sets the tone for the next section, where a third aspect is suggested.

### **Actors on the Stage need Direction**

Seeing the characters on the stage of the universe as actors as well as dancers allows the metaphor of ‘It’ and ‘Bit’ to be expanded somewhat. While we can identify the script as ‘Bit’ with the author as its generator, and the character as ‘It’ with the actor as its generator, there is a third personage who helps to guide the process to its completion, called the director. Of course; sometimes they have a different title, such as a choreographer or conductor, but the notion is that having a script and actors without direction leaves gaps in the preparation, leading to imperfect representations. So in addition to authors and actors in the Theater, Movies, or Video, there are directors, and they play an important part in creating a production that is realistic. In relation to “It from Bit” Physics, time and space are both the stage and the place for the audience to watch from, material objects are the actors, and energy or forces serve as director. This is a reasonable association. The part played by forces and energy in the universe is intermediary between information and objects, even when talking about the information that defines and energy that constitutes objects of form as substance. In addition to constituting matter, energy and forces also direct the evolution of form in the material universe, from the sub-atomic realm to the large scale structure of the cosmos. Particles and planets are probes in the realm of forces. So there is a natural third leg to the ‘It’ and ‘Bit’ duality, and this suggests the “It from Bit” metaphor is incomplete, along with “Bit from It” – unless we admit that forces and energy serve an intermediary role which is essential for ‘Bit’ to become ‘It,’ and the properties of ‘It’ to be propagated as ‘Bit.’

If our goal is to correctly make sense of things, we must admit all aspects of reality pertinent to our discussion. If our actors and dancers are portrayed by ‘It’ the objects, and the script generated by its author is depicted as ‘Bit’ the information, then our director is represented by the natural forces that supply the energy and direct the flow of formation, to assure the instructions of ‘Bit’ the author are carried out. If we draw an analogy to computers; the software and the hardware alone are not sufficient to make them function. Unless there is a source of energy, they will not run, nor can they be made to do useful work without the interactive direction of a human user. For physical systems, it is not possible to constitute or

shape objects of form without energy and forces to power the process or allow it to proceed, then objects once constituted are subject to natural forces – and are directed by those forces – for the duration of their existence. So instead of a binary system, where everything can be depicted unambiguously as ‘It’ or ‘Bit,’ we actually have a ternary system – where forces and energy are neither exclusively ‘It’ nor ‘Bit,’ in their nature, but instead have a blend of these properties and the built-in capacity to assume it-like or bit-like roles as needed. Ergo; energy and the natural forces which are its expression satisfy the condition necessary to make them a synthesis, in the dialectical sense, of ‘It’ and ‘Bit’ qualities, and this is an essential truth. Without energy and forces to create action, information does not matter, and cannot become matter. Likewise; matter is isolated from observation, without energy to carry information to observers about objects.

So the answer to the current question rests on understanding insights gained from a prior FQXi essay asking if the universe is analog or digital. The reader is reminded that in the ‘analog vs. digital’ debate; the author took a stand that the universe is decidedly *both* analog *and* digital, if we consider all pertinent aspects of reality. Without further discussion; I will state this is a reasonable view to take overall, and that such an assumption is appropriate to make here. The relevance to the current topic is mainly in that while objects do exist as discrete entities, and while information is often received as discrete bits of information, the global wavefunction, forces, and energy in general, can behave as perfectly smooth analog phenomena – rather than being discrete or digital in nature – when in transit or between discrete interactions. I think it is well-demonstrated at this point, that there is a coexistence of wave-like and particle-like properties, in physical entities and phenomena. So while both ‘It’ and ‘Bit’ appear to have a ‘Digital’ face, it is apparent that we should see energy and the natural forces as an essential dose of ‘Analog’ nature, which is needed to serve as the glue binding the two together. That is; there is a deficiency to a strictly binary analogy, which can only be overcome by perceiving reality as ternary and the unifying quality as fluid. The essential role played by energy and forces make them a part of both ‘It’ and ‘Bit’ in any physical system, and in that system’s observable and measurable properties. Both ‘It’ and ‘Bit’ are made of or brought to us by energy and forces entirely.

### **Concluding Remarks**

In the preceding discussion; I have attempted to deal with some of the issues complicating an answer to the question “It from Bit or Bit from It?” in the most general way, while keeping my focus mainly on Physics. There is always an interplay between information becoming stuff, and stuff becoming information, but this takes place on various levels at once. It can manifest as a top-down and bottom-up dynamic simultaneously, or in alternating fashion, because general information can coalesce into specific stuff, and any particular objects or conditions yield information specific to that set. As I stated earlier; possibilities lead to actualities, in general, but any specific condition or environment leads to

new possibilities. Things can be built up from the inside out and whittled down from the outside in, or vice versa, and sometimes both happen at once. So pinning down “It from Bit or Bit from It?” may not be a tractable problem to begin with. But in many natural systems; the most interesting place to look is along the fringes, such as a shoreline or the boundary between forest and field, where the boundary is a fractal. Natural boundary zones offer a broad range of unique habitats which allow flora and fauna to proliferate in far greater variety than those offering only one kind of terrain. The interpenetration of differing domains is therefore well-suited to the evolution of complexity in nature. And seeing there is a similar interplay between form and information, which ensues from an exchange of “It from Bit” and “Bit from It” roles, allows us to make better sense of a complex reality.

With the study of Information in Physics, it seems to be less a matter of determining the primacy of “It from Bit” or “Bit from It” once and for all, and more a matter of finding better ways to coax nature to reveal more of herself, or better ways to turn what we learn into human knowledge, by using two learning tools instead of just one. Perhaps it is appropriate to say that we must allow for nature to move *both* from information toward things *and* from things toward information, then to use both kinds of dynamism interactively. Just as our universe clearly displays both Quantum and Classical behaviors and attributes, we also reside in a universe where neither “It from Bit” nor “Bit from It” can be ruled out, as both aspects are clearly displayed. However; energy and forces are different from things and information, though they play a part in their story. If things are ‘It’ the actor, and ‘Bit’ is the author of the story, there is clearly a part played by energy and forces – that of the director. But it must be acknowledged that information can play a broader role, as architect of the theater that is space and time. In the contest essay on “What is ultimately possible in Physics?” I spoke of space and time as existing on hierarchal levels beyond matter and energy respectively, but in such a hierarchical representation – information is higher still. So in that sense; the upper hand must belong to “It from Bit,” over “Bit from It,” if we allow a sufficiently broad definition for quantifiable information. It is presumed there can be no ‘It’ beyond the Planck density, but clearly the primal basis of information can and must still be well-defined – even in the matter-free regime of the Planck era – for the universe to exist.

So information reigns supreme, in the universe before matter appears. The question then becomes “Is it still Physics, if there is no tangible and observable reality, or have we crossed into Philosophy and Religion?” Fortunately; what is required for the material universe to emerge is the most general kind of information – that which forms the primordial underpinnings of Mathematics. It appears that Plato was right, on some level, in positing the existence of archetypes of form which exist independent of material reality, because certain regularities of Math have a life of their own, and influence or shape the laws of Physics. For example; the properties of numbers allow there to be precisely four normed division algebras, for the Reals, Complex, Quaternions, and Octonions. This is not something humans devised, but rather it is something we discovered, and it is something we have verified and proved to be true. It would seem that like Plato’s archetypes, the nature of numbers and their properties

exist in the pure abstract – apart from the material universe in which we learn about them by example. Though we live in a universe full of examples of systems that naturally preserve the properties of numbers, it is not true that the nature of numbers is determined by the properties of material objects. The principles and objects of Mathematics have a regularity of form that is independent of the method used to elucidate that form, and are therefore properly seen as discovered rather than invented.

However; archetypal information is very far removed from the binary sense of 0 or 1, up or down, this or that, and so on. While we can imagine that the abstract information which shapes natural law could be reduced to a sequence of either/or decisions, with enough of them, there is clearly a need to admit the possibility for things which vary in a continuous range – if we are to explain all the properties of observable reality. In this sense; stating that every ‘It’ is defined solely by ‘Bit’ elements falls short of describing how information shapes form. While Plato posited that abstract geometric shapes like spheres are natural archetypes, he could not have imagined how wonderfully wild and varied are the properties of spheres in higher dimensions. Such properties are predetermined, and are in no way random or free to vary, yet they describe a panoply of specific possibilities we did not know existed until we explored them. Nonetheless; the same possibilities have been available for nature to explore since the beginning of time, as regularities of Math represent something that exists outside of space and time entirely – or are independent of the universe of matter and energy. Another way to state this is to say that Math reveals the underlying nature of the flow of information. When at FFP10, which was at UWA in Perth, Australia, I had the chance to discuss with Gerard ’t Hooft the prospect of a computing universe, and to ask if perhaps atoms of space at the Planck scale are what does the computing and he replied that they are not needed. Instead; he said that the laws of nature do the calculating for us, and I think he was referring to these mathematical absolutes at work in nature.

While all of this is a promising beginning; it leaves aside something I think is essential to any discussion of “It from Bit” questions, which is the progress of knowledge and the nature of the consciousness of the observer. One cannot raise the issue of a universe created by information, without bringing along questions about how information is perceived or interpreted, how knowledge is acquired, and so on. In fact; it demands we tackle what David Chalmers refers to as the ‘hard problem’ of consciousness, defining what constitutes conscious perceptual experience. This is perhaps why a proper treatment of this year’s essay question “It from Bit or Bit from It?” requires an approach reminiscent of the fanciful ancient tale I recited in the introduction. The progression of knowledge in Physics and the evolution of form in the Cosmos are both playful processes of discovery revealing the underlying archetypal information in a pre-determined range of possibilities there to be explored, and creating new ones. On some level, both the universe and human scientists learn what is real by exploring the extent of what is possible, and seeing what structures are the most useful and helpful for understanding or for creating something new. In my view; the same structures of information come into play whether the task is cognition or invention. Creative and



observational strategies are deeply intertwined in scientific research by necessity, as we must often first devise a suitable way to observe what we are looking to study, before we can find it. But this dynamic may be far more broadly applicable, or even universal in scope.

Therefore; the dance of information with form is best seen as a constant interplay where not only do the dancers interact with each other, but there is a continual exchange between dancers and the dance, where each is featured in turn. General information and open possibilities lead to actualities, then specific conditions engender new possibilities – and this cycle repeats – without end. Thus we see that both determinate and emergent features appear in any system, including the universe itself. This brings both top-down and bottom-up procedural hierarchies into play at once. There is building up from simpler elements, and paring down from endless ranges of possibilities, only some of which are simple binary or discrete choices. While form clearly exists in discrete units like sub-atomic particles, photons, atoms, and molecules, and some observable information is transmitted in a discrete spectrum, this can demonstrably arise from forces and interactions that display a continuous range of variability. This makes terms like ‘It’ and ‘Bit’ too confining to tell the whole story, because they presume that all of reality can be described and determined by discrete relations. As I stated in a previous essay; I think that *both* discrete *and* continuous aspects of reality must be simultaneously accepted as real, to understand the universe as it is. But as I stated here; our concept of an ‘It’ was learned in early childhood, in the pre-literate stage of our development. There is a hidden danger we will automatically treat information the same way, as divided up into discrete bits, therefore.

If we allow that there *can* be a continuous flow between information giving rise to form and form giving rise to information, a clearer picture will emerge. The exchange of roles and relationships is what gives meaning and existence to the whole thing, because it is the perspective induced by objects and relations that forms the core of Physics. So it really is not about “It from Bit or Bit from It?” but more a matter of “What is coming out of ‘It’ into the realm of ‘Bit,’ and what is coming out of ‘Bit’ into the realm of ‘It?’” In my view, Physics should admit the possibility for unobserved realities that serve to generate what *is* observed, but must focus primarily on what is in the realm of the observable. This means that ultimately; all we have to work with is information. In some sense; information is both the alpha and the omega, the beginning and the end. Perhaps instead of asking “It from Bit *or* Bit from It?,” we need to see reality as “It from Bit *and then* Bit from It” – which allows it to be a dance, an interplay, or a cyclical phenomena, rather than a simple relation. While it is quite clear that information of some nature does give rise to the universe of form, thus fulfilling Wheeler’s vision of “It from Bit,” this does not prevent “Bit from It” modalities from unfolding at the same time. So indeed they are both true outlooks, but the meaning of the story can only be seen by considering the interplay of the two – a Cosmic Dance.

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