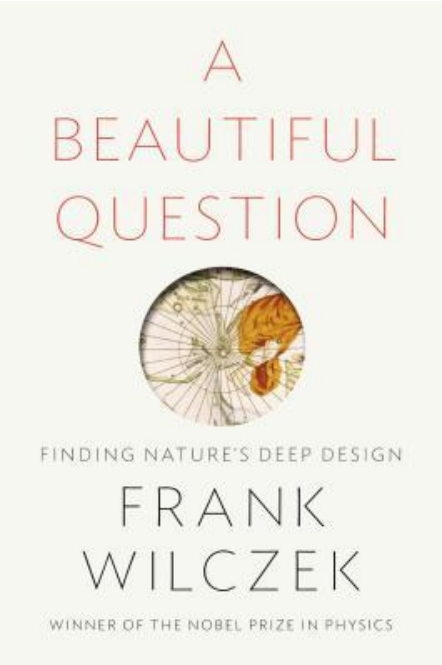

A Beautiful Question: Finding Nature's Deep Design

Frank Wilczek

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Does the universe embody beautiful ideas?

Artists as well as scientists throughout human history have pondered this “beautiful question.” With Nobel laureate Frank Wilczek as your guide, embark on a voyage of related discoveries, from Plato and Pythagoras up to the present. Wilczek’s groundbreaking work in quantum physics was inspired by his intuition to look for a deeper order of beauty in nature. In fact, every major advance in his career came from this intuition: to assume that the universe embodies beautiful forms, forms whose hallmarks are symmetry—harmony, balance, proportion—and economy. There are other meanings of “beauty,” but this is the deep logic of the universe—and it is no accident that it is also at the heart of what we find aesthetically pleasing and inspiring.

Wilczek is hardly alone among great scientists in charting his course using beauty as his compass. As he reveals in *A Beautiful Question*, this has been the heart of scientific pursuit from Pythagoras, the ancient Greek who was the first to argue that “all things are number,” to Galileo, Newton, Maxwell, Einstein, and into the deep waters of twentiethcentury physics. Though the ancients weren’t right about everything, their ardent belief in the music of the spheres has proved true down to the quantum level. Indeed, Wilczek explores just how intertwined our ideas about beauty and art are with our scientific understanding of the cosmos.

Wilczek brings us right to the edge of knowledge today, where the core insights of even the craziest quantum ideas apply principles we all understand. The equations for atoms and light are almost literally the same equations that govern musical instruments and sound; the subatomic particles that are responsible for most of our mass are determined by simple geometric symmetries. The universe itself, suggests Wilczek, seems to want to embody beautiful and elegant forms. Perhaps this force is the pure elegance of numbers, perhaps the work of a higher being, or somewhere between. Either way, we don’t depart from the infinite and infinitesimal after all; we’re profoundly connected to them, and we connect them. When we find that our sense of beauty is realized in the physical world, we are discovering something about the world, but also something about ourselves.

Gorgeously illustrated, *A Beautiful Question* is a mind-shifting book that braids the age-old quest for beauty and the age-old quest for truth into a thrilling synthesis. It is a dazzling and important work from one of our best thinkers, whose humor and infectious sense of wonder animate every page. Yes: The world is a work of art, and its deepest truths are ones we already feel, as if they were somehow written in our souls.

A Beautiful Question: Finding Nature's Deep Design Details

Date	:	Published July 14th 2015 by Penguin Press
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From Reader Review A Beautiful Question: Finding Nature's Deep Design for online ebook

Patrick says

(Disclaimer: I received this book through Goodreads First Reads.)

While the "question" Wilczek explores in this book is a compelling one, its pull is somewhat diminished by the foregone nature of the book's conclusion: Wilczek himself declares that quantum theory is a "definite answer 'yes'" just 8 pages in. With the drama of the hunt somewhat deflated by this bizarre spoiler, Beautiful Question goes from the advertised quest to something more like a meditation on the remarkable ability of scientists, from Pythagoras to Einstein, to uncover layer after layer of stunning structure and complex design. And that journey, moving less towards beauty than into it, is a hypnotic and illuminating one -- more than once I found myself meaning to polish off a chapter only to look up more than an hour later having gotten through hundreds of years of scientific progress.

That said, as a contemplation the book does often fail to live up to its promise. The prose is efficient but far from stunning, and too often seems wrapped up in its own satisfaction with possessing what it presents as "the answer." Many sections are frustratingly vague; the book seems stuck somehow between popular science and a legitimate exploration of the issues, often bringing up advanced topics I had never heard of (such as the "Platonic" structures of many algae and viruses) but only skimming the surface of actual explanation. On the other hand, I'm sure that I would have been lost or irritated had Wilczek gone too crazy with details that didn't interest me, and there are a few times (such as his exploration of Pythagorean acoustics) where he strikes just the right balance of economy and depth -- just the amount needed to appreciate the genuine structure of a given phenomenon, without too badly taxing the attention of a less-interested reader.

Overall, the book is a beautiful mess -- replete with joy, excitement, and yes, beauty, even as it ultimately fails as a narrative or an argument. Probably read best not as a single piece, but rather as a source of extended meditations on great realizations from the first geometry to the wildest dreams of modern physicists. As an ode to the (often-underrated) ways in which science can be good for the soul, it succeeds; it may not convince you that the universe is beautiful for any *reason*, but it should at least remind you that, yes, it's probably worth looking around once in a while.

Abhishek Hamal says

The way that the author/scientists leads the reader from the question to the answer is meticulously well done. Apart from some rhetoric repetition of some of the history of science (which I'm sure was pivotal to what was to come later both in the world and the book, and which mostly was meant for the first time readers I hope) the book takes you on a journey of all the beautiful ideals of science and how they fit with the reality. All in all I must say, this was a wonderful journey despite rough rhetorics though some of the insights from them were really good.

Jane Upshall says

I was excited to read this book . However with my limited knowledge of physics and mathematics , I struggled through. The beginning was easy read however it got a little crazy the further I read into it. I would only recommend to someone who has more knowledge in the subject.

Max says

Wilczek shows the correspondence between physics and art focusing on their use of symmetry. He explains that symmetry lies at the heart of the relationship between numbers and form and even perception. He reviews the importance of symmetry in the history of physics. Wilczek uses analogies, pictures and diagrams rather than equations to explain concepts. But make no mistake this is a serious physics book. Wilczek is a Nobel Prize winning physicist who has strong beliefs about the importance of symmetry to physics research. He prefers to build beautiful symmetric equations and look for evidence that validates them than to work from assembled observations and try to turn them into meaningful equations. Below are my notes.

Wilczek begins with the ancients. Starting with Pythagoras and his eponymous theorem we see that numerical relationships are also geometric ones. Digging into Pythagoras's musical interest we see how numerical relationships define musical ones such as chords even telling us which ones would be pleasing to our ears. Wilczek details the transfer of frequency or pitch from mechanical to electrical impulse tracing it from string to air to ear to neuron. Turning to Plato we see his focus on symmetry in the five platonic solids. Plato held four of them to be the atoms of his elements. Fire was the tetrahedron, water the icosahedron, earth the cube, and air the octahedron. The fifth, the dodecahedron was the shape of the universe. Plato realized structure is determined by symmetry just as physicists do today. So even though Plato was way off on the universe's building blocks he was right on this foundational concept of modern physics. Wilczek also recounts Plato's metaphor of the people chained in a cave who can only see shadows. Plato understood that there is much more to the world than what our senses can detect.

Next Wilczek discusses projective geometry. Brunelleschi pioneered techniques to achieve realistic perspective in painting. His Renaissance counterparts quickly adopted his methods to accurately depict three dimensions in two dimensions. The idea of perspective leads to fundamental concepts of modern physics: relativity (the essence of perspective), symmetry (maintaining the same state when rotated, moved, or other types of transformations), invariance (maintaining the same state from any perspective) and complementarity (looking not only different from a different perspective but to the exclusion of the other perspective).

Wilczek moves on to the scientific revolution. Newton changed the way physics was conducted. Famous for explaining gravity and motion, his greatest contribution may have been simply to demand quantitative precision. Qualitative assessments were no longer relevant. Maxwell, the author's favorite physicist, ushered in truly modern physics with his equations that explained light as an electromagnetic wave. His symmetrical equations helped establish the importance of symmetry in physics. Maxwell's equations paved the way for the twentieth century discoveries of relativity and quantum mechanics. Maxwell used observations made in Faraday's experiments to build his equations. Wilczek favors the reverse approach. Formulate symmetrical equations and look for phenomena where they apply.

The early twentieth century was notable for many great physicists: Rutherford, Planck, Einstein, Bohr, and many more. One often overlooked who should be included in such lists was the great mathematician, Emily Noether. She saw the connection between mathematical formulations of physical laws and physical quantities that were invariant. Noether's theorem holds that symmetries of physical laws yield quantities that are conserved. Time translation symmetry tells us that the laws of physics that applied in the past will do so in the future. The quantity that does not change with time is said to be conserved. In the case of time translation symmetry the conserved quantity is energy. It is invariant with respect to time. Spatial translation

symmetry yields momentum as a conserved quantity. Rotational symmetry yields angular momentum as a conserved quantity. Einstein employed Galilean symmetry in deriving special relativity. Galileo in a thought experiment described being below decks in the closed compartment of a ship. Changes in the ships motion at a constant velocity did not change the laws of physics in the compartment. Einstein showed that even with Galilean transformation the speed of light remained constant. Einstein was inspired by Maxwell's equations that showed the speed of light was a constant.

Wilczsek presents his version of the Standard Model; a name he feels belies its importance, calling his version Core Theory. The Standard Model excludes gravity, Core Theory includes it. Wilczek believes the conflict many see between quantum mechanics and general relativity is overstated. He does admit Core Theory has problems such as not explaining dark matter, dark energy or singularities. He describes the interplay between the four forces (electromagnetic, gravity, strong and weak) and the four respective properties of matter (electric charge, energy-momentum, strong charge and weak charge) that are described by the theory. In the case of gravity it is the density of energy and momentum that curves space-time or looking at it from a different perspective Wilczeck says energy-momentum density tells matter which way is straight. He employs the concept of property space. Populating space with values depicting distances between nearby points form a metric that maps the effect of energy-momentum on space time. Thus the metric of space-time determines the movement of energy-momentum objects, but energy-momentum objects determine the shape of the metric field. The concept of property fields and this same logic applies to the other three forces and their counterparts: charge and electromagnetic waves, as well as the strong and weak forces and their objects. From Wilczek's point of view the fundamental forces and the respective properties of matter in essence are yin and yang, a receptive component and a driving component in a constant tug of war.

The carriers of the four forces are the photon, graviton, color gluon and weakon. They are the quanta of the electromagnetic, metric, strong and weak fields. These force mediating particles Wilczek describes as avatars of local symmetries. Local symmetries are key to Wilczek. Local symmetries allow changes in quantities within equations without changing the results of the equations. They are local because the symmetry does not have to apply everywhere or all the time. It is out of these symmetries that the force carrying particles arise.

What exactly are protons and neutrons (together called nucleons)? They carry most of the universe's mass. They consist of quarks that are tightly contained by gluons but when close to each other quarks can be randomly arranged. This feature of the strong force that increases with the distance between quarks and is negligible when they are close together is called asymptotic freedom. One thing that stood out to me is that the mass of the quarks is tiny. Wilczek concludes, "almost all of the nucleon's mass, and thus almost all of the mass of ordinary matter in the Universe, arises from pure energy". The kinetic energy of the quarks and the field energy of the gluon fields supply, "Mass Without Mass, emerging directly from the purely conceptual, symmetry rooted equations of QCD." QCD, quantum chromodynamics, is the theory of the strong force.

Quarks, in addition to electrical charge, carry one of three different color charges which embody the strong force. The term color here is completely unrelated to spectral color. Unlike electrical charge, each color charge is three dimensional defining a place in its property space. So if a quark changes from one color to another it can be considered to be in two different places in property space. Gluons mediate color charge and interact with quarks. In this complicated dynamic there are eight types of gluons and six types of quarks. Moreover unlike photons, gluons interact with one another and can change the color of other gluons. Also gluons take their positions based on that of the quark so in QCD we have another example of yin and yang between color charged particles and color property space.

In the end, it seems that Supersymmetry (SUSY) is where Wilczek is taking us. He is a strong advocate having bet that by 2020 evidence of SUSY will be found. SUSY posits that there are quantum dimensions in which particles transform from one type to another. He points out that, "what can depend on where. The

same entity, located in different positions within a property space, often manifests itself as several different particles." The theory holds that substance particles (fermions) can change into force particles (bosons) and vice versa when entering quantum dimensions. Thus substance and force particles cannot exist without each other. "Both are the same thing, seen from different perspectives." So here we have it, the ultimate symmetry, the ultimate Yin and Yang and the ultimate beauty in Wiczek's eyes.

This book starts out easy and gets increasingly complicated. Of great help is an excellent glossary with detailed explanations of terms used in the text. The index is also well done and I used it much trying to reconcile concepts. Still, without prior familiarity with the topics I would have been completely lost by the end. Wilczek's presentation is refreshing and unique. It is connected by a theme, the evolution of the concept of symmetry. I selected this book to better understand symmetry which is at the forefront of physics today. For those with similar interests I highly recommend, A Beautiful Question.

Chris Kelly says

This book (styled as a "meditation" by the author) aims to answer a single question: does the universe embody beautiful concepts? And while I readily agree with Wilczek's answer (yes! Undoubtedly, yes!), his explanation of why leaves much to be desired. The opening chapters dealing with Pythagoras and Plato were an entertaining read to be sure but the book quickly descends into a quagmire of theoretical physics crossed with quasi-philosophical pondering. Wilczek continually uses flowery, poetical language as an attempt (I think) to sound profound but it serves only to obfuscate the science he is trying to explain.

The back jacket of the hardcover edition includes a laudatory quote from Deepak Chopra. I should have seen that as a warning....

Jimmy Ele says

I loved this book. It truly made me appreciate Pythagoras, Plato, Newton, Maxwell, and Einstein's insights a lot more. It is very easy to comprehend and comes replete with great pictures that help the reader visualize the beautiful ideas that are embodied in Nature's Deep Design (ElectroMagnetism, Gravity, Weak and Strong Force, Light, Sound, Geometry etc.) One of my favorite chapters was the chapter on the physics behind light and the color spectrum. I thought I knew what colors were, but quickly realized that I only had a surface understanding. After reading this book I am seeing all of the colors around me more deeply i.e. with an increased clarity. I appreciate the creation more and thus am increased in my admiration for the great Creator and Artisan's artistry, power, force, intelligence, and mercy. I am in shock that this book did not make it into the Good Reads Science Picks for this year. I don't think that it is very often that we get a Nobel Prize winning physicist to give us a physics history and art lesson. Frank Wilczek ends the book brilliantly by explaining to us with great depth of understanding the modern endeavor to unify all of the forces (by using supersymmetry as well as other concepts such as property space).

I recommend this book for anyone who is on the same quest for truth and beauty that Pythagoras, Plato, Newton, Maxwell, and Einstein were on.

Hillary says

I received this book for free through Goodreads First Reads.

I have just received this book and I am looking forward to reading it. I have already started reading, but just looking through teh first part I can see that it will take me some time to read thoroughly enjoy and understand the given material.

I will update my review once I have had the opportunity to complete this book.

Gary Beauregard Bottomley says

I had stopped reading popular science books because most of the new ones had nothing to say or they ended up in the land of woo. This book does neither.

This book can work for any audience. The artist will appreciate the beauty that the universe gives to us through its harmony of concordance, the obsessive reader of science books (as I used to be) will love the fact that the author takes one way beyond what they thought they knew and the PhD in physics will learn things he didn't know about the coherence of the universe.

In the beginning of the book he shows how the early Greeks established the comprehension of the world through numbers by first explaining music, and how the perfect Platonic forms relate to the real. At the heart of our understanding (and beauty) is the symmetry we use to understand the world around us. Every reader will end up absorbing his definition of symmetry: that which brings change without change.

He'll show how the first real jump in human understanding is when Pope Leo X ask Copernicus to fix that calendar so that Easter doesn't change relative to the seasons. Copernicus asked a question as a thought experiment "what if I were on the sun, how would that effect how I perceive the year on Earth".

The author takes the John Wheeler quote, "matter tells spacetime how to curve, and spacetime tells space how to move". He'll show how that same phenomenon can be applied to all the fundamental forces of nature. Each of the forces of nature have a law of conservation associated with them. He'll go in detail on Emmy Noether and how she shows that (I like any book that gives Emmy Noether her rightful place in history). This is when the book starts to go way beyond all the other pop science books I've read over the years and never talks down to the listener.

He dissects Maxwell's equations and shows how they came to be and what they really mean. Ultimately, he explains Einstein's General Theory with the rule of relative perspective (Copernicus and Galileo) to the constant for the speed of light that pops up in Maxwell's equations. Once again the book is taking me places other science books fear to tread.

He'll go through the particle zoo and tell you what the Higgs Field really means and how the photon itself is modeled in an accelerator as if it did have weight. He'll tell the listener the problems with the standard model and how the extra dimensions needed for SUZY (string theory) allows for the solution to a host of standard model problems and how we are very close with the current levels of energy at the LHC in finding confirmations to this.

A couple of things. This book can be a difficult read. I would definitely recommend listening to it rather than reading it. Because, I if I had read it, I would have spent days on the up, down, charm quarks and how they

go into the building the protons that build the universe. By listening to the book, I got the gist of the points and didn't overly dwell on the minutia. Another thing, this book is very comparable to Steven Weinburg's "To Explain the World". If you think this book is too difficult for you (that is you didn't follow what I wrote in this review), get his book instead. I recommend both books because they actually have a different philosophy on how they see the world. Wilczek would say from the fundamental models that describe the world emerge reality (e.g. atoms are an emergent property of our models). Weinburg would say that our understanding changes with our constricts we have There are differences in how each construct the structures underlying our universe ontologically. Each understand more than I ever will, I'm just fortunate that audible has made both books available to me.

We live in exciting times. The author quotes Keats, "that truth is beauty and beauty is truth" this book will show the listener why that is more true today than ever before.

Manuel Antão says

If you're into stuff like this, you can read the full review.

1/0: "A Beautiful Question - Finding Nature's Deep Design" by Frank Wilczek

(Original Review, 2015)

Just this morning my Chi Kung teacher at the Sheraton Hotel (I’m doing classes over there at lunch time), a Daoist (Taoist) monk, said virtually the same thing whilst quoting the Yi Jing (I Ching). In fact, the philosophy of movement underlying the entire system (often translated as Great Ultimate Fist) is based upon this principle. One might presume this aspect of human awareness reflects a primordial knowledge that precedes any particular culture's intellectual/philosophical continuum. Such primordial knowledge would inform and find expression in any sufficiently refined intellectual/philosophical cultural continuum. In fact, because this is so, this is where things get interesting. For example, I might speak of "the impossible contradiction of the infinite and the finite faced by Spinoza, theology and all previous idealist philosophies." And I might also say, "the integral components of a single unity within which the two opposites reside together in active unity and opposition, and hence in a logical contradiction."

Mark Hebwood says

Fighting it...

Oh wow. Reading this book was quite an experience. For one thing, to a person with no grounding in particle physics beyond what was included in a school curriculum (that person is me, and there was very little), reading speed is best described by reference to a log-scale: I read the first batch in a day, the second in 2 days, the third in 4, the fourth ... . But more fundamentally than that, I struggled with the book on a deeper level. I fought against some of Frank's ideas, and did not find it easy to get myself to a position from which I

could see the outlines of his thoughts in sharper focus. Other ideas I could not accept wholly, but needed to refine and modify for my own purpose. I struggled with his style, which at first I found a little bit too sanctimonious, and I felt the need to shield myself against what I saw as Frank's spiritualism.

And was it worth it? Yes. Absolutely. Either I got used to his style, or Frank narrated more pragmatically as his account developed, but after a while I made my peace with the way he talked about his subject. Having gained this confidence, I allowed myself to 'let in' more of the spiritualistic aspects of the book, and found the experience worth-while and enriching.

I kept on struggling, and fighting, and Frank kept on persuading, and explaining, and I understood more of what he might mean, and successfully reconciled some of my own views with his. It was hard work, it was exhausting yet exhilarating, painful yet mind-expanding.

Looking back on my reading experience, I had a great time with this book. Nothing worth having seems to come easily, and I feel I did have to work for some of the fresh insights I now have. In the end, it is this struggle that leaves me satisfied, it is the fight that makes me feel that I earned it.

Is it really *beauty* we are talking about?

This question is the essence of my struggle. For a while now, I have been interested in the relationship between 'beauty' and 'truth', or to put it less esoterically, in the idea that there may be a connection between the aesthetic appeal of a scientific theory and its resilience to falsification.

But what is 'beauty'? How can we define the aesthetic appeal of a scientific theory? This is what I struggled with, and I struggled *against* Frank, at least in the beginning. 'Beauty', to me, is too wide a concept to be meaningful in the context of this topic. 'Beauty' can mean a lot, and it can mean different things to different people. Frank defines what he means by 'beauty' on page 11; it is *symmetry* as a "love of harmony, balance, and proportion", and *economy* as the ability to produce "an abundance of effects from ... limited means".

This is fine. As far as it goes. But this definition does not incorporate *all* that human beings tend to describe as 'in proportion'. Oddly, it is a mathematically well-defined relationship that governs the *opposite* of symmetry that lies at the root of the human sense for harmony. This is the Fibonacci series, or rather the value of 1/2*[1+sqrt(5)] on which ratios between two consecutive numbers in the series converge. The Golden Ratio divides a line roughly in the proportions 1:2 and is therefore not strictly speaking *symmetrical*.

Still. "Symmetrical" may be defined, perhaps, as "periodically recurrant", and my definition of a 1:1 proportion may be unnecessarily restrictive. Indeed, the F-sequence (which Frank never mentions in the book) appears to embody Frank's second principle, 'economy', as I can construct spirals from it, and even reconstruct patterns I find in nature.

Fractals, as a self-repeating pattern that displays at every scale, no matter how often I magnify a local area, are another example of 'economy' and 'symmetry'. And these *do* feature in Frank's book, even though only in passing. On page 113, Frank refers to a fractal as "a strikingly beautiful work of abstract art". And this is where I would contradict Frank. First of all, it is not "abstract art". Abstract art is not even asymmetrical, it is an expression of the artist's thought that takes on an entirely new, and individual, interpretation in the beholder. And second, a fractal is not colorful, as Frank's plate M suggests. A fractal is a repeated application of a replacement operation, and we define the colour of a specific point in the iterations in accordance to chosen criteria of how it behaves (does it go off to infinity, does it stay confined in a particular area). In other words, there is no *natural* beauty beyond the extraordinary self-similarity of a fractal that would make it colourful, and hence a "striking work of art". I think in this instance, Frank confused man-made artifice with fundamental harmony.

However, as Frank developed his account, I think he changed his mind about what he thinks 'beauty' means. He never gives up the (in my opinion, meaningful) twin categories of symmetry and economy, but his thoughts mature into defining a relationship between Platonic *Ideals* and *Reals*. Frank associates the world of pure intellect with the Ideals and the world of empirical, experimental evidence with the Reals.

The Frankomarkian model of beauty

And as Frank's account started to develop along these lines, our two, quite distinct, ways to think about 'beauty' became unified. It is not really 'beauty' we are discussing here. It is a concept of fundamental harmony between a conscious mind (the human mind) and the patterns it finds 'outside' of itself. Once I understood this dynamic, I was even happy to call it 'beauty'. I mean, why not?

From that moment on, I stopped fighting his ideas and was able to follow him into a fascinating world. And what an enriching, and deeply satisfying world it was. Maxwell unified the electric and magnetic forces in theory before electromagnetic waves could be observed experimentally - and the speed of light came out in the wash! Frank's own work on QCD, and his idea of asymptotic freedom, impressively explains the strong force - and what an odd, "a-newtonian" force it is. Peter Higgs postulated a new, "mass-giving" boson with its associated field (Frank calls it 'fluid') 70 years before it was found in one of the last runs of the LHC pre-upgrade. Supersymmetry, although speculative, allows the unification of all non-gravitational forces, and probably gravity, too!

So did I like the book?

Well. I still do not follow Frank into his (moderately) spiritual world. I do not think it is amazing that carbon orbitals seek contact with four neighbouring carbon nuclei and thereby define the vertices of a regular tetrahedron, one of the five Platonic solids. I am not silenced in awe by the fact that zero-dimensional buckyballs reduce to a dodacahedron, the quintessential Platonic solid, once somebody removes the hexagonal surface areas that keep the pentagons apart. I hear Frank (and Nils Bohr) when he observes the similarity between the Eastern philosophy of Yin and Yang and the dualism between substance- and force particles, but I am not really inclined to see more than a metaphorical equivalence between the two.

But I loved the book beyond measure. I loved the struggle it offered me, and the engagement with Frank in the early chapters. I love the insight I now have in the dynamics of particle physics, its history and its potential future. I love the possibility that I might be wrong, and that the human sense of harmony and its apparent reflection in nature may be *more* than merely a metaphor, that it may highlight a deeper similarity between the particles that enable our thoughts and the particles we think about. But above all I love the fact - let us pause here and savour this certainty: the *fact* - that the human intellect is capable to understand the world as it is *before* experimental evidence confirms its findings.

And yes, I know that I am going to get into trouble with the philosophers for saying this. But I do not think my last point is epistemologically naive. We certainly have not reached the end of the journey. We may never get there. But whether we do, or don't, is irrelevant. What *is* relevant is that we are able to take the next step, and the next step after that.

The history of insights in particle physics has impressively shown that we *are* able to take the next step. And the human urge *to* take the next step may be the most fundamental thing that makes us human. If this is so, I'd rather continue travelling than arriving. If we ever arrived, we'd have nowhere left to go.

I can only recommend this book. Do read it.

David says

The beautiful question is, whether the laws of physics are based on beauty; are they simple, symmetric, proportioned and economical. Wilczek is a Nobel-Prize winner in physics. Regardless of whether physics is based on beauty, Wilczek has written a beautiful book. His style of writing is excellent, and the book is graced with plenty of engrossing diagrams and color illustrations.

The earliest astronomers tried to make the orbits of the planets simpler than they actually are. They tried to make their orbits fit into the so-called Platonic solids. Then they tried to make their orbits fit into circles. When observations did not fit this idea, they made circles upon circles, and unnecessary complicated the orbits. It wasn't until Newton saw that gravity affects both objects on Earth as well as the planets, that the orbits could be determined from a simple physical law. The law states that gravitation is proportional to the masses of the objects and inversely proportional to the square of their distance.

Wilczek traces the idea of symmetry into all of the realms of physics; special and general relativity, electro-magnetism, and quantum mechanics. He shows how Maxwell completed his famous set of equations by assuming a degree of symmetry, and correctly found that electromagnetic waves travel at the speed of light. To this day, Maxwell's equations serve as the basic laws of electricity and magnetism.

My favorite chapter is about Emmy Noether, a mathematician with deep insights into physics. She was discriminated against because she was a woman, so she worked without pay. As the Nazis came to power, she emigrated to the United States. She proved a remarkable theorem; each law of conservation in physics can be derived from a basic concept of symmetry. So, for example, she showed *why* there are a basic laws of conservation of energy and momentum; she showed that it these laws are equivalent to stating that the laws of physics are invariant in time and space. Wilczek calls this the most profound idea in all of physics. And many prominent mathematicians and physicists have said that Noether was the most important of all women mathematicians.

Toward the end of the book, Wilczek describes the alphabet soup of fundamental particles. He shows the symmetries in their existence and properties, in certain respects. However, many of the particles do not really abide by symmetries, though this may simply be because of our present-day lack of full understanding.

Clarissa Feio says

I do not come from a scientific background, and this is the first popular science book I read in the last 15 years, so it was definitely a challenge. I happened to come across this book in a book shop, and I fell in love with the premise. Naturally I was not able to understand everything Frank Wilczek wrote about, especially towards the end of the book, but did my best because I felt the book was worthwhile. I took copious notes and I learned a lot. For me this book was an adventure, and often the author's words moved me because his perspective of the physical world is so beautiful. I just feel sad I was not able to understand every single word in the book. I will probably try to read it again in the future.

Charlene says

This book, at its core is about beauty in nature and the power of that beauty to serve as a criterion for determining if a theory is true. Can we use beauty as a guide to discover the laws of the universe? It's a great

question. Wilczek points out the trouble the beauty criterion has caused from time to time, e.g. Kepler's beautiful, but wrong, theory about planetary orbits. In the end, Wilczek thinks beauty is a reliable indicator of reality.

The book reads like poetry and Wilczek is equally artists and physicist. He takes his reader back to the group of ancient thinkers, who are collectively known as Pythagoras and examines the symmetry and beauty in Pythagoras' Theorem. Looking at consonance and dissonance, he illustrates how the inner ear recognizes beauty as symmetry, e.g. we like a perfect fifths because our neurons like the beautiful math. Thus maybe math *is* beauty. Maybe the laws of nature *are* beauty.

Wilczek also describes the beauty of optics and of Newtonian physics in general. He provides a history of its shortcomings, which helps him usher in the beauty of Maxwell's equations, relativity, and quantum theory. His explanation of the standard model is wonderful and a good primer for those who are not familiar with the various particles.

Symmetry, and more importantly the breaking of symmetry -- from the Higgs nonzero field through the matter the Higgs creates, and onto the fractal nature of the many forms that matter takes -- seems to Wilczek to be fundamental to our universe. This is why the laws themselves would be expected to be beautiful in this way. I would have liked for him to talk more about networks, chaos, emergence, scaling and the like.

I would suggest readers who liked this book and wanted to keep thinking about these should read:

- Ian Stewart's Fearful Symmetry
- Lisa Randall's Warped Passages
- Geoffrey West's Scaling in Biology
- Albert-László Barabási's Linked
- John Kricher's Ecological Planet (One review called this basic. It is no longer basic when looked at through the lens of networks and complex emerging systems)
- Falkowski's Life's Engines
- Strogatz's Sync
- Scharf's Gravity's Engines
- Carroll's Particle at the End of the Universe
- Holmes' Secret Life of Dust
- Gleick's Chaos

Sinem Salva says

Kesinlikle okunmasini tavsiye ettigim muhtesem bir kitap. Fizik,bilim,sanat ve felsefe bir arada o kadar guzel islenmis ki bu kitap da, herkesde ve her yerde yakalayanamayacak bakis acilari sunuyor.
Fizik'de temel parcaciklarin aciklandigi Standard Model teorisinin otesine Higgs parcaciginin kesfi ile gecilmeye baslandi. Karanlik maddeye de bir yanit getiren Supersimetri teorisi suan CERN'de ki LHC deneyinde arastirilan cok onemli Standard Model otesi teorilerden. Supersimetriyi Sokrat-oncesi fizikci,bilim adami ve filozof olan Parmenides (Platon, Father Parmenides diye bahseder=) in "Change without Change" felsefesi ile birbirlerine yaklastirmasi, Parmenides'in siiri ile guzellik kavramina varmasi nobelli fizikci yazar Frank Wilczek'in cok ender rastlanacak bakis acisini gosteriyor. William Blake'den siire, fizikten parcaciklarin muhtesem dunyasina uzanan bir bas ucu kaynagi...

Christopher Willey says

I had a conversation with a friend, he just so happens to be an astrophysicist.

I felt like I was stepping all over my pud while talking with him. I didn't understand so much about so many things.

That's ok. To ask explore your ignorance is important to me, but the lovely thing is that I do t know enough to make assumptions- so my questions are thrilling. It's silly, but true!

This books explains graspable concepts like QCD theory, ideal to real, what = where, super symmetry, and wave functions in fluid dynamics. I also learned about Lee series, Grassman Numbers, and how exactly the four known forces in the universe work together. I was surprised at how much a role "color" plays.

It's similar to The Gene by Mukhergee in its exploration of Physics' and developments.

There is a lot to this one too... really important stuff here. Gonna have to go back on this one for actual notes.