Proposal for the essay Contest, It from Bit or Bit from It

Breaking the Code of Information, By William Amos Carine

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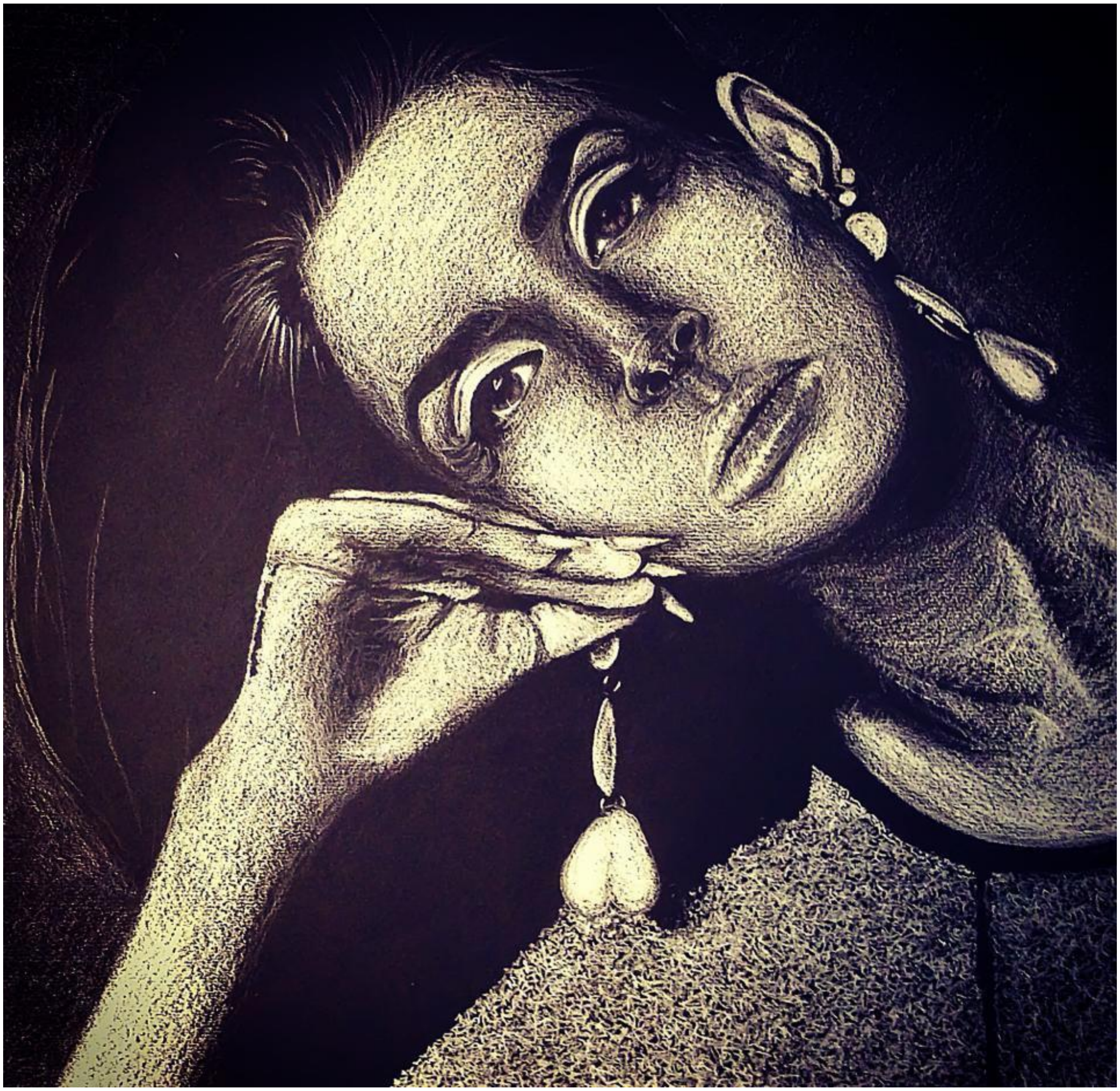
Physicists have long known about the posit of information, dating back to Maxwell, but it is only in recent times that the question of its validity has been posed. The thought experiment he used was of an immaterial demon that could separate hot from cold atoms in a container, by using speed to sort them out. The volume was separated into two halves by a wall, and when a hot particle was on a cold side, the spirit would open up a slit until order of hot and cold was established. Maxwell said this would lower entropy, which usually always increases. The only problem is that the fiend has to store the information, and then erase it to store more, a process that gives off heat (think of a laptop). So the entropy does increase, though only slightly. It is true that the rate of information transfer is documented in papers, which has been a useful tool as the technology industry boomed. But the reader may find surprise in that modern physicists do not know what it is. At times, information seems far away from a tangible, physical definition, while at others it circles directly around computable entities. For example, when two particles collide and shoot off in different directions, measuring one necessarily changes the state of the other, by information alone. Whereas with digital communication, only so much information, measured in bits, can be transferred. The previous and other conflicting viewpoints have led to considerations of what information actually is, and of whether or not it is foundational in science. The hope is that by addressing this set of fundamental questions, the discrepancies will be shown to be part of a whole, and true progress will be made in physics.

When physicists study the natural world, they try to quantify or measure an observable phenomenon. An example is waiting as the paint dries on some textured canvas, or sitting on a park bench, the process which can be broken up into small (or large) chunks of time, “units.” When one observes a box moving through space, the trajectory can be snapped into sections. The length of some line made by the path measures a distance. These cases are not necessarily rich or lucid about an instance of information in particular. It is only meant to emphasize that when studying events, they are often broken down into manageable pieces; instead of trying to think of a whole time or trajectory at once, they are divided. This is the it from bit view. A drawing made of little dashes or brief touches of the nib show a finished picture (the it) made from little dots (see marker drawing on the next page). Perhaps the best example of this is the development of matter being made out of atoms.



This is a drawing by artist Taylor Marie who has permitted its use here. The image of the girl is made out of white colored pencil from a black piece of paper. The minute dark regions, like those featured on the forehead, can be looked at as little dots, or sections where the medium is dark or not dark. These can be considered as information, where what is light or not can be stored, replicated and reproduced by a machine. The computer would not know that it is making a human being though. This overlying sense of entity (the person) is made up of information in "bits" of light or dark. The It from Bit view is interpreted as nature (the it) is made out of information in pieces called bits, those bits are then the chiaroscuro which brings the big picture into view.

Currently, some scientists believe that all of matter, our whole universe, and even the ability to form concepts consists of, at the smallest level, codes of info. There would have to be evidence to disprove that as the case, and to rationalize the error of progressing down this road of fundamental inquiry. The cautious reader may think it brash to take this path when it could be wrong. Without a risk of regarding this physical statement as a true hypothesis (at least temporarily) the number of other directions to take would be unlimited. But without granting it, one may be guilty of stopping in one's track moments before the solution is attained! This destination is a clearer understanding of known events, logically explained and believed to be revealable through the creative endeavors of the human intellect. On the other hand, some kind of limitation needs to be imposed.

If the statement that everything made of data is true, even the material objects of common day experience are storages of info that is taken for granted. But it is not just in objects, there is information everywhere. It is in one's social security number, or sent in that rushed email just before taking one's lunch break. However, it is a comparatively new idea that this information can be measured and quantified, much like reading recipe instructions for adding sugar to a baking mix. Knowing that the crystal is homogenous, that a certain quantity is called for follows (i.e. one measured cup will have to be the same as another). This leads to a standardization of units, in this case a certain volume of sugar divided by the mass of that volume of sugar, or simply, its density.

What is meant by "quantity" is what is left after something is broken into little pieces (crystals in this case) and then the number called for (cups). The units are the measure of those things that have been conceptualized for convenience. This has been the bare approach during the process of describing the atom and its components. First came the main idea, the love of which led to the pursuit that matter could be broken up into tiny-tiny pieces. But it took all the way until the early 1900's, when a young and audacious Einstein formed the marriage of various atoms to their empirical weights, to further prove the existence of atoms by observing their effect on the motion of other dust particles in a fluid. So the ideas that appear are then quantized and assigned calculable units of measure. Then predictions are made that may or may not compare well to the actual results, the analysis of the fit is what determines the truth content of the statement.

The idea of information was likewise broken into little segments. One way of thinking about information is as a strand of 0's and 1's, just like the computer binary. To give or assign a certain amount of this info, the string of numeric characters is broken down into little chunks of 4 digits. One could even imagine a line being drawn after 4 numbers have passed. Each resulting segment is info. This favors the "bit from it" synoptic.

Up to this point, pieces have been presented and then the whole was found, which often appears in written considerations like published works or equations. Big groups of facts are collected, and then laws or understanding formulated after this point. Nowadays, computer processing makes possible the coding of large size at high speeds, so much so that data storage is becoming a serious problem in astronomy labs, for example. But anyone who leads their scientific field knows one does not arrive at fundamental changes by looking at huge sets of data. It is by sheer gut and intuition that real advances in scientific thinking happen. The mind guesses the form of nature, and then this is followed by the formation of principles and laws.

In the real world of science, ideas tend to float around groups of physicists. This is why schools of thought have existed since even the ancient civilizations. Those are groups where scientists of a field think in a certain way, much like a school of philosophy. They come together to eat at the same table, and build by bouncing ideas off of one-another's thoughts. It is a way to sound out ideas by group communications. Further, the ideas of real change originate in the arts or theater- and are stored in the cultural knowledge of a generation or lifetime, until they are passed on or forgotten in death. Ideas first spring up in culture, or the collective past, then are linked together later with a new insight. So it is that ideas are often broadly present in a number of individual or even separate phenomena. If one is lucky, a more exact definition is established which unites those by a common trait.

In order to proceed in a meaningful way, a definition of information must be proposed. This must be one, which says what information is, and which gives a clue for a reasonable plan of pursuit. For progressing in this manner, a game-plan is sought. When scientists problem-solve, they grant the truth of some statement, at least temporarily. This may seem like unsound ground to start on, but it is common that one must rely on such a tentative statement of embark. This hypothesis must be meaningful when taken as true. Usually, it is then apparent what problems arise when this first step is taken. It is then the job of a physicist to come up with a remedying solution, and sort out good principles from those that have no use or ill justification. Here, the definition* will be used as our statement:

*The difference in the knowns and unknowns in a system, or, if one prefers,
the difference in entropy between two states.

The difficulties that this will cause will provide stress to change how information is viewed. Constant deprivation of answers is the motivation to ask the right questions.

Since it is difficult to understand what entropy is, it is best not to get hung up on the second half of the definition. When one has a set of known parameters and something that is sought or looked for, a working definition (or even an equation) is used to make a connection and facilitate an answer. And when one has a quantity for a concept, mathematics and other tools may be used to determine laws of nature. Having both in mind, arrived at now is the question of whether information follows the same development as other concepts have in the past, as previously discussed (i.e. subject to the same laws of nature as the rest of phenomena). To proceed to answer this, one must pretend to be, and treat it as, a historically inclined Physics professor would.

Leaving the details to the buff, and looking at the beginning of Newtonian physics, which started by Galileo's work on gravity, one notes that the mathematical treatment of distance, when compared to observations of planetary orbits and mass, helped guess the basic law of gravity. There was a lot of debate going on at that time about the shape the orbits and the relationship of position of these to the sun. With the correct path of the orbits described by Newton mathematically, the law of gravity 'fell into place,' so to speak. The reader should not get caught in the specifics or that this does not necessarily lead to any new developments with information. It is important to point out that the Newtonian method still influences scientific thinking today and consists of: a) using raw pieces of some quantity, and b) stating a hypothesis along with true statements. This scheme used with information could in fact add new information (in the sense of knowledge) to science again. It may help in the search for understanding info, even though Newtonian physics is labeled primarily as an "approximate" case that modern theories reduce to.

Likewise, if any new physics treat simple macroscopic objects much like the old physics does, this provides a proxy for starting investigations. It's like a check mark and an all-systems-go, at least for the test run- the draft of any new idea. It's a way of problem solving. So combining the values of data processing, including bit transfer rates, should lead to new treatments of info. This is analogous to saying that the info is part made out of bits itself and part of a sum or big picture, and also that the laws of reality are nothing more themselves than compositions of bits. The view just presented is one of saying both it and bit takes on the world are useful. This is a developing case where information is reasoned with in the same form that physical bodies were in the previous examples.

These considerations have attempted to show the (unjust) distinction between a world made out of little bits, of a whole broken down into pieces, and a place where this whole is the bit, including the laws. The problem's solution will necessarily and undoubtedly come from a different type of reasoning than the thinking which led to its development. However, it is interesting to note that the concept of time began to evolve as a physics unit only after length and mass were widely viewed as the important aspects of categorizing the physical world. It may not have been thought of in this sequential manner at the time though. Energy has not been discussed, and its involvement in thermic and entropy descriptions closely mimics information today; or if one prefers, its storage of data or processing has a heat of its own.

When energy was first being defined in physics, a set of observations about spheres in the sky and other earthly measures were being made. After looking at the mathematics and then the experiments (even observing the motion of the celestial bodies and the stars is an experiment), energy was generally accepted. The view of energy whose mathematical calculation had greatest correspondence to experiment was taken as "correct." The experiments gave the results needed to determine the truth content of two different ideas of energy prevailing at that time.
This was a trial and error approach to physics, in the main. But there is evidence today that all of these Newtonian developments, and even Einstein's workings, occurred with the use of a certain type of information (Fisher information, if you are curious), unbeknownst to scientists! If this is considered correct, it is followed by the possibility that information IS fundamental. It may seem like one should plunge right into the matter, and solve it before the dust settles. Instead, a basic example of info will be given first.

There is a square that will be regarded as a system of information. It is flat and may be rotated, or flipped to show its plane nature. Let this shape have thick barriers with raised edges, such that nothing that is on its surface can slide off, except in a special way, but also that new things aren't easily added atop it. Moving further, in these squares which we may call boards, dots are placed in regular squares. Now, each dot is either black or white, as the author of this submission is not Animal-Farm-persuasive enough to convince the reader that white ones can suddenly switch, or vice versa. They could be shades of grey, but it is not known if having a gradient would be physically useful.

These dots span regions of the board, and can be envisioned as to form lines, much like a square tennis racket is with nubs and cords. A zero is substituted for the white dots, and a number one for the black ones, or opposite. This process must be consistent, *i.e.*, using a color for one number, so that all of the dots of one color have a numeric value, different from the value of the other color. Doing this, strings of ones and zeros are formed.

Say that there are two squares now, and that they interact with another. When they do so, they exchange info. This exchange of info is the only proof of the existence of other states which differ from the one which will now be set up in the next paragraph.

Place at one board an observer, who happens to be a curious rug-dweller. The being wants to inquire into possibility of other squares besides the one known. To find another square, the being decides that an exchange of information will suffice as a reasonable reassurance of another board. The person then has to know how many dotted lines of white and black are on their board, before finding the other state. The dotted area is found out quite simply; where data is stored, the board is warm to the touch. Knowing what needs to be done now, this person sets out with tools to measure what parts are warm, and figures out that just ¾'s of the board is filled with info. Confident of the correctness of the measurements, the adventurer heads out into a part of space where there are hopes of "running into" another platform. Here, the being runs into a frequented region, and obtains a quarter (1/4) of information, by statistical definition. It does not matter to this system that the other state of the board is unknown (it could have had a full occupancy or 1/2); it just matters that information was by difference.

To clarify this situation, it should be noted that physical laws are often built on analysis of differences. Calculus computes a rate of change, which is the difference of one variable, with respect to a reference variable. Just as calculus is not concerned with flat or constant functions, neither is physics concerned with constant variables. When these variables are physical quantities, like distance and time, one comes up with mathematical patterns or constructs that describe the universe, or a part of it. The change in displacement of an object multiplied by its force weight is work. The change of velocity considering the moving object's mass is force. Time, by observation, is the movement of the hands on a clock to another location on its face. Each of these cases involves the use of analyzing differences which can be observed by the senses. The basic origins of concepts follow psychological interpretation of events, and then the mind combines the pieces together to describe rules of effect. Time accrues aging, energy makes change etc… Observations of changes of state are made, mathematical construction follows, even where observations are mind's thoughts and not data sets.

In the current time, information has been espoused by physicists, and seemingly the above developments were made using a certain type of information. This seems fine until a thought naturally occurs. If info is the key to creating these laws, i.e. by its leading to patterns, the idea of info being more vital to workings of nature than to matter itself is at hand. Differences in info going to the development of laws goes as far as saying that the physical properties observed are components the actual world itself. Another way of putting this, since info is the difference between two states, when info is changed or reduced in magnitude, the physical states of either object is changed. What makes this example interesting and conducive to the view that everything is information is that the segment of information that described something before is now representative of another physical state. Info itself determined the actual state of things. The physical state appears to come from the determination of the effective information. Also, data coming into a system is accompanied by a very minute amount of energy. So adding info does not appear to escape the single system view of conservation.

Previously in physics, states were known of macroscopic entities, and then information was taken as a measure of these states. That is, the info "extracted" from the two states was taken as a description of the two displays of nature- of things which really existed. However, as mathematics comes to form patterns out of info about these states, the thinking is reversed. It is now possible to think of the information between two points as that which is physical. With technology available, modeling nature with computers may make this a viable way to perform theoretical physics. However, to date the most fundamental changes occur when one intuits the correct progression and forms a hypothesis, which then leads to the foundational laws.

The fact that current attempts are still categorizing information (even though with advanced mathematical and technological tools) is likely attributed to their lack of a completeness score. Much like a dietary analysis, modern informational age developments do not have the meat for a healthy, full and square meal, however nutrient-dense they seem for the further development of themselves. By combining the outdated view of information, which describes real identities and not just probabilities, with the notion that progression can be made from this combination, a more satisfactory palate is arrived at. It says that information be regarded as a physical thing, cable of being measured, and worth a certain amount of energy.

In perspective, Newtonian space was seen as a backdrop for the differences to show up; it was akin to a blackboard that meant nothing unless equations in white chalk where written on it. Then later the idea of an aether was proposed, but experiments found the lack of evidence for one again and again. Moreover, the idea of spacetime in Einsteinian descriptions is viewed honestly as a type of aether. But nowadays, this black, the space, must be a carrier of information itself, and hence have an energy that is non-zero. Information is what makes up space, and must also be that which allows for constituents of time, the true nature of which is unknown to even the most forward thinking and capable physicists of this or any other time.

Breaking everything up into code or info requires that the world store data in some way. The way of knowing a state's existence leads to the difference of states being a change seen as time. So time is the extraction of information from differing states. What is matter or real is that which sticks around without exchanging significant amounts of info, like our everyday objects of experience. Thinking of this type gives Planck's constant as representative of the smallest amount of info that the universe can change because of its progression in some direction. The actual value of this is irrelevant here, only that it follows from some (extremely small) exchange between states. The author of this essay posits that it is equal to the unit required to erase and store again information in states. Time is seen more clearly as certainty that information stored will last in a system through exchanges. The probability of this certainty decreases with each further additional exchange of information from any given point, because it is harder to predict an increased number of exchanges. This gives a granular structure to even the progression of what we call Time. There is another point, which is inherent in these ideas if the reader has followed closely. Just because an entity (info or matter) becomes less certain, less attainable by measurement, does not make any less real its existence. The world stores information in a group of "current states," and time is the interchange of information from one state to the next, measured by some means. Also, it may be viewed dimensionally, just like space.

Assumptions about the nature of time and space, dealing with information, and also Relativity Theories, which will always be a part of the physics communities' past, must be considered in order to arrive at a better understanding of mass (or matter) and spacetime gravity. However, we embark on a topic which is neither clear nor relevant, to the subject matter specifically, so it may be best to take this as a weakness of the foregone argument. The question of how information ties into gravity is an area of pursuit for a more appropriate setting. Thus, it is speculated by the author of this essay that greater accumulation of storage units (chunks of matter and mass) means an increased quantity of information exchange and higher incidence of uncertainty. This uncertainty is associated with events further removed from the one at hand (*i.e.* specified further down in time) so that one can make a time, or its associated state, seem more 'distant', and effectively slow down that rate of exchange. The phenomena of stored info being over written must still be contended with. It could be that this overwrite function adds to the "jamming up" of info, while considering the possibility of "dating" or tracking back older data stored in a present state of time or a given progressive dimension. It is not known if the previous considerations will lead to a new theory or bare influence, yet they attempt to answer the fundamental questions, if in a speculative light.

What needs to be done is to find values for the information in, or order of state of, "empty space" itself. This would help further investigate any new theories, which predict such a result. This will also allow further development, and bring joy of unknown specifics to those physicists who contemplate such things! Finally, the code is a statement of the space being made out of the same thing as the matter in it, of a time that is the progression of increasing uncertainty. Information is more fundamental than the material objects of daily experience, but ways to have info make up a complete scheme are unknown. It is certain that the ideas which will be used in the future have to be simple. The only way to break this code is by collecting information itself using highly developed systems that the human kind has attained through its pursuit of knowledge and technology. Furthermore, it needs to be ultimately linked through the human kind intellect, which has itself developed by accumulating theories and concepts of life.