The Perception of Order

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Over the millennia, various objects, laws, and concepts have been considered fundamental. These fundamentals were thought to produce or generate everything. With time, most of the alleged fundamentals were shown to have been derived from other, deeper fundamentals. There is, however, one concept that has always withstood the test of time: the perception of order. Scientists have the ability to observe the seemingly chaotic universe around them and perceive order. We describe two methods that are used to determine such order. The paper closes with the consideration of this perception of order as being the only true fundamental.

Fundamentals: The Usual Suspects.

What is fundamental? What is at the deepest part of reality? What generates all the rest of our universe? The history of philosophy and science is literally littered with such ideas. Thales of Miletus (624 –546 BC), sometimes called the first philosopher, thought water was fundamental. Anaximander (610 – 546 BC), sometimes called the first scientist, felt that the universe is somehow created from infinity. Philosophers and scientists have continued to speculate on such topics ever since. The ancients had a periodic table of four fundamental elements: air, water, fire and earth. Modern chemists improved upon the list, resulting in a periodic table of 118 fundamental elements. In the 20^{th} century, physicists demonstrated that there is a deeper reality than just atoms. Every atom is comprised of a virtual zoo of subatomic particles. As time goes on, scientists discover deeper and deeper objects. The current view summarized in *The Standard Model* states there are about twenty subatomic particles that give rise to all the phenomena we experience. String theorists inform us that all subatomic particles consist of little vibrating strings of energy. Some physicists push other fundamentals, such as loop quantum gravity, which posits that the entire universe is made of small, interconnected loops.

More essential than the search for fundamental physical objects is the search for fundamental laws of physics. These laws describe all the dynamics that we experience. A complete list of such fundamental forces consist of a) gravity, which describes most large scale phenomena; b) electrical forces; c) magnetic forces; d) the weak nuclear force, which is responsible for radioactivity; and e) the strong nuclear force that is responsible for keeping certain subatomic particles together. Just as fundamental objects were shown to be composed of deeper objects, history has shown that fundamental laws are actually aspects of deeper laws. The process of demonstrating that one law is actually part of a larger, more fundamental law is called *unification*. Rather than showing that there is a plethora of various laws, scientists have shown that there are fewer and fewer laws that control everything. At the end of the 17^{th} century, Isaac Newton showed that the laws controlling falling apples on earth are the same laws that control the interactions of the sun, earth, and moon in the heavens, unifying terrestrial and celestial laws of motion. At the end of the 19^{th} century, Michael Faraday and James Clerk Maxwell showed that the laws that describe electricity and the laws that describe the workings of magnets are really two aspects of one more inclusive law, which we call *electromagnetism*. In the late 1950s Sheldon Glashow, Abdus Salam, and Steven Weinberg showed that electromagnetism and the weak nuclear force are two aspects of one larger force we call the *electroweak force*. In the 1970's, Sheldon Glashow and Howard Georgi showed that the electroweak force and the strong force might be amalgamated to get a *grand unified force* (GUT). Thus, at present, there can be essentially two fundamental forces: the grand unified force and gravity. If physicists are successful in unifying these two forces, we would have a *theory of everything* (TOE). In fact, one of the most appealing aspects of string theory is that it is a TOE.

Since the dawn of the natural sciences, mathematics has played an important role in describing the laws of physics. Pythagoras (570–495 BC) believed that nature was perfectly described by rational numbers and inferred from this that these numbers were fundamental and controlled everything in the universe. From the time of Galileo and Newton, the laws of physics needed to be expressed in mathematical terms. In modern times, mathematics has become the final arbiter of what constitutes a law of physics [Burtt]. In fact, despite lack of empirical evidence that string theory is the right model of the universe, many people believe it because it is mathematically beautiful.

Some scientists go farther and believe that mathematics is the most fundamental concept and that eventually all physical laws will simply come down to geometry or other parts of mathematics[1]. The problem with this is that even within the world of mathematics, there are disagreements as to what *are* its fundamental objects. The majority of researchers believe that all mathematical structures can be described by sets. In the past few decades, category theory has become somewhat of a rival to sets in foundational issues. Related to category theory is another, more modern school of philosophy that believes that mathematics deals with structures. Gottlob Frege and Bertrand Russell founded a school that believes that logic is fundamental and all of mathematics can be reduced to various forms of it. In addition to arguments about the true fundamental objects of mathematics, there are also arguments as to how one is to derive mathematical truths. Some schools of thoughts in this area include classicism, intuitionism, constructivism, finitism, etc. We do not want to get into what these schools actually believe. Suffice it to say that even in mathematics, it is not obvious what is a fundamental concept and what is a derived concept.

What are we to make of this history of fundamentals? Are we any closer to determining the truth as to what is fundamental? No matter what object or idea we claim to be fundamental, the probability it will be outdated sometime in the future is high. Even if we discover the universe is made of one type of object (say strings) and there is one TOE, is our job done? Perhaps there is a more fundamental rule or idea controlling the universe. Is there some bottom level, or is scientific truth a kind of infinite Matryoshka doll with one layer inside another? Perhaps it is, as the proverb states, "turtles all the way down."[2] On the other hand, just as the centuries'-long search for the source of the Nile eventually ended, maybe scientists' search for the most fundamental aspect of our world will also end[3]. Another possible scenario is that there is some infinite loop of fundamentals[4]. The final correct answer to these questions is above this humble author's pay grade.

There is, however, one concept that has always been true. This concept is not about what exists or what the laws of nature are. Rather this concept is about how the laws of nature are found.

Perceiving Symmetrical Order.

The one concept that is truly fundamental, since the dawn of time, is the human ability to look at the complex, chaotic universe around them and perceive that there is order and structure. We would like to highlight two methods that are used to find such order.

The first method for finding order I call *perceiving symmetrical order*. Start by asking what scientists study. It would be limiting to say that scientists study physical objects. They study a lot more. Physical objects interact with each other. It would also be a simplification to say that science studies physical phenomena. Rather, scientists study various perceptions of physical phenomena. We have to take into account how a particular phenomenon is viewed. I have come to call each of these perceptions a *perceived physical phenomenon* (PPP). Let us form the set of all PPPs and look at patterns in them to find structure and order.

Physicists taught us to use symmetry. We can use this symmetry to group different PPPs as one. We say a room or a face has symmetry if the left side can be swapped with the right side and it still looks the same. When physicists talk of symmetry, they refer to events that can be swapped with the results still being the same. If an experiment is performed here, and the same experiment is performed in a different location, the results of the experiments should be equivalent. We say such experiments have translation symmetry. Performing an experiment at different times should give the same results: such experiments have time symmetry. Another type of symmetry is from the point of view of various observers. Different observers should be able to describe the same event in their own way. For example, if one observer is stationary, and another one is moving, and they are witnessing the same phenomena, they should be able to calculate the same results. A classical example is that of a passenger in a moving car, throwing a ball up and down. The passenger sees the ball only moving vertically. He makes certain calculations about when the ball will land in the hand. In contrast, a stationary observer outside of the car sees the ball moving vertically and horizontally simultaneously. That observer must take the horizontal motion into account in his calculations. Symmetry demands that both observers reach the same results about when the ball will land. There are many other types of symmetry that phenomena must possess in order for them to be of interest to physicists. When various PPPs are combined as one[5], a law can be described to explain all the elements of that grouping. The larger the grouping, the more universal the law.

Symmetry came onto its own when Albert Einstein formulated the laws of special relativity. He postulated that the laws of physics must be the same whether they are observed by a stationary observer or an observer moving close to the speed of light. With this proviso (and the idea that the speed of light is invariant), the laws of special relativity were formulated. He used the symmetry considerations to describe the laws of nature and hence realized that symmetry was the defining characteristic of the laws of nature. Before Einstein, one could say, “the laws of nature have symmetry.” After Einstein, one must say, “that which has symmetry is a law of nature.”

Emmy Noether took the concept of symmetry further. She showed that every symmetry of a certain type corresponds to a conservation law. These conservation laws are extremely important to the laws of physics.

The fundamental notion is the ability to see such symmetries and, out of the chaos of our world (that is, the many separated PPPs), we can see the order. This is what science is all about. At present, the vast majority of the laws of physics can be recovered from just these symmetry considerations (see, for example, [Stenger] and [Sch]).

This model of grouping PPPs is very good for understanding certain processes in the advancement of science. For example, a controlled experiment is comprised of many PPPs, each corresponding to an alteration of a single variable. One then studies the results of all these PPPs to see which one should be linked with a larger group. A unification of different laws means there are two groupings that are linked together as a single grouping. Finding a more fundamental law means one grouping is shown to be a subset of a larger, more inclusive grouping. Science progresses by finding anomalies in the set of PPPs. That is, there is a PPP that should be grouped with others because of symmetry considerations but it simply does not fit. When there are enough anomalies, science might progress by a paradigm shift which demands a total new grouping of the relevant PPPs. A TOE would be a grouping of all the PPPs into one class that can be described by a single law.

We do not only perceive symmetrical order in science. In earlier work, Mark Zelcer and I showed that one could view mathematics from a symmetrical point of view as well (see [Yan1, Yan2, YZ1, YZ2]). We also show that the symmetrical order that we perceive in nature is a special type of symmetrical order that we perceive in mathematics. We use this to give a natural explanation for Wigner's unreasonable effectiveness of mathematics in the natural sciences.

It is important to emphasize that the fact that laws found with this method are the result of combining PPPs that happen in different times and different places, gives the impression that the law is universal. The laws must apply everywhere and at all times. Also, the fact that the laws found come from combing PPPs that come from different perceptions, gives one the impression that the laws are objective. They must be "out there" and independent of any human being's perception because no matter how they are perceived, they always look the same. But are these laws really universal and objective or is this just a consequence of how we combine the PPPs? We will return to this question shortly.

Perceiving Ensemble Order.

There is yet another way we find order in chaos. Rather than using symmetry considerations to group PPPs, we can group PPPs using a method we call *perceiving ensemble order*. That is, we find statistical laws by looking at an ensemble of PPPs as one. We look at a group of related events as a whole rather than individually.

A simple example is the repeated flipping of a fair coin, seeing if it lands on heads or tails. Each such flip is an individual PPP. Presumably, some flips will result in heads while others will result in tails. The key point is that if we group all these different PPPs, even though they provide different outcomes, we arrive at the statistical law that flipping a coin will result in about 50% heads and 50% tails. The more flips you take into account, the closer you will get to the fifty-fifty ratio that you expect.

Another example is to consider a pot of boiling chicken soup. Each molecule of the broth is heated up and going on its own seemingly random way. If one focused on each molecule, it would look as though the molecule was totally chaotic. However, by observing trillions of soup molecules together, we see an upward pressure on the lid of the pot. A more down-to-earth example is the stock market. While each individual stock is independent and seemingly fluctuates at random on its own, when you observe many stocks as a unit, certain trends emerge. The stock market is going up or going down.

Keep in mind that in all of these cases, the statistical law comes from the fact that we choose to "pull back" and study many different PPPs as one. We would not be able to determine any interesting laws if we looked at only a few flips of the coin, or only a few chicken soup molecules, or a few stock prices. If we flip a coin six times in a row, there are 64 possible outcomes. Only 20 of those 64 possible outcomes will be 50/50 heads-tails splits. That is, more than two-thirds of the time, it will not be an even split. Only by looking at many flips do we arrive at our statistical law.[6]

Such collecting of phenomena does not only occur with large-scale statistical phenomena. Physicists inform us that individual quantum phenomena are random[7] and not subject to any deterministic laws. However, by perceiving ensemble order, we formulate the statistical laws of quantum mechanics. Except for gravity, all our laws of physics are quantum in nature and hence we perceive order using such ensemble methods.

Science perceives both symmetrical order and ensemble order. These two methods also work together. For example, we can flip a coin 100 times today and we can flip a coin 100 times tomorrow. Symmetry demands that the results should be similar. It should be stressed that we are not saying that these two methods are the only way laws of nature are found. However, for now, we will focus on these methods.

Before we go further, let us pose a philosophical question. Are the laws that are found by perceiving ensemble order objective? Are they independent of the observer and the observation? As we have stated, we only find these laws when we look at a certain large group of phenomena. If we look at smaller groups, these laws will not apply. To what extent are they independent of human observation? We will deal with this question shortly.

The Nature of Laws of Nature.

The standard view is that there exist a few preexisting eternal laws of nature --- hopefully one --- and that scientists use the above two methods to find these laws. The laws are universal (everywhere applicable) and objective (independent of human observation). In that case, the two methods mentioned above are fundamental to discovering the fundamental laws of the universe.

There is, however, a radical school of thought that is worthy of contemplation. Several scientists and philosophers, such as Nancy Cartwright, Ronald N. Giere, Vic Stenger, and Bas C. van Frassen, have a nonstandard notion of a law of nature and, to an extent, even question the existence of such laws.

Let us first meditate on the true nature of laws of nature. We begin with a few criticisms of the standard view of laws of nature. They are typically thought of as rules, usually expressed in mathematical language, that control the interactions of various physical objects. The first criticism is that these laws are not physical things. They are metaphysical entities. Do they really exist? Are they “out there” waiting to be found? This is somewhat bothersome for scientists.

Another problem with the usual view of the laws of nature is that they are simply not really true [Cart1, Cart2, Giere]. Consider Isaac Newton’s famous law of that states that two objects will be attracted to each other with a force proportional to the product of their masses and inversely proportional to the square of the distances between them. The problem is that there have never existed two objects to which this law applies. In order for Newton’s law to apply, the objects need to be exactly spherical symmetric, homogeneous, without any charge, neither accelerating nor decelerating, etc. The observer of the two objects must not be accelerating or decelerating. The law also (wrongly) assumes that there are no other objects in the universe. Any other object would influence the forces in uncomputable ways. Another example is Galileo’s studying gravity by observing balls rolling down ramps. The laws that he found assume that the ball is perfectly spherically symmetric, the ramps are perfectly flat and frictionless (an impossibility), there is no air resistance, etc.

Yet another problem with these laws was alluded to above. The laws found using perceived symmetrical order and ensemble order are not really universal and objective. They only seem as though they are. The laws that are found with these two methods depend on what is observed. They do not describe the universe; rather they describe what we chose to observe.

With these criticisms in mind, let us pose the question: exactly what constitutes the laws of nature? Various thinkers have had different thoughts in this area. I will try to summarize some of the views. First, they do not apply to the real world. The real world is just too complex and chaotic for the laws. Rather, the laws apply to idealizations of the real world. They apply to simplified versions of a real world that does not really exist. Second, instead of saying that there are metaphysical forces that control the physical universe, we say they are mental models that we use to describe certain features of the simplified, idealized universe. Simply said, the universe is too chaotic but we can simplify certain phenomena to agree with models that we have in our heads. They are also not about the objective universe; rather the laws are rules that model what we will see when we look at the universe a certain way. If we look at the universe another way, we will need different models.[8] The laws of nature are like a rainbow. They depend on how they are looked at and are a type of illusion.

Let us come back to the question at hand. What is really fundamental? Can laws that depend on the observers and the observations be truly fundamental? I think not. The only true fundamental idea is our ability to pick and choose the order that we see around us. The order that we see is only an illusion. However, this ability to have such an illusion is real and very fundamental.

Perceiving Order in Chaos.

A standard view is that the laws are really out there and it is only our perception of the laws that are somewhat illusory. This view would say that the universe is controlled by exact metaphysical objective rules. The standard view of the laws of physics maybe correct. It would be hard to say that the laws do not exist.[9] However, I would like to demonstrate that one does not need laws of physics for there to be a perception of order in our universe. Even if the universe was totally chaotic, a scientists would be able to pick and choose the phenomena they see and report on the order they found. How can this order be seen if there is total chaos? The concept that there is any order within chaos is a bit hard to swallow. Chaos is the exact opposite of order.

We offer a simple computer experiment for the purpose of demonstrating how one can select order out of total chaos. Consider Figure 1, which is a matrix with 35 rows and 35 columns. Each entry of the matrix has a random digit between 0 and 9. When filling the entries of the matrix, we did not take into account any of the neighboring entries.

Spend some time examining the figure to see if you can find any patterns. It should be obvious that it is a total chaotic mess. However, if you stare at it long enough, you will find the sequence “1 2 3” in row 16, starting in column 12. This is the only “1 2 3” pattern found horizontally. However, this is not the only type of pattern for which we can search. We can also search for the pattern “3 2 1.” What about expanding the search from just looking horizontally to also looking vertically and diagonally? Do you see a lot of patterns? Let us go farther and search for any one of the eight sequences “0 1 2,” “1 2 3,” “2 3 4,” … “7 8 9?” Fortunately, we can easily program a computer to search for all such patterns. Figure 2 has all the patterns of this type from Figure 1.

The popular word search puzzle found in the fun pages of a local newspaper is also about finding certain patterns in seeming chaos. There is a matrix of letters in which words can be found. There is, however, a major difference between word search and our little experiment: the creators of a word-search puzzle put the hidden words in the matrix. In contrast, we did not put in any patterns in our matrix. Random numbers were entered and yet patterns exist.

Sequential patterns are not the only patterns in the chaos. There are many other types of patterns we can search for in the matrix. Figure 3 shows all the repeating number patterns in our matrix. There are still other types of patterns to search for. We can look for sequences like {x x+2 x+4}, the digits of pi, Fibonacci numbers, square blocks of repeating numbers, etc. The pattern that we find depends on how we look for them. This is analogous to the types of models that we have for physical phenomena.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	6	4	7	6	6	3	5	4	3	5	7	2	7	2	4	5	1	3	9	3	1	2	5	4	8	9	4	2	0	7	7	4	8	0	9
2	3	2	2	2	3	3	4	7	6	5	8	0	2	8	4	2	5	1	3	2	5	7	4	2	6	0	6	4	2	5	4	2	7	3	1
3	2	8	9	2	6	5	2	3	5	5	0	9	6	0	3	4	2	5	2	6	0	4	7	8	6	4	3	4	7	7	4	3	6	2	2
4	0	6	8	9	9	1	9	1	5	9	5	5	7	4	9	8	9	0	2	3	7	9	1	0	1	5	7	9	4	2	5	8	0	7	6
5	7	0	6	5	2	2	7	1	3	6	0	0	2	2	2	9	3	9	9	3	8	6	5	2	9	1	2	6	0	5	9	9	6	1	3
6	2	6	6	3	4	3	4	8	3	6	3	4	9	8	2	2	9	5	1	0	5	1	4	2	3	9	7	5	7	1	3	1	2	6	5
7	3	6	8	9	7	3	5	2	6	1	6	6	4	0	1	4	1	9	5	1	3	4	9	6	6	4	2	2	3	0	8	9	9	6	7
8	2	7	8	6	0	8	7	2	4	1	4	4	6	1	5	4	2	6	4	3	7	4	8	2	3	1	5	4	0	6	8	0	0	0	1
9	9	2	8	2	3	4	9	6	6	8	1	8	9	3	5	0	5	2	1	6	8	8	5	2	7	5	8	3	4	3	7	2	5	2	6
10	7	7	6	0	2	1	6	4	3	0	9	4	6	6	6	9	2	2	7	8	8	2	2	0	1	2	6	7	1	9	7	4	7	6	0
11	5	9	6	5	0	1	7	4	1	4	7	9	1	7	5	0	4	8	7	2	0	8	4	5	4	3	9	7	9	9	9	8	7	1	2
12	5	9	1	6	5	3	1	3	8	5	9	2	5	5	5	7	4	4	2	3	3	8	9	7	8	6	5	9	8	9	9	0	0	7	9
13	8	7	6	5	0	5	7	8	7	6	4	1	3	6	3	1	3	0	5	3	8	4	3	4	9	8	5	6	8	4	3	0	7	4	8
14	7	0	0	4	3	2	7	5	1	3	8	9	4	3	4	1	1	7	7	4	2	2	3	9	5	2	7	7	5	9	2	4	8	5	9
15	1	5	9	3	1	1	8	4	5	8	4	5	0	6	5	1	0	8	6	7	2	5	5	5	7	9	4	5	5	5	1	4	2	4	3
16	2	8	4	9	8	1	0	6	7	0	4	1	2	3	0	5	1	3	6	2	0	5	5	5	9	7	9	6	6	1	6	0	9	8	8
17	2	7	3	8	8	2	1	6	1	0	5	9	8	6	5	5	0	0	7	7	6	9	0	5	1	1	5	2	4	9	8	2	8	8	8
18	9	9	8	7	3	3	0	7	2	2	8	2	2	5	4	0	3	5	4	4	0	3	6	6	6	6	8	2	1	2	9	4	6	1	0
19	0	6	0	6	7	1	3	1	8	0	3	2	7	0	4	6	5	0	5	7	4	3	5	6	6	5	4	1	1	4	6	8	7	6	3
20	7	5	1	4	9	3	1	0	4	5	0	6	8	3	6	9	7	3	8	7	2	7	7	8	6	7	8	5	2	1	0	0	0	2	8
21	1	2	9	4	1	4	2	0	6	0	8	3	7	6	8	4	6	3	6	9	5	8	9	8	5	0	8	5	8	0	8	7	1	1	4
22	4	9	4	0	7	5	0	2	4	6	4	6	4	7	9	8	8	6	3	8	7	3	2	4	2	8	0	4	8	3	4	4	7	9	4
23	0	0	3	2	5	2	3	0	7	1	8	1	1	6	6	6	4	7	0	6	2	3	8	4	6	8	5	7	5	2	4	6	8	4	8
24	6	5	2	1	8	3	2	9	5	5	2	4	7	5	3	0	2	0	5	5	9	6	2	6	2	7	9	8	7	2	4	3	1	5	9
25	1	3	8	1	2	7	2	7	2	5	4	7	9	8	2	0	6	6	3	3	9	5	3	1	8	1	9	4	3	7	6	0	9	5	5
26	3	6	9	2	5	2	2	7	8	6	5	6	4	9	9	9	0	9	2	6	4	5	6	9	7	9	9	0	3	9	9	5	9	8	1
27	8	8	9	3	0	9	6	9	9	6	4	3	2	4	2	7	9	1	2	7	5	5	7	0	9	1	0	1	3	2	8	5	6	9	6
28	8	0	8	9	8	8	1	6	4	9	6	0	6	4	5	3	1	3	7	5	6	2	4	7	9	2	3	4	4	6	2	3	7	1	1
29	8	2	9	7	2	0	3	8	0	1	9	3	9	5	7	9	9	5	7	6	0	7	9	3	4	4	8	4	5	7	3	9	0	1	0
30	3	7	1	7	5	1	9	1	2	8	2	0	6	7	5	4	2	8	1	5	9	5	0	7	0	9	5	9	6	1	7	1	9	1	6
31	1	6	9	4	1	6	8	2	8	9	1	0	4	1	5	0	5	3	9	5	5	3	7	5	2	9	4	4	9	1	1	9	7	0	1
32	9	0	6	1	7	5	2	0	7	5	9	0	6	6	6	6	5	4	8	1	8	2	1	0	1	4	6	2	5	1	0	4	9	6	8
33	4	8	6	4	7	3	9	5	6	4	4	8	1	4	8	4	0	8	5	7	1	7	2	1	8	7	1	9	4	6	9	1	1	3	7
34	9	7	2	9	1	1	4	1	6	9	4	5	6	9	1	5	8	2	8	3	7	8	5	8	2	4	0	3	9	6	5	6	4	8	1
35	9	4	8	1	6	2	2	9	2	1	3	5	0	7	7	1	7	3	2	4	6	7	5	8	4	9	8	5	6	1	3	0	6	2	4

Figure 1. A Random Matrix

Figure 2 and Figure 3 are really filters. They show the extracted order that can be found in the chaos of Figure 1. The numbers that do not contribute to the order are left out. This is exactly what scientists do when they look for laws of nature. They let all the unstructured parts fall through their fingers and concentrate on the order.

There is nothing magical here. Some simple probability theory demonstrates that some patterns will be found. Consider the probability of finding the sequence “1 2 3” in the top left corner. The chances of the first box having a “1” is 1/10. The chances of having a “2” in the next box is also 1/10. The same holds for the “3” in the third box. The chances of having these three numbers in order in the first three boxes is

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1							5	4	3								1																8		
2						3		7	6	5						2		1															7		
3							2								3				2														6		
4						1		1						4						3			1												
5				5	2	2											3							2											
6				3	4	3										2									3										
7					7	3									1						3					4									
8						8										4						4			3		5								
9				2	3	4	9								5					6			5	2		5									
10														6					7					0	1	2	6						7		
11										4								8		2				5	4	3		7			9	8	7		
12				6						5											3								8	9	9				
13	8	7	6	5				8	7	6					3							4							8		3				
14				4	3	2									4													7			2				
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18		9	8	7		3				2																									
19				6							3													6	6	5	4					8	7	6	3
20						3										9							7		6	7	8		2	1	0			2	
21						4									8							8					8						1		
22			4			5								7							7														
23			3											6						6		3													
24			2										7	5					5				2			7	9	8	7						
25				1										8						3				1	8			4							
26				2											9				2		4	5	6	9					3						
27				3		9					4	3	2					1			5	5							3	2					
28					8																6		4			2	3	4	4						
29				7																				3					5						
30																4													6						
31									8						5													4							
32									7					6		6	5	4				2	1	0					5						
33									6																					6					
34											4	5	6																						
35																																			

Figure 2. Sequential Patterns in the Random Matrix.

(1/10) × (1/10) × (1/10) = 1/1,000. However, we are looking for this sequence in almost every one of the 1,225 possible positions. This means that the probability of there being a sequence “1 2 3” anywhere in the matrix is 1,225/1,000. No wonder we found one! We are looking for such a pattern in eight different directions: two horizontal, two vertical, and four diagonal directions. We are also looking for any of the eight sequences. In total, we are looking for $8 \times 8 = 64$ possible patterns in each box of Figure 1. It is no wonder that Figure 2 has so many found patterns!

We made many choices in our experiment. If we had made different choices, we would have arrived at different results. The amount of structure found depends on various variables. The larger the matrix, the more patterns will be found. If we used more than 10 possible entries for the matrix, we would have found less structure. The more possible patterns that we search for, the more patterns will be found.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1										5						5								4											
2		2	2	2						5							5						4												
3										5								5				4													
4															9																				
5													2	2	2	9																			
6																	9																		
7			8															9																	
8			8																				8									0	0	0	
9			8																			8													
10													6	6	6						8									9					
11				5																									9	9	9				
12					5								5	5	5													9		9					
13						5										1																			
14																1						2			5										
15					1											1					2	5	5	5				5	5	5					
16					8	1										5				2		5	5	5											
17				8			1								5									5									8	8	8
18			8											5									6	6	6	6									
19																6								6	6										
20															6										6						0	0	0		
21														6																					
22																															4				
23														6	6	6												7			4				
24							2		5																		9		7		4				
25							2			5												5					9		3	7					
26							2				5			9	9	9						5				9	9		3						
27	8								9												5	5			9				3						
28	8									9										5														1	
29	8										9																							1	
30						1			2			0																		1		1		1	
31					1			2				0																		1	1				
32				1			2					0	6	6	6	6			8											1					
33																		8		7															
34																	8				7														
35																						7													

Figure 3. Repeating Patterns in the Random Matrix.

In conclusion, it is not strange to find some patterns in our random matrix. Similarly, it is not strange that we find order in the world around us. We are witness to a large amount of chaotic events. It is possible to select from those chaotic events of which some have symmetry order or ensemble order. By examining those groupings of PPP, we can find the laws that describe them. Even if the universe is totally lawless and chaotic, it is fundamental that we will be able to find some order in the chaos.

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[1] This is taken to the extreme with a phrase that is bandied about: “A particle *is* an irreducible representation of the double cover of the Poincaré group.” Notice the particle is not represented by the representation. Rather, the particle *is* the representation.

[2] The story of this phrase is nicely told by Stephen Hawking on page 1 of [Hawking]:
A well-known scientist (some say it was Bertrand Russell) once gave a public lecture on astronomy. He described how the earth orbits around the sun and how the sun, in turn, orbits around the center of a vast collection of stars called our galaxy. At the end of the lecture, a little old lady at the back of the room got up and said: "What you have told us is rubbish. The world is really a flat plate supported on the back of a giant tortoise." The scientist gave a superior smile before replying, "What is the tortoise standing on?" "You're very clever, young man, very clever," said the old lady. "But it's turtles all the way down!”

The phrase even made it into the Supreme Court proceedings by the son of the late Brooklyn College professor Salvatore Eugene Scalia:
“In our favored version, an Eastern guru affirms that the earth is supported on the back of a tiger. When asked what supports the tiger, he says it stands upon an elephant; and when asked what supports the elephant he says it is a giant turtle. When asked, finally, what supports the giant turtle, he is briefly taken aback, but quickly replies "Ah, after that it is turtles all the way down.”

— Antonin Scalia, "RAPANOS v. UNITED STATES."

[3] For more on the end of science debate see Section 8.1 of [OLR].

[4] This scenario is actually pushed by John Wheeler in his “It from Bit” [Whl] paper, “Physics gives rise to observer-participancy; observer-participancy gives rise to information; and information gives rise to physics.”

[5] We are actually forming an equivalence relation on the set of all PPPs. Each equivalence class will correspond to a law of nature.

[6] This is the content of the law of large numbers.

[7] The question of hidden variables discusses the type of randomness. If there are hidden variables, then the randomness comes from our lack of knowledge. In contrast, if there are no hidden variables, then the randomness is inherent in nature. Whichever view you take, the randomness is there.

[8] There is an analogous situation in quantum mechanics. In 1967, Simon B. Kochen and Ernst Specker proved what came to be called the *Kochen-Specker Theorem*. This states that when measuring a particular property of a particle, the result will depend on what other properties are being measured at the same time. For example, if you want to measure if a particle has spin in the x direction, it depends if you are also measuring in the y direction or you are also measuring in the z direction. You can get a “yes” answer to one question and a “no” answer to the other question. This limitation is called *contextuality*, i.e., the answer to the question depends on the context of the question. In contrast, the naïve view of the universe is *noncontextuality*, i.e. the belief that the answer to a particular question is independent of the context of the question.

A baby example of contextuality is Heisenberg’s famous uncertainty principle. This says that in a quantum system, the results from measuring property x and then measuring property y may be different from the results of first measuring property y and then measuring property x. One may ask what the value of property x is. The answer is that it depends on whether or not property y was measured first.

In a similar way, we are saying that the laws of nature are contextual models. The models depend on how they are measured.

[9] The atheist who proclaims there is no God is as guilty of metaphysical speculations as the theist who proclaims there is a God. Only the agnostic who expressed his ignorance is innocent of all metaphysical speculations.