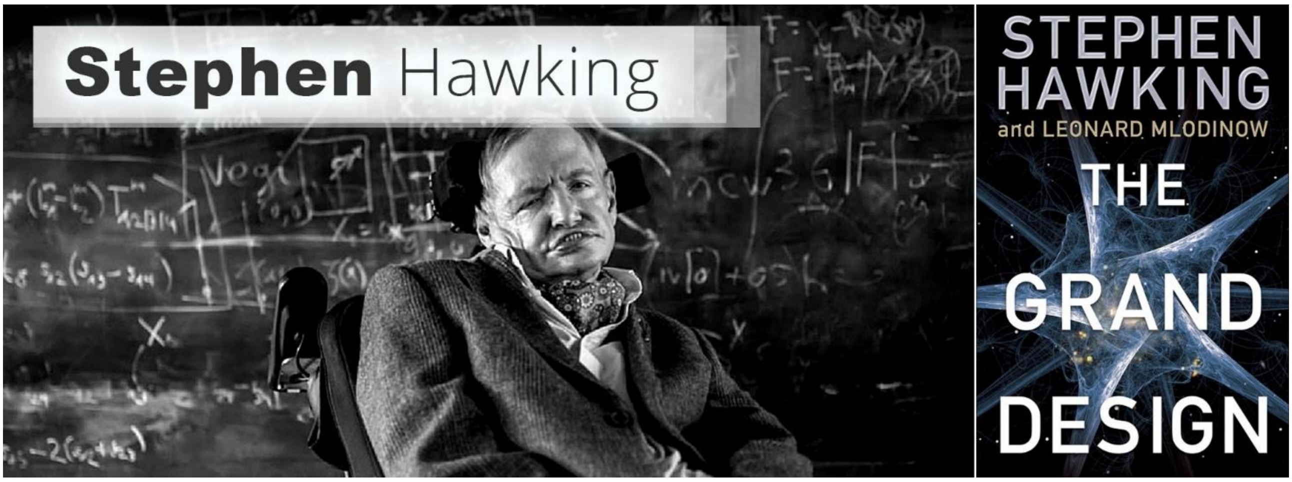
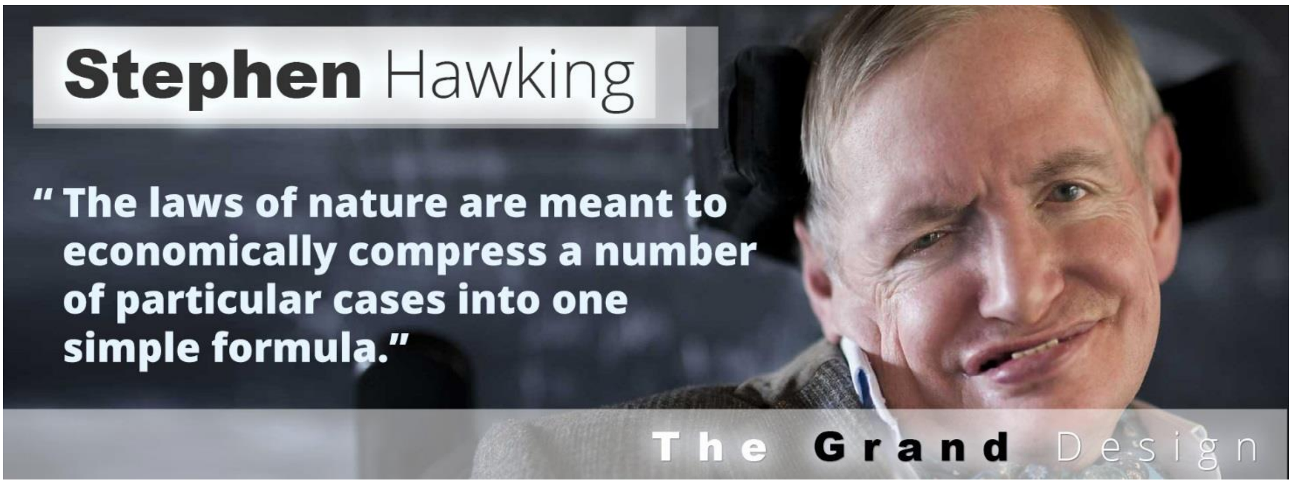
An Edit of The Grand Design

08.72b__An-Edit-of__The-Grand-Design_by_Leonard-Mlodinow_and_Stephen-Hawking__(6-Oct-2018)

Below we find some extracts from The Grand Design that have influenced S-World. The only place where I offer original content is the final chapter where we hear about as-if renormalization and the 87 Quintillion Histories.

by Leonard Mlodinow and Stephen Hawking





The Grand Design CHAPTER 1

by Leonard Mlodinow and Stephen Hawking

WE EACH EXIST FOR BUT A SHORT TIME, and in that time explore but a small part of the whole universe. But humans are a curious species. We wonder, we seek answers. Living in this vast world that is by turns kind and cruel, and gazing at the immense heavens above, people have always asked a multitude of questions: How can we understand the world in which we find ourselves? How does the universe behave? What is the nature of reality? Where did all this come from? Did the universe need a creator? Most of us do not spend most of our time worrying about these questions, but almost all of us worry about them some of the time.

Traditionally these are questions for philosophy, but philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics. Scientists have become the bearers of the torch of discovery in our quest for knowledge. The purpose of this book is to give the answers that are suggested by recent discoveries and theoretical advances. They lead us to a new picture of the universe and our place in it that is very different from the traditional one, and different even from the picture we might have painted just a decade or two ago. Still, the first sketches of the new concept can be traced back almost a century.

According to the traditional conception of the universe, objects move on well-defined paths and have definite histories. We can specify their precise position at each moment in time. Although that account is successful enough for everyday purposes, it was found in the 1920s that this "classical" picture could not account for the seemingly bizarre behavior observed on the atomic and subatomic scales of existence. Instead it was necessary to adopt a different framework, called quantum physics. Quantum theories have turned out to be remarkably accurate at predicting events on those scales, while also reproducing the predictions of the old classical theories when applied to the macroscopic world of daily life. But quantum and classical physics are based on very different conceptions of physical reality.

The Grand Design Quantum theories can be formulated in many different ways, but what is probably the most intuitive description was given by Richard (Dick) Feynman, a colorful character who worked at the California Institute of Technology and played the bongo drums at a strip joint down the road. According to Feynman, a system has not just one history but every possible history. As we seek our answers, we will explain Feynman's approach in detail, and employ it to explore the idea that the universe itself has no single history, nor even an independent existence. That seems like a radical idea, even to many physicists. Indeed, like many notions in today's science, it appears to violate common sense. But common sense is based upon everyday experience, not upon the universe as it is revealed through the marvels of technologies such as those that allow us to gaze deep into the atom or back to the early universe.

Until the advent of modern physics it was generally thought that all knowledge of the world could be obtained through direct observation, that things are what they seem, as perceived through our senses. But the spectacular success of modern physics, which is based upon concepts such as Feynman's that clash with everyday experience, has shown that that is not the case. The naive view of reality therefore is not compatible with modern physics. To deal with such paradoxes we shall adopt an approach that we call model-dependent realism. It is based on the idea that our brains interpret the input from our sensory organs by making a model of the world. When such a The Grand Design model is successful at explaining events, we tend to attribute to it, and to the elements and concepts that constitute it, the quality of reality or absolute truth. But there may be different ways in which one could model the same physical situation, with each employing different fundamental elements and concepts. If two such physical theories or models accurately predict the same events, one cannot be said to be more real than the other; rather, we are free to use whichever model is most convenient.

In the history of science we have discovered a sequence of better and better theories or models, from Plato to the classical theory of Newton to modern quantum theories. It is natural to ask: Will this sequence eventually reach an end point, an ultimate theory of the universe, that will include all forces and predict every observation we can make, or will we continue forever finding better theories, but never one that cannot be improved upon? We do not yet have a definitive answer to this question, but **we now have a candidate for the ultimate theory of everything, if indeed one exists, called M-theory. M-theory is the only model that has all the properties we think the final theory ought to have, and it is the theory upon which much of our later discussion is based.**

M-theory is not a theory in the usual sense. It is a whole family of different theories, each of which is a good description of observations only in some range of physical situations. It is a bit like a map. As is well known, one cannot show the whole of the earth's surface on a single map. The usual Mercator projection used for maps of the world makes areas appear larger and larger in the far north and south and doesn't cover the North and South Poles. To faithfully map the entire earth, one has to use a collection of maps, each of which covers a limited region. The maps overlap each other, and where they do, they show the same landscape. **M-theory is similar. The different theories in the M-theory family may look very different, but they can all be regarded as aspects of the same underlying theory. They are versions of the theory that are applicable only in limited ranges—**for example, when certain quantities such as energy are small. Like the overlapping maps in a Mercator projection, where the ranges of different versions overlap, they predict the same phenomena. But just as there is no flat map that is a good representation of the earth's entire surface, there is no single theory that is a good representation of observations in all situations. The Grand Design

We will describe how M-theory may offer answers to the question of creation. According to M-theory, ours is not the only universe. Instead, M-theory predicts that a great

many universes were created out of nothing. Their creation does not require the intervention of some supernatural being or god. Rather, these multiple universes arise naturally from physical law. They are a prediction of science. Each universe has many possible histories and many possible states at later times, that is, at times like the present, long after their creation. Most of these states will be quite unlike the universe we observe and quite unsuitable for the existence of any form of life. Only a very few would allow creatures like us to exist. Thus our presence selects out from this vast array only those universes that are compatible with our existence. Although we are puny and insignificant on the scale of the cosmos, this makes us in a sense the lords of creation.

To understand the universe at the deepest level, we need to know not only how the universe behaves, but why.

Why is there something rather than nothing?
Why do we exist? The Grand Design Why this particular set of laws and not some other?

This is the Ultimate Question of Life, the Universe, and Everything. We shall attempt to answer it in this book. Unlike the answer given in The Hitchhiker's Guide to the Galaxy, ours won't be simply "42."

The Grand Design by Professor Stephen Hawking & Leonard Mlodinow
Chapter 3. What Is Reality?

Transcribed by Krissy 18th December 2018

A few years ago, the city council of Monza, Italy, barred pet owners from keeping goldfish in curved goldfish bowls. The measure's sponsor explained the measure in part by saying that it is cruel to keep a fish in a bowl with curved sides because, gazing out, the fish would have a distorted view of reality. But how do we know we have the true, undistorted picture of reality? Might not we ourselves also be inside some big goldfish bowl and have our vision distorted by an enormous lens? The goldfish's picture of reality is different from ours, but can we be sure it is less real?
The goldfish view is not the same as our own, but goldfish could still formulate scientific laws governing the motion of objects they observe outside their bowl. For example, due to the distortion, a freely moving object that we would observe to move in a straight line would be observed by the goldfish to move along a curved path. Nevertheless, the goldfish could formulate scientific laws from their distorted frame of reference that would always hold true and that would enable them to make predictions about the future motion of objects outside the bowl. Their laws would be more complicated than the laws in our frame, but simplicity is a matter of taste. If a goldfish formulated such a theory, we would have to admit the goldfish's view was a valid picture of reality.
A famous example of different pictures of reality is the model introduced around AD 150 by Ptolemy (ca.85-ca.165) to describe the motion of celestial bodies. Ptolemy published his work in a thirteen-book treatise usually known under its Arabic title, Almagest. The Almagest begins by explaining reasons for thinking that the earth is spherical, motionless, positioned at the

center of the universe, and negligibly small in comparison to the distance of the heavens. Despite Aristarchus's heliocentric model, these beliefs had been held by most educated Greeks at least since the time of Aristotle, who believed for mystical reasons that the earth should be at the center of the universe. In Ptolemy's model, the earth stood still at the center and the planets and the stars moved around it in complicated orbits involving epicycles, like wheels on wheels.
This model seemed natural because we don't feel the earth under our feet moving (except earthquakes or moments of passion). Later European learning was based on the Greek sources that had been passed down so that the ideas of Aristotle and Ptolemy became the basis for much of Western thought. Ptolemy's model of the cosmos was adopted by the Catholic Church and held as official doctrine for fourteen hundred years. It was not until 1543 that an alternative model was put forward by Copernicus in his book De revolutionibus orbium coelestium (On the Revolutions of the Celestial Spheres), published only in the year of his death (though he had worked on his theory for several decades).
Copernicus, like Aristarchus some seventeen centuries earlier, described the world n which the sun was at rest and the planets revolved around it in circular orbits. Though the idea wasn't new, its revival was met with passionate resistance. The Copernican model was held to contradict the Bible, which was interpreted as saying that the planets moved around the earth, even though the Bible never clearly stated that. In fact, at the time the Bible was written people believed the earth was flat. The Copernican model led to a furious debate as to whether the earth was at rest, culminating in Galileo's trial for heresy in 1633 for advocating the Copernican model, and for thinking "that one may hold and defend as probable an opinion after it has been declared and defined contrary to the Holy Scripture." He was found guilty, confined to house arrest for the rest of his life, and forced to recant. He is said to have muttered under his breath

"Eppur si muove," "But still it moves." In 1992 the Roman Catholic Church finally acknowledged that it had been wrong to condemn Galileo.

So which is real, the Ptolemaic or Copernican system? Although it is not uncommon for people to say that Copernicus proved Ptolemy wrong, that is not true. As in the case of our normal view versus that of the goldfish, one can use either picture as a model of the universe, for our observations of the heavens can be explained by assuming either the earth or the sun to be at rest. Despite its role in philosophical debates over the nature of the universe, the real advantage of the Copernican system is simply in the frame of reference in which the sun is at rest.

A different kind of alternative reality occurs in the science fiction film The Matrix, in which the human race is unknowingly living in a simulated virtual reality created by intelligent computers to keep them pacified and content while the computers suck their bioelectrical energy (whatever that is). Maybe this is not so far-fetched, because many people prefer to spend their time in the simulated reality of websites such as Second Life. How do we know we are not just characters in a computer-generated soap opera? If we lived in a synthetic imaginary world, events would not necessarily have any logic or consistency or obey any laws. The aliens in control might find it more interesting or amusing to see our reactions, for example, if the full moon split in half, or anyone in the world on a diet developed an uncontrollable craving for banana cream pie. But if the aliens did enforce consistent laws, there is no way we could tell there was another reality behind the simulated one. It would be easy to call the world the aliens live in the "real" one and the synthetic world a "false" one. But if - like us – the beings in the simulated world could not gaze into their universe from the outside, there would be no reason for them to doubt their own pictures of reality. This is the modern version of the idea that we are all figments of someone else's dream. These examples bring us to a conclusion that will be important in this book: There is no picture- or

theory-independent concept of reality. Instead we will adopt a view that we will call model-dependent realism: the idea that a physical theory or world picture is a model (generally of a mathematical nature) and a set of rules that connect the elements of the model to observations. This provides a framework with which to interpret modern science.
Philosophers from Plato onward have argued over the years about the nature of reality. Classical science is based on the belief that there exists a real external world whose properties are definite and independent of the observer who perceives them. According to classical science, certain objects exist and have physical properties, such as speed and mass, that have well-defined values. In this view our theories are attempts to describe those objects and their properties, and our measurements and perceptions correspond to them. Both observer and observed are parts of a world that has an objective existence, and any distinction between them has no meaningful significance. In other words, if you see a herd of zebras fighting for a spot in the parking garage, it is because there really is a herd of zebras fighting for a spot in the parking garage. All other observers who look will measure the same properties, and the herd will have those properties whether anyone observes them or not. In philosophy that belief is called realism.
Though realism may be a tempting viewpoint, as we'll see later, what we know about modern physics makes it a difficult one to defend. For example, according to the principles of quantum physics, which is an accurate description of nature, a particle has neither a definite position nor a definite velocity unless and until those quantities are measured by an observer. It is therefore not correct to say that a measurement gives a certain result because the quantity being measured had that value at the time of the measurement. In fact, in some cases individual objects don't even have an independent existence but rather exist only as part of an ensemble of many. And if a theory called the holographic principle proves correct, we and our four-dimensional world may

be shadows on the boundary of a larger, five-dimensional space-time. In that case, our status in the universe is analogous to that of the goldfish.
Strict realists often argue that the proof that scientific theories represent reality lies in their success. But different theories can successfully describe the same phenomenon through disparate conceptual frameworks. In fact, many scientific theories that had proven successful were later replaced by other, equally successful theories based on wholly new concepts of reality.
Traditionally those who didn't accept realism have been called anti-realists. Anti-realists suppose a distinction between empirical knowledge and theoretical knowledge. They typically argue that observation and experiment are meaningful but that theories are no more than useful instruments that do not embody any deeper truths underlying the observed phenomena. Some anti-realists have even wanted to restrict science to things that can be observed. For that reason, many in the nineteenth century rejected the idea of atoms on the grounds that we would never see one. George Berkeley (1685-1752) even went as far as to say that nothing exists except the mind and its ideas. When a friend remarked to English author and lexicographer Dr Samuel Johnson (1709-1784) that Berkeley's claim could not possibly be refuted, Johnson is said to have responded by walking over a large stone, kicking it, and proclaiming, "I refute it thus." Of course, the pain Dr Johnson experienced in his foot was also an idea in his mind, so he wasn't really refuting Berkley's ideas. But his act did illustrate the view of philosopher David Hume (1711-1776), who wrote that although we have no rational grounds for believing in an objective reality, we also have no choice but to act as if it is true.
Model-dependent realism short-circuits all this argument and discussion between the realist and anti-realist schools of thought

According to model-dependent realism, it is pointless to ask whether a model is real, only whether it agrees with

observation. If there are two models that both agree with our observation, like the goldfish's picture and ours, then one cannot say that one is more real than the other. One can use whichever model is convenient in the situation under consideration. For example, if one were inside the bowl, the goldfish's picture would be useful, but for those outside, it would be very awkward to describe events from a distant galaxy in the frame of a bowl on earth, especially because the bowl would be moving as the earth orbits the sun and spins on its axis.

We make models in science, but we also make them in everyday life. Model-dependent realism applies not only to scientific models but also to the conscious and subconscious mental models we all create in order to interpret and understand the everyday world. There is no way to remove the observer – us – from our perception of the world, which is created through our sensory processing and through the way we think and reason. Our perception – and hence the observations upon which our theories are based – is not direct, but rather is shaped by a kind of lens, the interpretive structure of our human brains.

Model-dependent realism corresponds to the way we perceive objects. In vision, one's brain receives a series of signals down to the optic nerve. Those signals do not constitute the sort of image you would accept on your television. There is a blind spot where the optic nerve attaches to the retina, and the only part of your field of vision with good resolution is a narrow area of about 1 degree of visual angle around the retina's center, an area the width of your thumb when held at arm's length. And so, the raw data sent to the brain are like a badly pixilated picture with a hole in it. Fortunately, the human brain processes that data combining the input from both eyes, filling in gaps on the assumption that the visual properties of neighbouring locations are similar and interpolating. Moreover, it reads a two-dimensional array of data from the retina and creates from it the impression of three-dimensional space. The brain, in other words, builds a mental picture or model.

The brain is so good at model building that if people are fitted with glasses that turn the images in their eyes upside down, their brains, after a time, change the model so that they again see things the right way up. If the glasses are then removed, they see the world upside down for a while, then again adapt. This shows that what one means when one says “I see a chair” is merely that one has used the light scattered by the chair to build a mental image or model of the chair. If the model is upside down, with luck one’s brain will correct it before one tries to sit on the chair.

Another problem that model-dependent realism solves, or at least avoids, is the meaning of existence. How do I know that a table still exists if I go out to the room and can’t see it? What does it mean to say that things we can’t see, such as electrons or quarks- the particles that are said to make up the proton and neutron - exist? One could have a model in which the table disappears when I leave the room and reappears in the same position when I come back. but that would be awkward, and what if something happened when I was out, like the ceiling falling in? How, under the table-disappears-when-I-leave-the-room model, could I account for the fact that the next time I enter, the table reappears broken, under the debris of the ceiling? The model in which the table stays put is much simpler and agrees with observation. That is all one can ask.

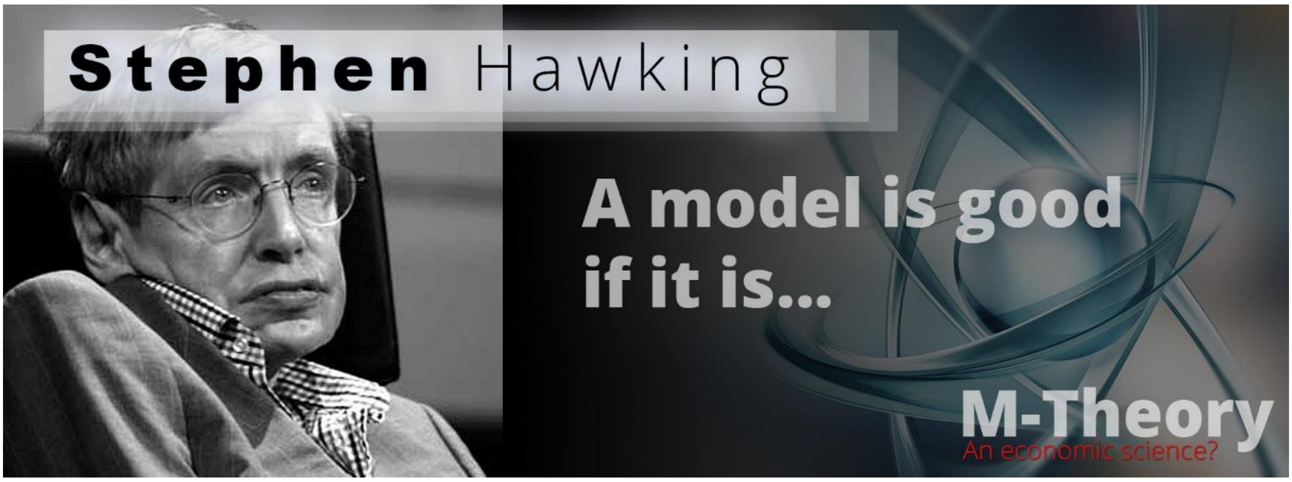
In the case of subatomic particles that we can’t see, electrons are a useful model that explains observations like tracks in a cloud chamber and the spots of light on a television tube, as well as many other phenomena. It is said that the electron was discovered in 1897 by British physicist J. J. Thomson at the Cavendish Laboratory at Cambridge University. He was experimenting with currents of electricity inside empty glass tubes, a phenomenon known as cathode rays. His experiments led him to the bold conclusion that the mysterious rays were composed of “corpuscles” that were material constituents of atoms, which were then thought to be the indivisible fundamental unit of matter. Thomson did not “see” an electron, nor was his speculation directly or unambiguously demonstrated by his experiments. But the model has proved crucial in applications from fundamental science to engineering, and today all physicists believe electrons, even though they cannot see them.

Quarks, which we all cannot see, are a model to explain the properties of the protons and neutrons in the nucleus of an atom. Though protons and neutrons are said to be made of quarks, we will never observe a quark because the binding force between quarks increases with separation, and hence isolated, free quarks cannot exist in nature. Instead, they always occur in groups of three (protons and neutrons), or in pairings of a quark and an anti-quark (pi mesons) and behave as if they were joined by rubber bands.

The question of whether it makes sense to say quarks really exist if you can never isolate one was a controversial issue in the years after the quark model was proposed. The idea that certain particles were made of different combinations of a few sub-subnuclear particles provided an organizing principle that yielded a simple and attractive explanation for their properties. But although physicists were accustomed to accepting particles that were only inferred to exist from statistical blips in data pertaining to the scattering of other particles, the idea assigning reality to a particle that might be, in principle, observable was too much for physicists. Over the years, however, as the quark model led to more and more correct predictions, that opposition faded. It is certainly possible that some alien beings with seventeen arms, infrared eyes, and a habit of blowing clotted cream out their ears would make the same experimental observations that we do but describe them without quarks. Nevertheless, according to model-dependent realism, quarks exist in a model that agrees with our observations of how subnuclear particles behave.

Model dependent realism can provide a framework to discuss questions such as: If the world was created a finite time ago, what happened before that? An early Christian philosopher, St. Augustine (353-430), said that the answer was not that God was preparing hell for people who ask such questions, but that time was a property of the world that God created, and that time did not exist before the creation, which he believed had occurred not that long ago. That is one possible model, which is favored by those who maintain that the account given in Genesis is literally true even though the world contains fossils and other evidence that makes it look much older. (Were they put there to fool us?) One can also have a different model, in which time continues back 13.7 billion years to the big bang. The model that explains the most about our present observations, including the historical and geological evidence, is the best representation we have of the past. The second model can explain the fossil and the radioactive records and the fact that we receive light from galaxies millions of light-years from us, and so this model – the big bang theory – is more useful than the first. Still, neither model can be said to be more real than the other.

Some people support a model in which time goes back even further than big bang. It is not yet clear whether a model in which time continued back beyond the big bang would be better at explaining present observations because it seems the laws of the evolution of the universe may break down the big bang. If they do, it would make no sense to create a model that encompasses time before the big bang, because what existed then would have no observable consequences for the present, and so we might as well stick with the idea that the big bang was the creation of the world.



A MODEL IS A GOOD MODEL IF IT:

1. Is elegant
2. Contains few arbitrary or adjustable elements
3. Agrees with and explains all existing observations
4. Makes detailed predictions about future observations that can disprove or falsify the model if they are borne out.

For example, Aristotle's theory that the world was made of four elements, earth, air, fire, and water, and that objects acted to fulfil their purpose was elegant and didn't contain adjustable elements. But in many cases, it didn't make definite predictions, and when it did, the predictions weren't always in agreement with observation. One of these predictions was that heavier objects should fall faster because their purpose is to fall. Nobody seemed to have thought that it was important to test until Galileo. There is a story that he tested it by dropping weights from the Leaning Tower of Pisa. This is probably apocryphal, but we do know he rolled different weights down an inclined plane and observed that they all gathered speed at the same rate, contrary to Aristotle's prediction.
The above criteria are obviously subjective. Elegance, for example, is not something easily measured, but it is highly prized

among scientists because laws of nature are meant to economically compress a number of particular cases into one simple formula. Elegance refers to the form of a theory, but it is closely related to a lack of adjustable elements, since a theory jammed with fudge factors is not very elegant. To paraphrase Einstein, a theory should be as simple as possible, but no simpler. Ptolemy added epicycles to the circular orbits of the heavenly bodies in order that his model might accurately describe the motion. The model could have been made more accurate by adding epicycles to the epicycles, or even epicycles to those. Though added complexity could make the model more accurate, scientists view a model that is contorted to match a specific set of observations as unsatisfying, more of a catalogue of data than a theory likely to embody any useful principle.
We'll see in Chapter 5 that many view the "standard model," which describes the interactions of the elementary particles of nature, as inelegant. That model is far more successful than Ptolemy's epicycles. It predicted the existence of several new article before they were observed and described the outcome of numerous experiments over several decades to great precision. But it contains dozens of adjustable parameters whose values must be fixed to match observations, rather than being determined by the theory itself.
As for the fourth point, scientists are always impressed when new and stunning predictions prove correct. On the other hand, when the model is found lacking, a common reaction is to say the experiment was wrong. If that doesn't prove to be the case, people still often don't abandon the model but instead attempt to save it through modifications. Although physicists are indeed tenacious in their attempts to rescue theories they admire, the tendency to modify a theory fades to a degree that the alterations become artificial or cumbersome, and therefore "inelegant."
If the modifications needed to accommodate new observations become too baroque, it signals the need for a new model. One

example of an old model that gave way under the weight of new observations was the idea of a static universe. In the 1920s, most physicists believed that the universe was static, or unchanging in size. Then, in 1929, Edwin Hubble published his observations showing that the universe is expanding. But Hubble did not directly observe the universe expanding. He observed the light emitted by galaxies. That light carries a characteristic signature, or spectrum, based on each galaxy's composition, which changes by a known amount if the galaxy is moving relative to us. Therefore, by analysing the spectra of distant galaxies, Hubble was able to determine their velocities. He had expected to find as many galaxies moving away from us as moving toward us. Instead he found that nearly all galaxies were moving away from us, and farther away they were, the faster they were moving. Hubble concluded that the universe is expanding, but others, trying to hold on to the earlier model, attempted to explain his observations within the context of the static universe. For example, Caltech physicist Fritz Zwicky suggested that for some yet unknown reason light must slowly lose energy as it travels great distances. This decrease in energy would correspond to a change in the light's spectrum, which Zwicky suggested could mimic Hubble's observations. For decades after Hubble, many scientists continued to hold on to the steady-state theory. But the most natural model was Hubble's, that of an expanding universe, and it has come to be the accepted one.

In our quest to find the laws that govern the universe we have formulated a number of theories or models, such as the four-element theory, the Ptolemaic model, the phlogiston model, the big bang theory, and so on. With each theory or model, our concepts of reality and of the fundamental constituents of the universe have changed. For example, consider the theory of light. Newton thought that light was made up of little particles or corpuscles. This would explain why light travels in straight lines, and Newton also used it to explain why light is bent or refracted when it passes from one medium to another, such as from air to glass or air to water.

The corpuscle theory could not, however, be used to explain a phenomenon that Newton himself observed, which is known as Newton's rings. Place a lens on a flat reflecting plate and illuminate it with light of a single color, such as a sodium light. Looking down from above, one will see a series of light and dark rings centred on where the lens touches the surface. This would be difficult to explain with the particle theory of light, but it can be accounted for in the wave theory.

According to the wave theory of light, the light and dark rings are caused by a phenomenon called interference. A wave, such as a water wave, consists of a series of crests and troughs. When waves collide, if those crests and troughs happen to correspond, they reinforce each other, yielding a larger wave. That is called constructive interference. In that case the waves are said to be "in phase." At the other extreme, when the waves meet, the crests of one wave might coincide with the troughs of each other. In that case the waves cancel each other and are said to be "out of phase." That situation is called destructive.

The Grand Design
Chapter 5. **The Theory of** Everything

by Professors **Stephen Hawking** and **Leonard Mlodinow**

The known forces of nature can be divided into four classes:

1. **Gravity.** This is the weakest of the four, but it is a long-range force and acts on everything in the universe as an attraction. This means that for large bodies the gravitational forces all add up and can dominate over all other forces.

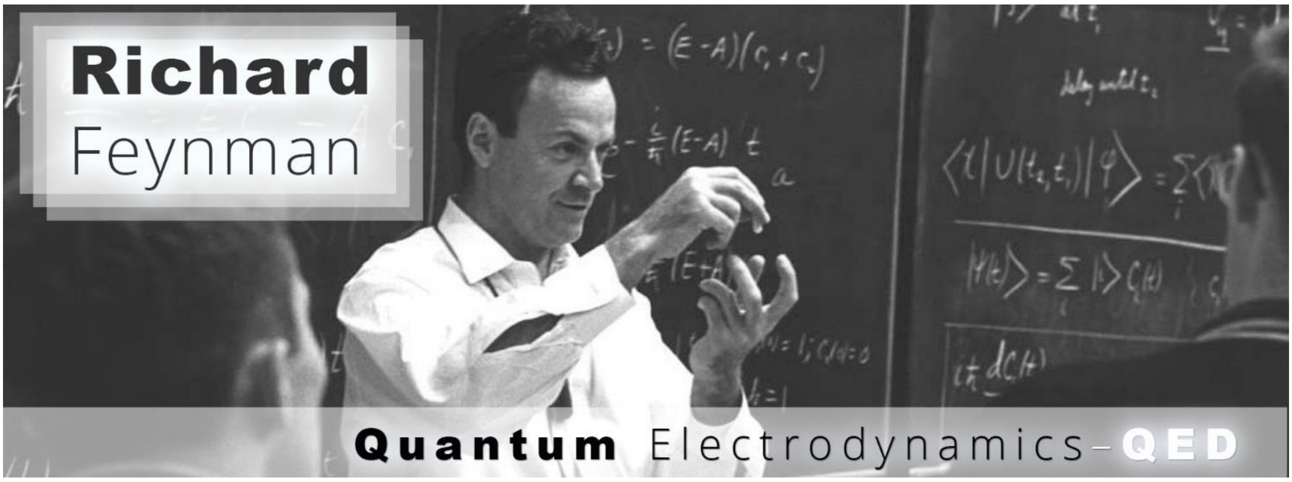
2. **Electromagnetism.** This is also long-range and is much stronger than gravity, but it acts only on particles with an electric charge, being repulsive between charges of the same sign and attractive between charges of the opposite sign. This means the electric forces between large bodies cancel each other out, but on the scales of atoms and molecules, they dominate. Electromagnetic forces are responsible for all of chemistry and biology.

3. **Weak Nuclear Force.** This causes radioactivity and plays a vital role in the formation of the elements in stars and the early universe. We don't, however, come into contact with this force in our everyday lives.

4. **Strong Nuclear Force.** This force holds together the protons and neutrons inside the nucleus of an atom. It also holds together the protons and neutrons themselves, which is necessary because they are made of still tinier particles; quarks. The strong force is the energy source for the sun and nuclear power, but, as with the weak force, we don't have direct contact with it.

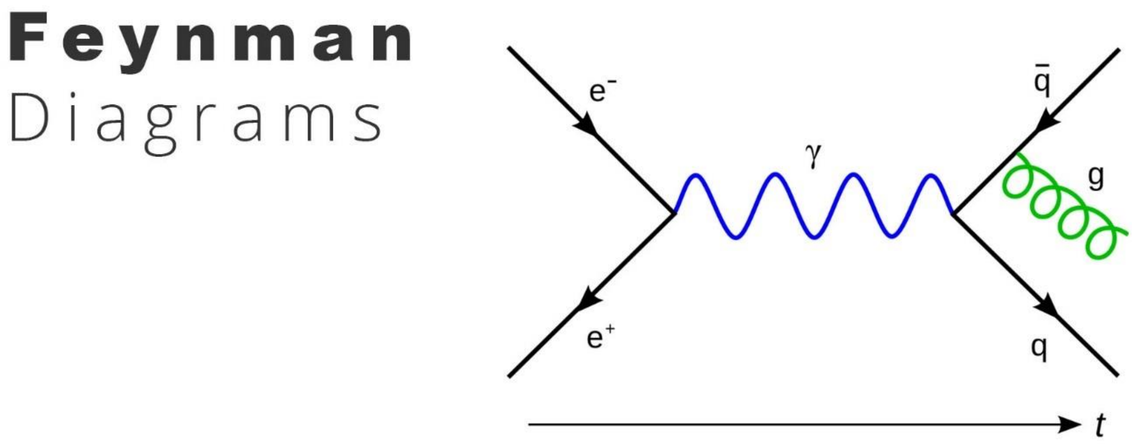
The first force for which a quantum version was created was electromagnetism. The quantum theory of the electromagnetic field called quantum electrodynamics, or QED for short, was developed in the 1940s by Richard Feynman and others and has become a model for all quantum field theories.

A particle of light is an example of a boson. According to QED, all the interactions between charged particles—particles that feel the electromagnetic force—are described in terms of the exchange of photons.



The predictions of QED have been tested and found to match experimental results with great precision. But performing the mathematical calculations required by QED can be difficult. The problem, as we'll see below, is that when you add to the above framework of particle exchange the quantum requirement that one include all the histories by which an interaction can occur—for example, all the ways the force particles can be exchanged—the mathematics becomes complicated. Fortunately, along with inventing the notion of alternative histories—Feynman also developed a neat graphical method of accounting for the different histories, a method that is today applied not just to QED but to all quantum field theories.

Feynman's graphical method provides a way of visualizing each term in the sum over histories. Those pictures, called **Feynman diagrams**, are one of the most important tools of modern physics. **In QED the sum over all possible histories can be represented as a sum over Feynman diagrams.**



The process of renormalization involves subtracting quantities that are defined to be infinite and negative in such a way that, with careful mathematical accounting, the sum of the negative infinite values and the positive infinite values that arise in the theory almost cancel out, leaving a small remainder, the finite observed values of mass and charge.

Once we have fixed the mass and charge of the electron in this manner, we can employ QED to make many other very precise predictions, which all agree extremely closely with observation, **so renormalization is one of the essential ingredients of QED.**

The success of renormalization in QED encouraged attempts to look for quantum field theories describing the other three forces of nature. People have therefore sought **a theory of everything** that will unify the four classes into a single law that is compatible with quantum theory. This would be the holy grail of physics.

The strong force can be renormalized on its own in a theory called QCD, or quantum chromodynamics. Since earlier observational evidence had also failed to support GUTs (Grand Unified Theories), most physicists adopted an ad hoc theory called the standard model, The standard model is very successful and agrees with all current observational evidence**,** but it is ultimately unsatisfactory because it does not include gravity.

The **closed loops** in the Feynman diagrams for gravity produce infinities that cannot be absorbed by renormalization because in general relativity there are not enough renormalizable parameters (such as the values of mass and charge) to remove all the quantum infinities from the theory. We are therefore left with a theory of gravity that predicts that certain quantities, such as the curvature of space-time, are infinite, which is no way to run a habitable universe. That means the only possibility of obtaining a sensible theory would be for all the infinities to somehow cancel, without resorting to renormalization.

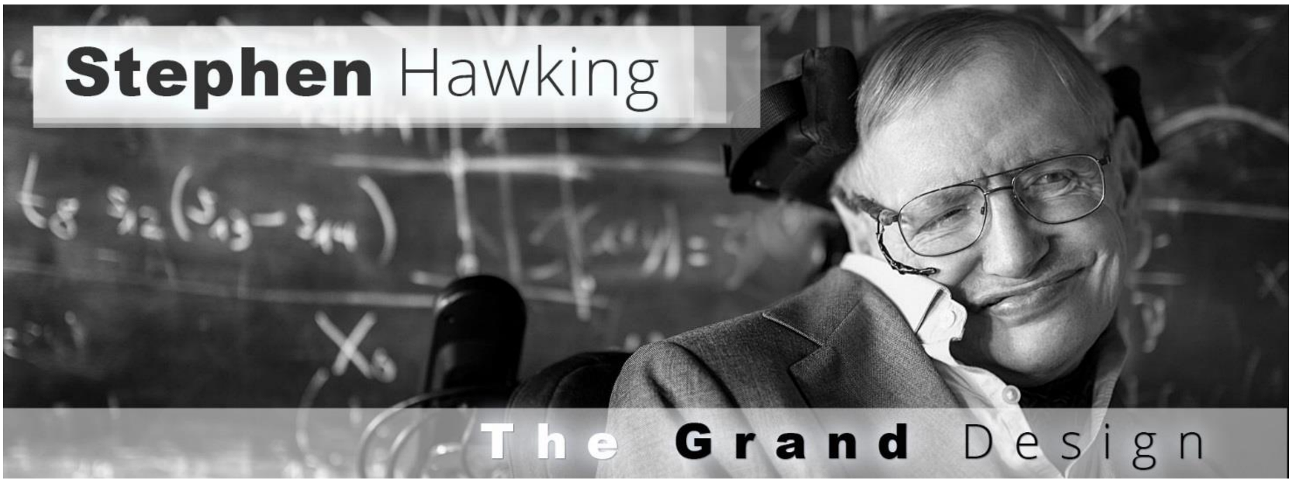
In 1976 a possible solution to that problem was found. It is called supergravity. **The prefix "super" was not appended because physicists thought it was "super"** that this theory of quantum gravity might actually work. Instead, **"super" refers to a kind of symmetry the theory possesses, called supersymmetry.**

In physics a system is said to have a symmetry if its properties are unaffected by a certain transformation such as rotating it in space or taking its mirror image.

One of the important implications of supersymmetry is that force particles and matter particles, and hence force and matter, are really just two facets of the same thing. Practically speaking, that means that each matter particle, such as a quark, ought to have a partner particle that is a force particle, and each force particle, such as the photon, ought to have a partner particle that is a matter particle. This has the potential to solve the problem of infinities because it turns out that **the infinities from closed loops of force particles are positive while the infinities from closed loops of matter particles are negative**, so the infinities in the theory arising from the force particles and their partner matter particles tend to cancel out.

The idea of **supersymmetry** was the key to the creation of supergravity, but the concept had actually originated years earlier with theorists studying a fledgeling theory called **string theory.** String theories also lead to infinities, but it is believed that in the right version they will all cancel out. They have another unusual feature: They are consistent only if space-time has ten dimensions.

Then, around 1994, people started to discover dualities—that different string theories, and different ways of curling up the extra dimensions, are simply different ways of describing the same phenomena in four dimensions. Moreover, they found that supergravity is also related to the other theories in this way. String theorists are now convinced that the five different string theories and supergravity are just different approximations to a more fundamental theory, each valid in different situations.



That theory is called M-theory. No one seems to know what the "M" stands for, but it may be "master," "miracle," "matrix, "or "mystery." It seems to be all four. People are still trying to decipher the nature of M-theory, but that may not be possible. It could be that the physicist's traditional expectation of a single theory of nature is untenable, and there exists no single formulation. **It might be that to describe the universe, we have to employ different theories in different situations.** Each theory may have its own version of reality, but according to model-dependent realism, **that is acceptable so long as the theories agree in their predictions whenever they overlap,** that is, whenever they can both be applied.

Whether M-theory exists as a single formulation or only as a network, we do know some of its properties. First, M-theory has eleven spacetime dimensions, not ten.

The mathematics of the theory restricts the manner in which the dimensions of the internal space can be curled. **The exact shape of the internal space determines both the values of physical constants, such as the charge of the electron, and the nature of the interactions between elementary particles.**

In other words, it determines the apparent laws of nature. We say “apparent” because we mean the laws that we observe in our universe—the laws of the four forces, and the parameters such as mass and charge that characterize the elementary particles.

But the more fundamental laws are those of M-theory.”

End of Extract from:
The Grand Design
CHAPTER 5. THE THEORY OF EVERYTHING.
by Professors **Stephen Hawking** and **Leonard Mlodinow**

BEYOND 87 Quintillion Histories, and the Conclusion of The Grand Design

From Supereconomics Book 3 – 64 Reasons Why – Complete Book.

The previous extract links the idea of Alternate Histories with renormalization, Supersymmetry, String Theory and M-Theory, but misses out LQG (Loop Quantum Gravity.)

I have included the section primarily in the hope that someone, (be they economist, engineer, physicist, mathematician or other) will be able to apply the renormalization or find an As-If renormalization method to go beyond 87 quintillion histories.

Currently in the broad spectrum of 2020 to 2080 with 1 billion Simulation Events there remains 87,714,630,433,327,500,000 (87 quintillion histories). But as we have seen, we may need more than a billion Simulation Events per history. Renormalization, if it can be applied direct or **As-If** could effectivly increase simulations by many zeros like:
87,714,630,433,327,500,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

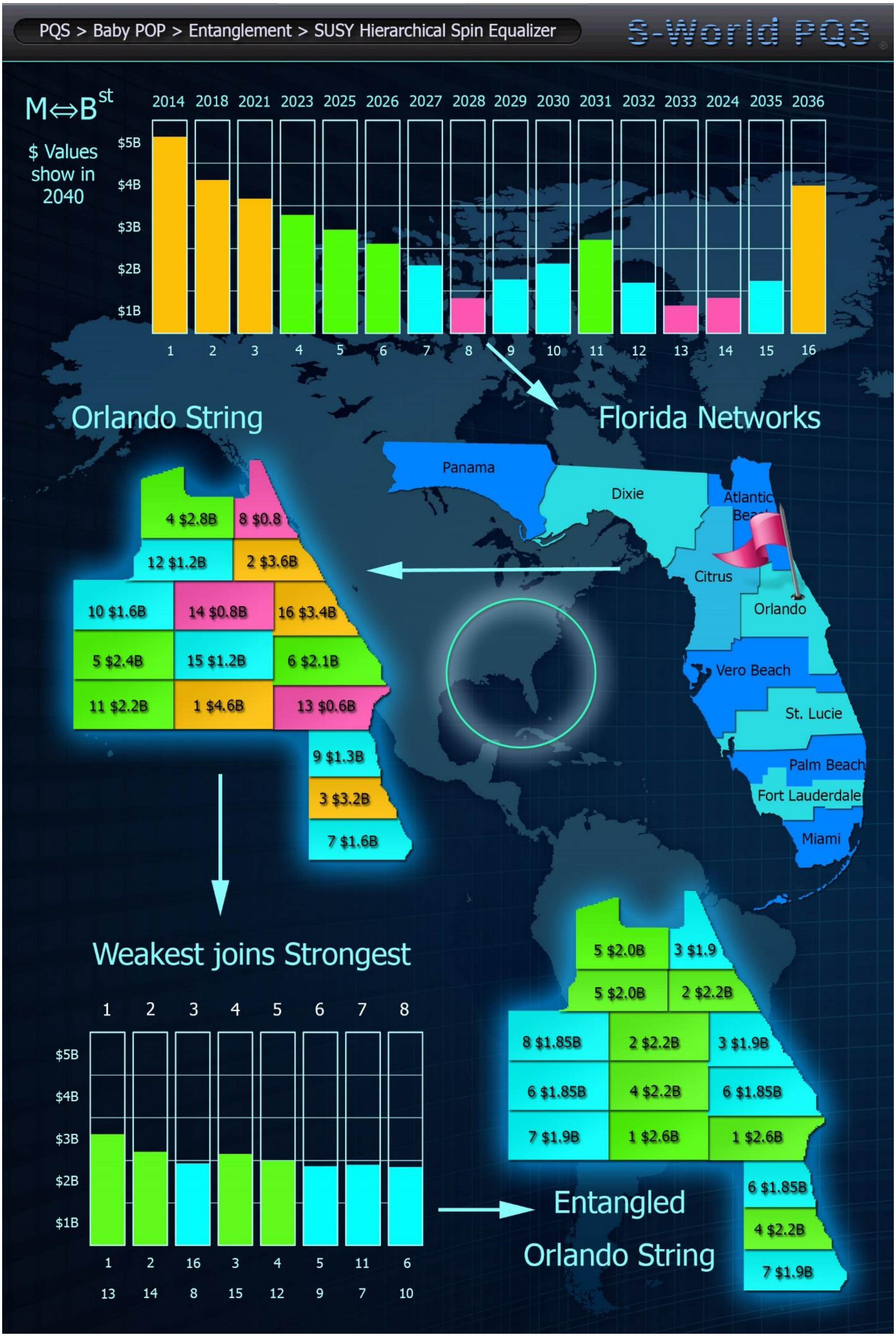
or

87,714,630,433,327,500,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

So whilst it's out of my sphere of command of knowledge, it may be possible by specialists. One thing I have done to assist this process is to quantize Network Credits (see spreadsheet tab POP Đimensions (3)).

Even if we can't do renormalization, the Grand Design section is important as it shows the importance of paths and histories in particle and theoretical physics, which I hope increases the importance of the histories approach to economics we adopt in Supereconomics.

As for Supersymmetry, the physics that helped name Supereconomics, I now have two clear examples, the As-If SUSY Hierarchal Spin Equalizer from 2012 seen right (or below if reading the PDF). And the Superpartner approach to how individual companies in the Malawi Grand Śpin Network expand into larger Đimensional networks that were created while writing this chapter. And is looking good as a major system for modelling the path of small companies into large networks.



PQS > Baby POP > Entanglement > SUSY Hierarchical Spin Equalizer
S-World PQS
M⇔B st
$ Values show in 2040
2014 2018 2021 2023 2025 2026 2027 2028 2029 2030 2031 2032 2033 2024 2035 2036
$5B $4B $3B $2B $1B
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Orlando String
Florida Networks
4 $2.8B
8 $0.8
12 $1.2B
2 $3.6B
10 $1.6B
14 $0.8B
16 $3.4B
5 $2.4B
15 $1.2B
6 $2.1B
11 $2.2B
1 $4.6B
13 $0.6B
9 $1.3B
3 $3.2B
7 $1.6B
Panama
Dixie
Atlantic Beach
Citrus
Orlando
Vero Beach
St. Lucie
Palm Beach
Fort Lauderdale
Miami
Weakest joins Strongest
1 2 3 4 5 6 7 8
$5B $4B $3B $2B $1B
1 2 16 3 4 5 11 6
13 14 8 15 12 9 7 10
5 $2.0B
3 $1.9
5 $2.0B
2 $2.2B
8 $1.85B
2 $2.2B
3 $1.9B
6 $1.85B
4 $2.2B
6 $1.85B
7 $1.9B
1 $2.6B
1 $2.6B
6 $1.85B
4 $2.2B
7 $1.9B
Entangled
Orlando String

Unfortunately, despite many attempts at the LHC (Large Hadron Collider), no trace of supersymmetry or string theory has been detected. What that means for M-theory can't be good. But does not stop the basic idea of Supereconomics as an economic theory attributing the idea of many maps of economics that may vary in places but agree in important places.

Hawking:
"Each theory may have its own version of reality, but according to model-dependent realism, that is acceptable so long as the theories agree in their predictions whenever they overlap, that is, whenever they can both be applied."

Getting back to renormalization and the Feynman Sum Over histories I have done some research and found mention of QCD, Renormalization and paths/histories in Carlo Rovelli's; Reality Is Not What It Seems: The Journey to Quantum Gravity.

The Following is from in Carlo Rovelli's book;

Systems in Quantum Theory

A physical system manifests itself only by interacting with another. The description of a physical system, then, is always given in relation to another physical system, one with which it interacts. Any description of a system is therefore always a description of the information which a system has about another system, that is to say; the correlation between the two systems.

The description of a system, in the end, is nothing other than a way of summarizing all the past interactions with it and using them to predict the effect of future interactions.

Consider two simple postulates:

(1) The relevant information in any physical system is finite.
(2) You can always obtain new information on a physical system

Here the relevant information is the information that we have about a given system as a consequence of our past interactions with it. Information allowing us to predict what will be the result for us of future interactions with this system.

The first postulate characterises the granularity of quantum mechanics, the fact that a finite number of possibilities exists.

The second characterizes its indeterminacy, the fact that there is always something and unpredictable which allows us to obtain new information. When we acquire new information about a system; total relevant information cannot grow indefinitely because of the first postulate, **and part of the previous information becomes irrelevant, that is to say, it no longer has any effect upon predictions of the future.**

In quantum mechanics when we interact with a system, we don't only learn something we also cancel a part of the relevant information **about the system.**

The entire formal structure of quantum mechanics follows in large measure from these two simple postulates, therefore the theory lends itself in a surprising way to being expressed in terms of information.

Reality Is Not What It Seems

The Journey to Quantum Gravity

By Carlo **Rovelli**

I included this section because of the cancelling out method of compression, cancelling new histories that we know from experience will make no change is important. *(we need to make room for new storage)*

Another book on a similar subject is Quantum Space – Loop Quantum Gravity and the Search for the Structure of Space, Time, and the Universe by Jim **Baggott**

This book championed the **As-If** reasoning method in:

As If – MASS RENORMALIZATION

Re Normalization,
We do not need to make the mathematics of the network work exactly like quantum mechanics to use Renormalization. All we need to do is teach the AI to govern the histories **As-if** it was using renormalization, to remove infinities or in our case places where data is of no use.

"Mass **Renormalization**

The theorists realised that the problems with the early version of QED were a result of the electron interaction with its own self-generated electromagnetic field, causing some terms in the equations to mushroom to infinity. As a result of these interactions, the electron gathers a covering of virtual particles around itself. These virtual particles have energy, and as we know from $M=E/C^2$ the mass of such a dressed electron is, therefore, greater than its bare-mass, or the mass the election would be expected to possess if it could be separated from its own electromagnetic field. It's impossible to know the bare mass of the electron is, but the equations of QED could now be manipulated to solve the problem.

The theorists discovered that subtracting the equation describing the electron in one physical situation, from the equation describing in the electron in a different situation, meant that they could get rid of infinite terms. Subtracting infinity from infinity doesn't seem on the surface to be a very sensible thing to attempt, but it was found that the result was not only finite it was also right.

This sleight of hand is called Mass Renormalization."

Quantum Space

Loop Quantum Gravity
and the Search for the Structure of
Space, Time, and the Universe
By Jim **Baggott**

Don't let the big words fool you into thinking I understand the two books above, The Grand Design I'm familiar with, but The Journey to Quantum Gravity and Quantum Space is a big test, but I had been looking for more detail on the Feynman Sum Over Histories and QCD renormalisation and these books delivered.

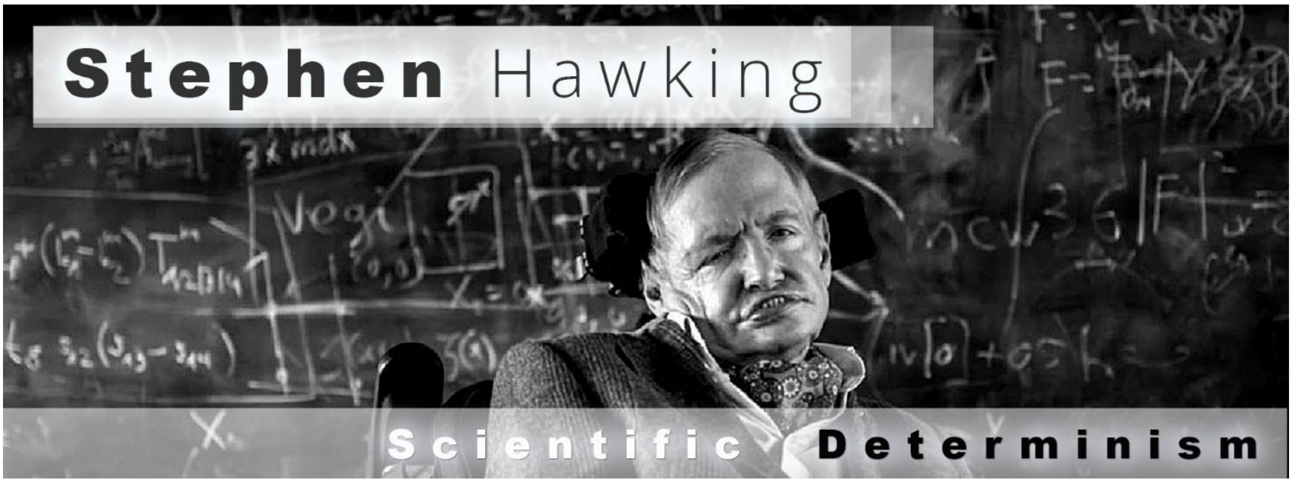
I know only bits of the books. A big leap was however taken in understanding the quantization principle and applying it to our money (network credits), so now there is no unit smaller than 0.0001 cents, which I hope will eventually lead to a way to cancel the uneventful histories **As-If** they were infinities.

There may be a simpler way to cancel null interest results using calculus, which uses infinities such as Pi or 33.333333… to work out solutions to much bigger problems, for instance, the global economy seen throughout the eyes of S-World Angelwing can be shepherding the micro day to day spending of all in the network, would be more manageable than it is now.

Whilst there is no specific point from the following section, it is nice to know the end of the Grand Design story. And note I will be approaching Leonard Mlodinow and Lucy Hawking about the use of this chapter and the previous ones.

The Grand Design
Chapter 8. **The Grand** Design

by Professors **Stephen Hawking** and **Leonard Mlodinow**



We leave this chapter with an edit of the concluding chapter in The Grand Design: For no reason in particular other than the sharing of how a black hole is created and how it contains positive energy.

Scientific Determinism: There must be a complete set of laws that, given the state of the universe at a specific time, would specify how the universe would develop from that time forward. These laws should hold everywhere and at all times; otherwise they wouldn't be laws. There could be no exceptions or miracles.

Even a very simple set of laws can produce complex features similar to those of intelligent life. Any set of laws that describes a continuous world such as our own will have a concept of energy, which is a conserved quantity, meaning it doesn't change in time. The energy of empty space will be a constant, independent of both time and position. One can subtract out this constant vacuum energy by measuring the energy of any volume of space relative to that of the same volume of empty space, so we may as well call the constant zero. One requirement any law of nature must satisfy is that it dictates that the energy of an isolated body surrounded by empty space is positive, which means that one has to do work to assemble the body. That's because if the energy of an isolated body were negative, it could be created in a state of motion so that its negative energy was exactly balanced by the positive energy due to its motion. If that were true, there would be no reason that bodies could not appear anywhere and everywhere. Empty space would therefore be unstable. But if it costs energy to create an isolated body, such instability cannot happen, because, as we've said, the energy of the universe must remain constant. That is what it takes to make the universe locally stable—to make it so that things don't just appear everywhere from nothing.

If the total energy of the universe must always remain zero, and it costs energy to create a body, how can a whole universe be created from nothing? That is why there must be a law like gravity. Because gravity is attractive, gravitational energy is negative: One has to do work to separate a gravitationally bound system, such as the earth and moon. This negative energy can balance the positive energy needed to create matter, but it's not quite that simple. The negative gravitational energy of the earth, for example, is less than a billionth of the positive energy of the matter particles the earth is made of. A body such as a star will have more negative gravitational energy, and the smaller it is (the closer the different parts of it are to each other), the greater this negative gravitational energy will be. But before it can become greater than the positive energy of the matter, the star will collapse to a black hole, and black holes have positive energy. That's why empty space is stable. Bodies such as stars or black holes cannot just appear out of nothing. But a whole universe can.

Because gravity shapes space and time, it allows space-time to be locally stable but globally unstable. On the scale of the entire universe, the positive energy of the matter *can* be balanced by the negative gravitational energy, and so there is no restriction on the creation of whole universes. Because there is a law like gravity, the universe can and will create itself from nothing. Spontaneous creation is the reason there is something rather than nothing, why the universe exists, why we exist. It is not necessary to invoke God to light the blue touch paper and set the universe going.

Why are the fundamental laws as we have described them? The ultimate theory must be consistent and must predict finite results for quantities that we can measure. We've seen that there must be a law like gravity, and that for a theory of gravity to predict finite quantities, the theory must have what is called **supersymmetry** between the forces of nature and the matter on which they act. **M-theory is the most general supersymmetric theory of gravity. For these reasons M-theory is the *only* candidate for a complete theory of the universe.** If it is finite—and this has yet to be proved—it will be a model of a universe that creates itself. We must be part of this universe, because there is no other consistent model.

M-theory is the unified theory Einstein was hoping to find. The fact that we human beings—who are ourselves mere collections of fundamental particles of nature—have been able to come this close to an understanding of the laws governing us and our universe is a great triumph. But perhaps the true miracle is that abstract considerations of logic lead to a unique theory that predicts and describes a vast universe full of the amazing variety that we see. **If the theory is confirmed by observation,** it will be the successful conclusion of a search going back more than 3,000 years. **We will have found the grand design.**