Particle Physicist's Curriculum
(Vol. 1)

This curriculum is designed to be an as-available approach to becoming a particle physicist. This curriculum is prepared under the assumption of genuine interest for the field. The meaning of life (for humans) is fun productivity. If your ideal life consists of a fun and productive career in one (or more) of the many fields in particle physics: this curriculum is the single best resource on the planet for attaining that aim through self-education. If you are not excited about anything concerning the subject of particle physics, there is a chance your true interests lay elsewhere. Your ideal career will be a job you can't wait to get to in the morning (or night). Your dream career is one that you'd do for fun if money were no issue (hypothetically). If that's the case with particle physics, please see below:

The material below is presented in no particular order. Pick whichever is the most interesting to you and start there. As you learn the fundamentals of "the cool stuff", the less interesting material becomes more interesting as you begin to see its relevance. Don't worry about the things that seem daunting. As you learn more, hesitation will become interest. Then curiosity.

Particle Physicist's Curriculum consists of material from free or commercially available online sources.

Audio Courses & Audiobooks

All material currently **available at www.audible.com** [x3 speed encouraged]

The underlining is for ease of navigating the list, and has no relevance concerning content)

1. The Joy of Science (Robert M. Hazen)
2. The Nature of Matter: Understanding the Physical World (David W. Ball)
3. Particle Physics for Non-Physicists: A Tour of the Microcosmos (Steven Pollock)
4. The Theory of Everything: The Quest to Explain All Reality (Don Lincoln)
5. Thermodynamics: Four Laws That Move the Universe (Jeffrey C. Grossman)
6. Smashing Physics (Jon Butterworth)
7. The Higgs Boson and Beyond (Sean Carroll)
8. Mysteries of Modern Physics: Time (Sean Carroll)
9. Einstein's Relativity and the Quantum Revolution: Modern Physics for Non-Scientists (Richard Wolfson)
10. The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for Ultimate Theory (Brian Greene
11. Thinking Fast & Slow (Daniel Kahneman)
12. Redefining Reality: The Intellectual Implications of Modern Science (Steven Gimbel)
13. The Information: A History, a Theory, a Flood (James Gleick)
14. Physics of the Impossible: A Scientific Exploration (Michio Kaku)
15. The Hidden Reality: Parallel Universes and the Deep Laws of the Cosmos (Brian Greene)
16. Zoom: From Atoms and Galaxies to Blizzards and Bees: How Everything Moves (Bob Berman)
17. Seven Brief Lessons on Physics (Carlo Rovelli)
18. Quantum: A Guide for the Perplexed (Jim Al-Khalili)
19. The Big Picture: On the Origins of Life, Meaning, and the Universe Itself (Sean Carroll)
20. Neutrino Hunters: The Thrilling Chase for a Ghostly Particle to Unlock the Secrets of the Universe (Ray Jayawardhana)
21. Farewell to Reality: How Modern Physics Has Betrayed the Search for Scientific Truth (Jim Baggott)
22. The Trouble with Physics: The Rise of String Theory, The Fall of a Science, and What Comes Next (Lee Smolin)
23. The Interstellar Age: The Story of the NASA Men and Women Who Flew the Forty-Year Voyager Mission (Jim Bell)
24. Mars Rover Curiosity: An Inside Account from Curiosity's Chief Engineer (Rob Manning, William L. Simon)
25. Origins: Fourteen Billion Years of Cosmic Evolution (Neil deGrasse Tyson, Donald Goldsmith)
26. The Fabric of the Cosmos: Space, Time, and the Texture of Reality (Brian Greene)
27. A Brief History of Time (Stephen Hawking)
28. From Eternity to Here: The Quest for the Ultimate Theory of Time (Sean Carroll)
29. Gravity's Engines: How Bubble-Blowing Black Holes Rule Galaxies, Stars, and Life in the Cosmos (Caleb Scharf)
30. The Universe: Leading Scientists Explore the Origin, Mysteries, and Future of the Cosmos (John Brockman
31. Rise of Rocket Girls: The Women Who Propelled us from Missiles to the Moon to Mars (Nathalia Holt)
32. Space: A Novel (James A. Michener)
33. Time Reborn: From the Crisis in Physics to the Future of the Universe (Lee Smolin)
34. The Life and Death of Stars (Keivan G. Stassum)
35. Black Holes, Tides, and Curved Spacetime (Benjamin Schumacher)
36. Welcome to the Universe (Neil deGrasse Tyson, Michael A. Strauss, J. Richard Gott)
37. Cosmos (Carl Sagan)
38. Parallel Worlds (Michio Kaku)
39. Letters from an Astrophysicist (Neil deGrasse Tyson)
40. Physics of the Future (Michio Kaku)
41. The Big Picture (Sean Carroll)

YouTube

YouTube Channels that aid in the study of Particle Physics

(Material available at **www.youtube.com**)

CRASH COURSE – YouTube Channel

1. Physics – (There are **46 courses** on this Playlist – all of which are essential to the Particle Physicist's Curriculum).
2. Chemistry – (There are **46 courses** on this Playlist – all of which are essential to the Particle Physicist's Curriculum).
3. Astronomy – (There are **47 courses** on this Playlist – all of which are essential to the Particle Physicist's Curriculum).
4. Engineering – (There are **47 courses** on this Playlist – all of which are essential to the Particle Physicist's Curriculum).
5. Computer Science – (There are **41 courses** on this Playlist – all of which are essential to the Particle Physicist's Curriculum).
6. Statistics – (There are **45 courses** on this Playlist – all of which are essential to the Particle Physicist's Curriculum).
7. Artificial Intelligence – (There are **21 courses** on this Playlist – all of which are essential to the Particle Physicist's Curriculum).

Physics Girl – YouTube Channel

1. Dianna's Intro Physis Class/Physics 101 – (There are **21 courses** on this Playlist that are essential to the curriculum)
2. The Physics of Light – (There are **21 courses** on this Playlist – all of which are essential to the curriculum)
3. Electricity and Magnetism - (There are **21 courses** on this Playlist – all of which are essential to the curriculum)

YouTube Channels that aid in the study of Particle Physics

YouTube search:

- **FermiLab**
- **AK Lectures**
- **Michael Van Biezan**
- **Gooferking Science**
- **Nile Red**
- **For the Allure of Physics**
- **Veritasium**
- **A Level Physics Online**
- **Cowen Physics**
- **Physics Videos by Eugene Khutoryansky**
- **Joe Scott**
- **Domain of Science**
- **3Blue1Brown**
- **Scientific American Space Lab**
- **The Science Channel**
- **Doc Schuster**
- **Dr Physics A**
- **LAE Physics**
- **Minute Physics**
- **Physics Girl**
- **PBS Spacetime**
- **Sixty Symbols**
- **Lasseviren1**
- **Professor Leonard**
- **Mathbff**
- **Khan Academy**
- **CERN**
- **NASA**
- **SciShowSpace**
- **The Backyard Scientist**
- **Stanford Institute for Theoretical Physics**
- **CMS Experiment**
- **ATLAS Experiment**
- **Krista King**
- **Mathispower4u**
- **ProfRobBob**
- **Commutant**
- **Dr Chris Tisdell**
- **Fort Bend Tutoring**
- **NYU Physics**
- **Weakly Interacting massive particles – Topic**
- **Particle Physics – Topics**

Website Links

Phet Interactive Simulations – Physics Simulations phet.colorado.edu/en/simulations/category/physics

- Quantum Chemistry Simulations phet.colorado.edu/en/simulations/category/chemistry/quantum
- Math Simulations phet.colorado.edu/en/simulations/category/math

Physics Forums – physics forums http://www.physicsforums.com

AIP **(American Institute of Physics)** – advances, promotes, and serves the physical sciences for the benefit of humanity. https://www.aip.org

Apps

The following apps will aid in the study of particle physics.

- **Quantum** (Francisca Vasconcelos) https://play.google.com/store/apps/details?id=vasconcelos.francisca.quantumphysics
- **Quantum EN** (Stepan Brychta) https://play.google.com/store/apps/details?id=brychta.stepan.quantum_en
- **Quantum Tunnelling** (Andrew Rich) https://play.google.com/store/apps/details?id=com.CapstonePhys.QMPotentialTest
- **Physics: The Standard Model** (Appocalypse) https://play.google.com/store/apps/details?id=standardmodel.namespace

OPEN CULTURE

Free online courses

www.openculture.com/freeonlinecourses

ASTRONOMY Courses Section

1. Astronomy 101 (Scott Miller, Mercedes Richards, Stephen Redman)
2. Exploring Black Holes: General Relativity & Astrophysics (Edmund Bertschinger)
3. Introduction to Astrophysics (Joshua Bloom)
4. Introduction to Cosmology (James Bullock)
5. Introduction to General Astronomy (Alex Filippenko)

CHEMISTRY Courses Section

1. Chemical Structure and Reactivity (Peter Vollhardt)
2. Chemistry (Chemical Stoichiometry) (Carnegie Mellon)
3. General Chemistry for Engineers (Larry Brown)
4. Introduction to Chemical Engineering (Channing Robertson)
5. Introduction to Quantum Chemistry (K. Mangala Sunder)
6. Introduction to Solid State Chemistry (Donald Sadoway)

ENGINEERING Courses Section

1. Basic Electronics (T.S. Natarajan)
2. Chemical Engineering: Process Dynamics and Controls (Peter Woolf)
3. Convex Optimization 1 (Stephen Boyd)
4. Digital Signal Processing (E. Ambikairajah)
5. Electrical-Digital Signal Processing (S.C Dutta Roy)
6. Electro Magnetic Fields (Harishankar Ramachandran)
7. Elementary Fluid Mechanics (Mark Stacey)
8. Fields and Waves (Duncan MacFarlane)
9. Fluid Mechanics (T.I. Eldho)
10. Image Processing (Owen Carmichael)
11. Information and Entropy (Paul Penfield and Seth Lloyd)
12. Information Theory and Coding (S.N. Merchant)
13. Introduction to Microelectric Circuits (Chang-Hasnain)
14. Microelectric Devices and Circuits (Sayeef Salahuddin)
15. Nano-to-Macro Transport Processes (Gang Chen)
16. Nanomanufacturing (John Hart)
17. Understanding Lasers and Fiberoptics (Shaoul Ezekiel)

PHYSICS Courses Section

1. Advanced Quantum Mechanics (Leonard Susskind)
2. Atomic and Optical Physics 1 (Wolfgang Ketterle)
3. Atomic and Optical Physics 2 (Wolfgang Ketterle)
4. Classical Field Theory (Suresh Govindarajan)
5. Exploring Black Holes: General Relativity & Astrophysics (Edmund Bertschinger)
6. Electromagnetism and Optics (Michael Thorpe)
7. Fundamental Lessons from String Theory (Cumrun Vafa)
8. Fundamentals of Physics 1 (Ramamurti Shankar)
9. Fundamentals of Physics 2 (Ramamurti Shankar)
10. Inflationary Theory (Alan Guth)
11. Introduction to Astrophysics (Josh Bloom)
12. Introduction to Cosmology and Particle Physics (Sean Carroll)
13. Introduction to Solar System Astronomy (Richard Pogge)
14. Modern Theoretical Mechanics: Special Relativity (Leonard Susskind)
15. Modern Theoretical Physics: Statistical Mechanics (Leonard Susskind)
16. Physics: What We Still Don't Know (David Tong)
17. Quantum Electrodynamics (Richard Feynman)
18. Quantum Mechanics 1 (Ruza Markov)
19. Quantum Mechanics 2 (Ruza Markov)
20. Physics 1: Classical Mechanics (Walter Lewin)
21. Physics 2: Electricity and Magnetism (Walter Lewin)
22. Physics 3: Vibrations and Waves (Walter Lewin)
23. Physics for Scientists and Engineers (Achilles Speliotopoulos)
24. Soft X-Rays and Extreme Ultraviolet Radiation (David Atwood)
25. Solid State Basics (Steven Simon)
26. Statistical Mechanics 1: Statistical Mechanics of Particles (Mehran Kardar)
27. Statistical Mechanics 2: Statistical Mechanics of Fields (Mehran Kardar)
28. The Feynman Lectures on Physics, Vol.1: Mainly Mechanics, Radiation, and Heat (Richard Feynman)
29. Wave Physics (F. Romanelli)

COMPUTER SCIENCE Courses Section

1. Advanced Data Structures (Erik Demaine)
2. Advanced Operating Systems Structures and Implementation (John Kubiatowicz)
3. Basic Concepts of Operating Systems & System Programming (Anthony Stoica, Anthony Joseph)
4. Bits: The Computer Science of Digital Information (Harry Lewis)
5. Computational Camera and Photography (Ramesh Raskar)
6. Computer Graphics (Kenneth Joy)
7. Computer Language Engineering (Martin Rinard)
8. Computer Networks (S. Ghosh)
9. Computer Science: Foundations of Computer & Information Security (Matt Bishop)
10. Computer Systems (Stan Warford)
11. Computer System Engineering (Robert Morris, Samuel Madden)
12. Computer Systems Security (Nickolai Zeldovich)
13. Database System Design (Rob Meredith)
14. Data Structures (Joshua A. Hug)
15. Design and Analysis of Algorithms (Charles Martel)
16. Design in Computing (Richard Buckland)
17. Discrete Mathematics and Probability Theory (Umesh Vazirani)
18. Discrete Stochastic Processes (Robert Gallagher)
19. Efficient Algorithms and Intractable Problems (Christos Papadimitriou, Satish Rao)
20. Introduction to Algorithms (Charles Leiserson, Erik Demaine)
21. Introduction to Computer Graphics and GPU Programming (Eric Chan, Hanspeter Pfister)
22. Introduction to Computer Programming for Scientists and Engineers (Roberto Horowitz)
23. Introduction to Computer Science and Programming (Eric Grimson, John Guttag)
24. Introduction to Computer Science: Programming Methodology (Mehan Sahami)
25. Introduction to Computer Science: Programming Abstractions (Julie Zelenski)
26. Introduction to Computer Science: Programming Paradigms (Jerry Cain)
27. Introduction to Computer Graphics (Prem Kalra)
28. Introduction to Computing for Non-Majors (JT Chirco)
29. Introduction to Electrical Engineering and Computer Science I (Multiple Professors)
30. Introduction to Embedded Systems (Sanjit Seshia, Edward A. Lee)
31. Introduction to Formal Systems & Computation (Multiple Professors)
32. Introduction to Information Studies (Robert Frost)
33. Mathematics for Computer Science (Tom Leighton)
34. Multicore Programming Primer (Saman Amarasinghe)
35. Network Security (Eugene Stafford)
36. Operating Systems and System Programming (Multiple Professors)
37. Performance Engineering of Software Systems (Multiple Professors)
38. Probabilistic Systems Analysis and Applied Probability (John Tsitsiklis)
39. Quantum Computing for the Determined (Michael Nielsen)
40. Software Engineering (Multiple Professors)

MATH Courses Section

1. A First Course in Linear Algebra (N J Wildberger)
2. Abstract Algebra (Benedict Gross)
3. Against All Odds: Inside Statistics (Pardis Sabeti)
4. Analytic Geometry and Calculus (Benjamin Johnson)
5. Calculus (F. Michael Christ)
6. Differential Equations (Arthur Mattuck)
7. Differential & Integral Calculus (Steve Butler)
8. Introduction to Probability and Statistics (Deborah Nolan)
9. Linear Algebra (Gilbert Strang)
10. Multivariable Calculus (Dennis Auroux)
11. Rational Trigonometry (N J Wildberger)
12. Single Variable Calculus (David Jerison)
13. Statistics: Introduction to Probability (Joseph Blitzstein)
14. Vector Calculus (Chris Tisdell)

TEXTBOOKS

(All currently available at **www.amazon.com**)

Text Material – According to your budget, preview everything you can about each book, and pick which ones you're most interested in first.

1. Universe: The Definitive Visual Guide (DK Publishing)
2. Basic Physics: A Self-Teaching Guide (Karl F. Kuhn)
3. A Most Incomprehensible Thing: Notes Toward a Very Gentle Introduction to the Mathematics of Relativity (Peter Collier)
4. Quantum Mechanics: The Theoretical Minimum (Leonard Susskind)
5. The Theoretical Minimum: What You Need to Know to Start Doing Physics (Leonard Susskind)
6. The Cartoon Guide to Chemistry (Larry Gonick)
7. The Cartoon Guide to Physics (Larry Gonick)
8. The Cartoon Guide to Algebra (Larry Gonick)
9. The Cartoon Guide to Calculus (Larry Gonick)
10. The Cartoon Guide to Statistics (Larry Gonick)
11. Fundamentals of Physics: Mechanics, Relativity, and Thermodynamics (R. Shankar)
12. Quantum Field Theory for the Gifted Amateur (Tom Lancaster, Stephen J. Blundell)
13. Calculus: An Intuitive and Physical Approach (Morris Kline)
14. Basic Physics: A Self-Teaching Guide (Karl F. Kuhn)
15. The Particle Garden: Our Universe As Understood By Particle Physicists (Gordon Kane)
16. Quantum Mechanics (Auletta, Fortunato, and Parisi)
17. Deep Down Things: The Breathtaking Beauty of Particle Physics (Bruce A. Schumm)
18. Modern Particle Physics (Mark Thomson)
19. Introduction To The Physics of Particle Accelerators (Mario Conte and William Mackay)
20. Quantum Computing Since Democritus
21. Statistical Analysis Techniques Techniques in Particle Physics (Ilya Narsky and Frank C. Porter)
22. Many Worlds (Saunders, Barrett, Kent, & Wallace)
23. Quantum Theory of Many-Particle Systems (Alexander L. Fetter and John Dirk Walecka)
24. Most Wanted Particle: The Inside Story of the Hunt for the Higgs (Jon Butterworth)
25. An Introduction to the Physics of Nuclei and Particles (Richard Dunlap)
26. Techniques for Nuclear and Particle Physics Experiments (William R. Leo)
27. QED: The Strange Theory of Light and Matter (Richard P. Feynman)
28. Special Relativity in General Frames: From Particles to Astrophysics (Eric Gourgoulhon)
29. QCD and Collider Physics (Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology) (R. K. Ellis and W. J. Stirling)
30. Schaum's 3,000 Solved Problems in Physics (Alvin Halpern)
31. Theoretical Mechanics of Particle and Continua (Alexander L. Fetter)
32. Linear Algebra and its Applications (Strong)
33. Nonlinear Mechanics: A Supplement to Theoretical Mechanics of Particles and Continua (Alexander L. Fetter)
34. The Feynman Lectures on Physics
35. Feynman's Tips on Physics
36. Particle Detectors (Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology) (Claus Grupen and Boris Shwartz)
37. Radiation Detection and Measurement (Glenn F. Knoll)
    a. Student Solutions Manual to accompany Radiation and Measurement (Glenn F. Knoll)
38. Decoherence and the Quantum to Classical Transition (Schlosshauer)
39. The Emergent Multiverse (Wallace)
40. No Bullshit guide to math and physics (Ivan Savov)
41. A Student's Guide to Vectors and Tensors (Daniel A. Fleisch)
42. A Student's Guide to Waves (Daniel Fleisch)
43. A Student's Guide to Maxwell's Equations (Daniel Fleisch)
44. A Student's Guide to Lagrangians and Hamiltonians (Patrick Hamill)
45. A Student's Guide to Entropy (Don S. Lemons)
46. A Modern Approach to Quantum Mechanics
47. Relativity, Gravitation and Cosmology: A Basic Introduction (Ta-Pei Cheng)
48. Principles of Quantum Mechanics, 2nd Edition (R. Shankar)
49. Cosmology (Steven Weinberg)

PODCASTS

Particle Physics Podcasts are compensatory of classroom discussion. They'll allow you to be immersed in social conversation of the material contrary to the lecture form of many of the above media.

1. Physics World
2. The Titanium Physicists Podcast
3. StarTalk
4. The Infinite Monkey Cage
5. Physics Central
6. Oxford Department of Physics
7. 60 Second Science
8. Quirks & Quarks

T.L.U.V.I. POSTERS

(All posters available at www.theupwardeducation.com/tluviposters)

Particle Physics

- TLUVI Poster #1 – Glued On
- TLUVI Poster #3 – Fabrics of the Universe #1
- TLUVI Poster #4 – Foundations of Universe
- TLUVI Poster #6 – Chemistry

Notes & Personal Additions to Curriculum

Experiential Learning

Potential Careers, Condensed Wisdom, and Creative Compensations

Pink = Education or Business based Blue = Technology based Green = **Research based**

Potential Careers in the field of Particle Physics

Many of these span two or three of the colored categories above. The color correlation used is the more defining form of the vocation.

Astronomer	Physics Writer	Science Policy Analyst
Laboratory Manager	Physics Editor	Software Engineer
Chief Research Officer	Accelerator Physicist	Nanostructure Physicist
Cosmologist	Accelerator Technologist	Quantum Chemistry
Professor	Condensed Matter Scientist	Quantum Computing
Experimental Molecular Physicist	Nuclear Diagnostic Technologist	
Quants (Market Analysis)	Solid State Physicist	

Brief Career Descriptions

*Descriptions quoted from online searches of the fields.

Accelerator Physicist – designs, integrates, and operates systems for new particle accelerators for fusion and medical applications.
Accelerator Technologist – calibrate the systems, review the schedule, make any adjustments to the particle beam before running test, and result analysis.
Astronomer – study the universe and the objects within it. Performs tests, collects and analyzes data, uses mathematical principles to learn the cosmos.
Astrophysicist – uses physics, math, and computing knowledge to investigate the formation of stars, planets, and galaxies.
Chief Research Officer – establishes and executes the overall vision and strategy for the firm while overseeing survey research, data science, and data analytics.
Condensed Matter Scientist – Study the physical properties of matter in molecules, nanostructures, or novel compounds.
Cosmologist – study, examine and work out theories of the universe. Work with data collected by others, analyzing it while exploring and testing theories.
Experimental Molecular Physicist – design and build the expensive experiments which are used to discover new particles beyond the Standard Model.
Laboratory Manager – Maintains laboratory equipment performance by establishing quality standards; developing operations, quality, and troubleshooting procedures; ensuring staff compliance; certifying instrument performance; arranging equipment replacement, service, and repair.
Nanostructure Physicist – Manipulate matter on the nanoscale, developing new materials and equipment as well as drugs and diagnostic tools.
Quants (Market Analysis) – analyzes and elucidates financial risks and probabilities (for companies) using mathematical equations somewhat similar in function to quantum mechanics. [Does not involve any actual particle physics]
Quantum Chemistry – strives to accurately predict chemical and physical properties of molecules and materials, which is useful to many fields of science and engineering.
Quantum Computing – help design the software and hardware that enables near-term explorations and scientific experiments with quantum computing.
Physics Editor – provides daily news and commentary about a selection of physics papers and journals. Identifies appropriate papers for coverage.
Physics Writer – writes articles and papers on the work being done in the realm of physics (from classical to quantum).
Professor – provides tutoring and academic counseling to students, maintains classes related records, and assesses student coursework.
Science Policy Analyst – monitors, analyzes, and disseminates written information on science legislation, budget, policy, leadership, and related matters.
Software Engineer – research, design, and write new software programs and computer operating systems. Evaluate the software and system that make computers and hardware work.
Solid State Physicist – Study of rigid matter, or solids, through methods such as quantum mechanics, crystallography, electromagnetism, and metallurgy.
Nuclear Medicine Technologist – perform tests for diagnosis and medical research. Prepare and give small doses of radioactive drugs to patients, then use high-level imaging equipment to record images of the radioactive material in the body.

Particle Physics Overview

This section of the curriculum gets as close as possible to providing condensed wisdom traditionally only attained through experience in professional or institutional settings (universities, labs, sites, etc.). Mastering all the details and particularities of the information below (bolstered by your knowledge from above) will produce the technical skill necessary to (somewhat) seamlessly transition into most of the careers listed above without much orientation needed.

The Big Bang

The Big Bang was the creation of our universe from the remnants of the last one. It was the origin of all matter, fields, and everything in the universe, and it is estimated to have occurred over 13.8 billion years ago. Within the singularity of the big bang, the three different fields of the universe (and all the energy within them) were united as one **Homologous Cosmic Structure (HCS)**. The standards of particle creation and destruction, standards of energy, motion, and momentum, and standards of all interactions to ever take place were set by the way in which the HCS energy dissipated into the universe.

Since time is motion, and motion produces heat, what "existed" before the singularity (outside of it, that is) was: absolutely nothing at absolute zero. Absolute zero is timelessness, and can only exist outside the realm of a universe (like ours) with the potential for motion. Therefore, when the Big Bang occurred, it occurred "into" an absolute zero void. The HCS expansion of the universe expanded into the **Absolute Zero Void (AZV)** and occupied the AZV space with the very first "stuff" of our iteration of the universe. As time was created (with the creation of motion), the HCS started expanding into infinity. With so much room to do so, the HCS started differentiating into separate fabrics of the universe.

<u>*The AZV and the singularity being "remnants of a previous universe" have not been confirmed. The Absolute Zero Void (AZV) is a term used to reference everything outside of the original singularity that birthed this universe.</u> However, they are the most reasonable conclusion to be drawn from a comprehensive integration of all the data that has been confirmed (as is elucidated below…).

Laws of Thermodynamics

1. **Associative Energy:** If A is identical to B, and B is identical to C, then A and C are identical.
2. **Energy is conserved:** Energy can neither be created nor destroyed; it can only change forms.
3. **Entropy increases:** The net disorganization of systems (entropy) can only increase over time.
4. **Absolute Zero is unreachable:** Absolute Zero means "no motion", and everything is always moving all of the time.

The Higgs Field

The Higgs Field can best be conceptualized as a grain that permeates everything everywhere in the known universe (including all the vacuums of space outside and between galaxies). The edge of the universe would be the point in the universe (incalculably far from any known matter) where the Higgs Field ends and the AZV void (if there is any still left) begins. The Higgs Field imparts mass onto quanta of energy intense enough to perturb the field. Since waves are not solid objects, they can occupy the same space as the Higgs field. **High frequency waves shift the net organization of the Higgs field space.** Specifically, high-frequency energy – in the form of waves – condenses the Higgs Field. The condensation of the Higgs Field imparts mass to high frequency waves. Mass is an object's resistance to acceleration. From now on, the terms particles and waves will be synonymous. Massive particles (meaning particles/waves with mass) are the building blocks of the universe. While their condensation of the Higgs Field is negligible on the individual (particle-by-particle) basis, massive particles – when stacked – create atoms; atoms create molecules, molecules create planets, and from planets emerge people. Gravity is the pulling force of massive objects. An atom's gravitational pull ain't nothing much; a planet's gravitational pull is a bit more consequential (to say the least).

When the Higgs field differentiated from the HCS, it created a membrane between the remaining HCS and the Absolute Zero Void (AZD). The HCS can no longer be called the HCS, since the Higgs Field has been freed – making the structure no longer a homologous universe. That's okay, because the spreading and expansion of the Higgs field freed up space in the **Cosmic Energy Soup (CES)** to expand and differentiate. Electromagnetic and Color charges were homologous within the CES, but soon differentiated from each other. The points in the universe where all three fabrics (color charge, electric charge, and Higgs field) formed stable and lasting interference with each other formed quarks. In addition, stable, constructively interfering perturbations of the Higgs field and Electromagnetic force (without the Strong Force fabric) produce Charged Leptons. Beyond that, stable perturbations that are solely in the Higgs field are known as Neutrinos, and they are produced when a charged lepton separates from a body of mass (a massive boson, to be precise). Neutrinos can be viewed as mass debris from particle interactions.

The higher the energy of a particle, the more pull it has on the Higgs field.

The energy of a particle is determined by:

1. **The number of universal fabrics/fields it interacts with. The more fields, the more energetic.**
2. **Its velocity, spin, frequency, wavelength, and amplitude.**
3. **The intensity of its charge for each field.**

After Quarks and Leptons stabilized out of the big bang, the variety of potential interactions with quarks had a habit of forming stable bonds of complementary constructive waves. These waves harmonized into a stable atmosphere. That process was – and this process is – known as hadronization. This is the point in the universe where protons and neutrons formed.

The majority of the positive energy in the universe (that exists today) was trapped inside protons (and neutrons, to a lesser extent) during hadronization. The Strong Force of hadrons creates a closed system that does not easily allow influence from non-Strong Force particles. The net effect of the components of a hadron creates the net electromagnetic charge of the hadron. Quarks held the majority of positive charges in the universe (on the inside of hadrons), and Charged Leptons such as electrons retained the majority of negative charges.

A general rule of the universe is that things usually stabilize as soon as they are capable of doing so. As soon as there was enough expansion of the big bang into (previously AZV, now Higgs-filled) space for energy fluctuations to cool down to less frantic levels, all of the energy in the universe started settling into stable connections with each other. First there was the formation of fermions (quarks, charged leptons, neutrinos) as stable wave entities in the Higgs field. Then, quarks formed bonds into stable hadrons. Then, hadrons started forming stable bonds with charged leptons – forming the first atoms. As the universe continued to expand, accretion continued on increasingly larger scales. Since then, at every level, scale, and spot in the universe, energy constantly fluctuates between the states of concentration and dissipation of energy – via motion. **As one point in space loses energy, another point in space gains energy, but the total amount of energy in the universe remains the same.**

The Higgs Field is the canvas that contains the motions of the universe. By imparting mass onto objects, it allows the high-energy particles of the universe to slow down, form stable bonds with each other, and congregate to form larger and larger entities. If there were no Higgs Field, there would be nothing keeping all the particles in the universe from flying off in opposite directions. Everything in the universe runs on the concepts of concentration and dissipation; the Higgs Field is what allows concentration (and bonding) of the components of the universe.

Quantum Field Theory

QFT organizes the fabrics of the universe into respective fields. Concentrations of the field's forces produce charges. **Since all energy is conveyed through some physical means, decelerating charges produce concentrations of ongoing momentum (bosons). The combination of concentrated fields produces fermions. Bosons are the transferred momentum of fermions.** A quark is a combination of the strong, electromagnetic, and higgs fields/fabrics within a stable, low E formation. A charged lepton is a combo of the electromagnetic and higgs field. Neutrinos only carry higgs charge (mass), and no other charge. **QFT is the <u>theory</u> that studies the <u>fields</u> (or fabrics) that regulate the smallest particles of the universe (<u>quanta</u>).** Quantum Field theory involves the study of quarks, leptons, and bosons. These "particles" are actually perturbations in the fields (often times referred here as 'fabrics' – of the universe) that occupy known space. Massive waves – and even massless waves, at times – behave like solid objects in many scenarios, which is why it is equally appropriate to refer to them as particles.

Fundamental and Composite Particles

Fundamental particles/Point particles are the smallest things in the entire universe. Though most of them can decay into less energetic particles, they cannot be divided into individual components. Composite particles are compositions of more than one fundamental particle whose frequencies sync (stably or temporarily) to form one large particle (made up of the smaller point particles). Composite particles are particles composed of other particles.

Quarks and leptons are fermions. Bosons are fermion momentum. Photons and Gluons are massless, stable, bosons. The W+, W-, Z, and Higgs Bosons are all massive, unstable, bosons. Photons (light waves) transmit electromagnetic momentum as neutral particles. Gluons transmit quark momentum and color charge as bosons with dual charges (one color, and one anti-color charge).

Virtual Particles, Valence Particles, & Quantum Foam

Virtual Particles are unstable particles that exist temporarily. Virtual bosons – when inside composite particles such as hadrons or atoms – are somewhat equivalent to 'splashes' in their particle fields. Everything in the universe is moving all of the time, and just because we don't see things happening doesn't mean that they aren't happening. Imagine a placid lake with unmoving water that is perfectly still. If it were to rain, the raindrops would splash into the lake, and cause droplets to splash up from the lake on impact. In quantum mechanics: the droplets splashing up from the lake are Virtual Particles. The raindrops causing the splashes are unseen forces causing what's known as "Quantum Fluctuations" or "Quantum Foam". Quantum fluctuations are the splashing of virtual particles – and their corresponding anti-particles – in and out of existence by unseen forces. Those unseen forces are things like cosmic rays, neutrinos, or any other free particle. From the perspective of any point in the universe, it's like rain coming from all directions at once. These quantum fluctuations and their virtual particles can have an impact on real particles and their behavior, momentum, or interactions.

An incalculable number of virtual quarks and gluons are popping in and out of existence every second in the heart of every hadron in the universe. Hadrons are matter-anti-matter reactors that are in constant motion (rapidly exchanging color-anti-color charges and interactions). Valence quarks are the quarks inside hadrons that contribute to the overall net properties of the hadron (such as its neutral/colorless/"white" color charge, and its overall electric charge). While the quantity of virtual particles contributes to a hadron's mass (most of it, actually), they don't contribute to its other net properties (electric and color charges). Virtual quarks inside hadrons are known as Sea Quarks.

A valence electron, on the other hand, is one that is available to participate in the formation of chemical bonds (as opposed to being a permanent resident of the atom in question). A valence quark is a stay-at-home resident of a hadron that contributes to the hadron's exterior properties. A valence electron is one that is capable of interacting with its neighbors to produce bonds.

Charges

- **Electric Charge**
  - Electric charge is the two-pole system (positive and negative) of energy that permeates the known universe. Opposite charges (such as positive and negative) attract. Like charges (negative and negative) repel. Neutral charges (such as photons and neutrons) can only be effective through their momentum – they do not attract, repel, or transmit electric charge.
  - The electric charge of a particle is perhaps the most renown of all the particle properties. Humans have more cause to notice the immediate effects of electric charge than they do of color charge (you don't – and never will – stand any risk of being "colorcuted", for example).
  - Color charge is the most powerful on the extremely small scale; gravity is most powerful on the extremely large scale, and electric charge is most powerful with everything in between (while still having a strong presence on the extremely large and small scales).
- **Color Charge**
  - Color charge is the 6 Charge spectrum (R, B, G, Anti-Red, Anti-Blue, Anti-Green) governing strong force interactions (dominant to electromagnetic and massive/gravity influences). Red, Blue, and Green color charges can be seen as positive (+) charges, and Anti-Red, Anti-Blue, and Anti-Green can be viewed as "negative" color charges.
  - The concept known as QCD confinement identifies the process that automatically pairs valence quarks into stable, color-neutral (white) combinations. Hadrons are composite particles composed of quarks and gluons. Baryons are 3 quark composite particles that are either composed entirely of normal matter quarks (with R, B, and G charge), or entirely of anti-matter quarks (Anti-Red, Anti-Blue, and Anti-Green charges), but never a mix of matter and anti-matter.. Mesons (2 quark composite particles) consist of one quark with a color charge, and one anti-quark with an anti-color charge.
- **Mass (charge)**
  - Mass is generated by the higgs field in the same way that electric charge is generated by the electromagnetic field, and color charge is generated by the strong force / color field.
  - A charge is a concentration of a field's energy around a center of a mass. Since the higgs field generates mass for a particle: mass is a concentration of higgs field energy around a pre-existing concentration (of energy) that is energetic enough to perturb the higgs field (into a concentrated state). If the higgs field were an amusement park ride, it would read: "you must be THIS strong to activate the mass charge". The "strength" of a particle is determined by its wave function properties and momentum.
- **Gravity**
  - Gravity is a one-way (attractive only) charge determined by the mass of an object, and its ability to condense space-time (and the higgs field) around it. The Higgs Field imparts mass onto objects. The more mass an object has, the more it condenses its local space/Higgs field. The more space/Higgs field is condensed, the greater its pull on the area surrounding it. The inherent pull (or charge) that mass has on its surrounding space is its gravitational field – much like how color and electric fields pull (or push) on the charges of their own respective fields.

Entropy

The more time passes, the more disorganized everything gets. The second law of thermodynamics states that entropy always increases. Since the universe is expanding (fringe of Higgs field expanding into AZV), the potential for future motion is expanding. The more potential motion there is, the more disorganized the universe will get. Since time is motion, and motion is ceaseless and irreversible: one-way time means one-way motion, one-way motion means that a direction of motion (the past) is cut off from further opportunity of motion. Since there is always more motion (and space for motion) in the future than in the past, entropy always increases with time (universally; not necessarily locally).

Symmetry

Symmetry is the balance of energy and organization in a system. If the universe is the system: The Higgs Field is universally asymmetric. The Electromagnetic field and Strong Force field can produce symmetric composite particles and macro-states from symmetric and asymmetric sources. The universe is indescribably more asymmetric than it is symmetric – and a good thing, too. Asymmetry is at the heart of variety.

Strong Force and QCD

- **Confinement**
  - Quarks do not occur in isolation, they are confined to hadrons. Confinement is caused by the unique property of color charge to increase its strength with distance. Gluons are the force carrier of color charge. Think of gluons as rubber bands that tie valence quarks to each other inside hadrons. The further the quarks get from each other, the stronger the bond gets between them. This is caused because gluons have two different color charges: one color, and one anti-color charge. Color and anti-colors are attracted to each other. The double binding factor of color-anti-color attraction, and the natural constructive interference between quarks (and gluons) exchanging gluons means that the more distance is between the two valence quarks, the more opportunities for constructive interference (and the stronger the "glue" that is its result).
  - When pushed to extremes, the binding QCD string (the aforementioned "rubber band") that holds two quarks together builds up so much energy that it is capable of creating another quark-anti-quark pair to partner with the ones trying to be separated from their parent hadron. The term confinement comes from the fact that every time you try to isolate a quark, the mere process of doing so either: (A) Isn't powerful enough to break the QCD string holding the quark(s) to its parent hadron, or (B) *Is* powerful enough to break the string, but the energy of the reaction instantaneously creates a new hadron; so that no quark is ever by itself.
- **Asymptotic Freedom**
  - When forced together due to high energy compressive environments, the QCD strings attaching quarks loses its strength – much like a rubber band loses its tension when compressed. The result of quarks forced into close proximity due to a highly energetic/compressive environment is known as a quark-gluon plasma. Examples of where you'd find such entities are in neutron stars and (possibly) black holes – where the energy is so intense that hadronization cannot occur.
- **Hadron energies**
  - Atomic nuclei are the seat of mass. Protons and neutrons are the seat of atomic nuclei. Valence quarks are the constituents of protons and neutrons, but are not what compose most of its mass – that would be the QCD binding energy created by virtual gluons. The incalculable and indefinite QCD strings tying valence quarks and sea quarks together are responsible for more than 98% of a hadron's mass. Mass and energy are interchangeable. And even though gluons are massless, they are most definitely energetic, and there are quite a lot of them (to say the least) inside the heart of every hadron.

Electromagnetism and QED

Electromagnetism is the intermediary fabric of the universe that is by far the most mobile when it comes to information exchange between massive entities. Electric charge is a two-pole system (+ and -) whose symmetric and asymmetric organizations allow for the forming of atoms, chemical bonds, and molecules. Magnetism is a secondary effect produced by uniform electrical currents. All charged particles have an intrinsic magnetism caused by a combination of their spin and electric charge.

Quantum Electrodynamics is the study of how electrons and photons interact with each other. The natural state of an electron is in a nebulous electric cloud. When that cloud is hit by momentum of any sort (in the form of a photon, or another electron) it becomes the "particle" electron that we usually think of regarding the subject. Electrons acted upon by a force not itself shows properties of a particle. Electrons in their "natural state" (un-acted upon) are in the form of a nebulous "probability wave".

General and Special Relativity

General Relativity: The laws of physics behave the same everywhere in the universe.
Special Relativity: The laws of physics are perceived differently from different reference points.

Gravity and the Higgs Field

Interaction with the Higgs Field is what gives objects mass. The more massive an object is, the stronger its gravitational influence. A fundamental particle's mass is determined by: (1) The number of universal fields it interacts with [Color and/or Electric charge], (2) It's (Wave) Frequency (3) It's Momentum. Even the most massive of fundamental particles possesses very little mass relative to what it takes to have a gravitational influence. Stable fundamental particles combine to form composite particles. Composite particles combine to form molecules. As more and more molecules (of miniscule mass) aggregate, more and more mass is added to an entity, AND, more and more space is occupied.

The Higgs Field permeates all space in the universe. Massive objects occupy space. The more particles an entity (like a star or planet) is made up of, the more massive it is – and the more space it occupies. The more space an entity occupies, the more it condenses the Higgs field occupying that space. The Higgs field is directly responsible for an entity's mass. An entity's mass is directly related to its gravitational influence. The more massive an entity is, the more it condenses the Higgs field (ie: surrounding space), and the stronger its gravitational influence.

The Weak Interaction

The "Weak Force" is often talked about as if it is its own field/fabric of the universe. Whenever you hear or see the term "Weak Force" or "Weak Interaction", someone is talking about either the creation or annihilation of particles. W and Z bosons are the mediators of the weak force; they're actually just (temporarily stable) quantum scale explosions. Neutrinos are leftover debris (in the form of "bits of mass") from Weak Force interactions. The Weak Interaction is what auto-assembles the properties of colliding mass into their resulting particles.

Bremsstrahlung Radiation

The first law of Thermodynamics states that energy can neither be created nor destroyed – it can only change forms. This means that every action – meaning: every acceleration or deceleration of a particle – must have some physical cause. Acceleration of a massive particle is caused by the absorption of a boson (or the effects of a magnetic field); deceleration of a massive particle is caused by the emission of a boson. The emission of a boson is energy being released from the momentum of the massive particle. Bremsstrahlung Radiation is when a charged particle is decelerated by the electric field of another charged particle. The loss of momentum of the decelerated charged particle is emitted as a photon.

Pauli Exclusion Principle

Two massive particles cannot occupy the same quantum states (ie: space/area) at the same time. Massless particles (photons and gluons) can. Think of the Pauli Exclusion Principle as the "no-ghost" rule. Mass is a particle's resistance to acceleration. Massive particles cannot accelerate 'through' one another. They can collide and deflect from one another, they can collide and transform into new particles, they can form stable (or unstable) bonds with one another when in close proximity, but they cannot occupy the same space at the same time.

Eigenstates/Eigenvalues

Particle physics is a realm of probabilities – and not "certainties". An "eigen"-anything is referring to something that has been definitively defined. Because particle physics is on such a small scale that any and all factors affect the outcome of an experiment, the amount of data that can be gathered on particle properties is somewhat limited. If you can measure a particle's exact position, you lose data on its momentum (because you interrupted it's momentum to measure the position); if you measure a particle's exact momentum, you cannot define its exact position (because you displaced it to discover the momentum). **An eigenstate is knowing the exact state of something (instead of a probability). An eigenvalue is the exact value (not probability) of the known eigenstate.**

Decoherence

Quantum decoherence is essentially a particle's tendency to dissipate into its environment. If you put a glass of water in a freezer, the water molecules would cohere, and keep the volume of water together. If you were to put a glass of water out in the open – at room temperature: eventually, over time, you'd have an empty glass. The same goes for particles. The freezer was an "isolated system" is this analogy. When left in total isolation, (which never happens) particles *would* cohere. When interacting with any matter or fields (as everything is doing all the time), particles will decohere. The rate at which decoherence occurs is determined by the stability of the particle, and the entropy of the environment.
Which would cause a donut to disintegrate faster: throwing it into full sink, or throwing it into a full hurricane?

Particle Accelerators and Particle Detectors

Particle accelerators shoot particle beams into each other; particle detectors capture the data from the particle collisions. The specifications of the accelerators determine the types of particles that are used in the collisions. The types of particles used in the collisions determine the type of particles that will be produced by the collisions. Particle detectors are capable of detecting cosmic rays as well – and don't always have to be paired with a particle accelerator. The two major types of particle accelerators are Linear Accelerators and Synchrotrons.
Linear Accelerators – Shoot particles in a straight line at each other (not as strong as synchrotrons).
Synchrotrons – Synchrotrons whirl particles around in a gigantic circle (to increase momentum) before colliding them.

Cosmic Rays

Stars and singularities emit all sorts of particles during their very energetic lifespan. Consider these 2 cosmological beings to be faucets pouring particles in all directions – non-stop, all the time. Those emitted particles are called cosmic rays. They keep on keeping on until they are dissipated by the universe (via decoherence), or by the things within the universe (via absorption or refraction).

Black Holes

A "Black Hole" is the name give to the 'visible' (or invisible) 'atmosphere' of a singularity. A singularity is a dead star whose mass is so great that – despite gravity normally being the weakest of universal forces: the gravity of the singularity overpowers all the other universal fields (electric and color charge) and condenses matter to such a small, dense, point that not even light is fast enough to escape its influence.

Hawking Radiation is the very (very, very) slow decay of a singularity at its perimeter. At the event horizon of a singularity (the black hole) there is a "point of no return". On the other side of that point of no return, subatomic particles are capable of moving fast enough to escape the gravitational influence of the singularity (and fly off in the opposite direction). Hawking radiation is at the edge of a black hole where quantum fluctuations do not collapse back into each other (as they normally do), but instead: one is sucked into the black hole, and one continues off going the other way in space. The one that continues off into space is the radiation of Hawking Radiation, and is the only known way in which singularities can, eventually – over the course of many millennia – dissipate.