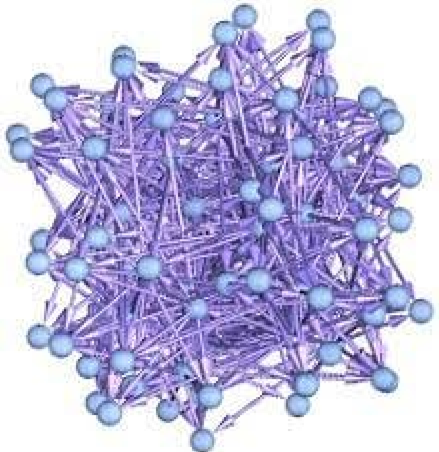
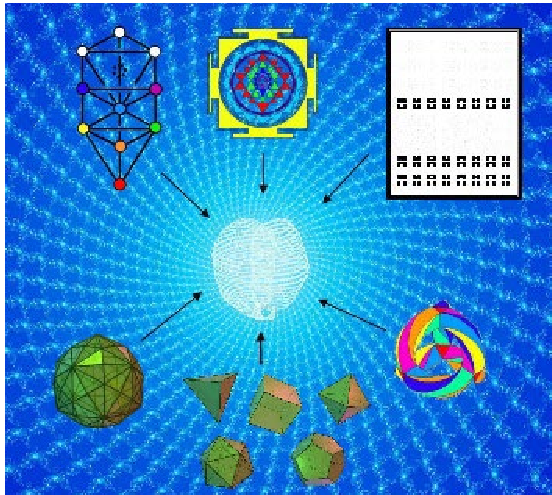
# The Information Algorithmic Ruliad of Western Physics

AlephTalks

Mysticism: Where Science, Art and Spirituality Meet

16 November 2023

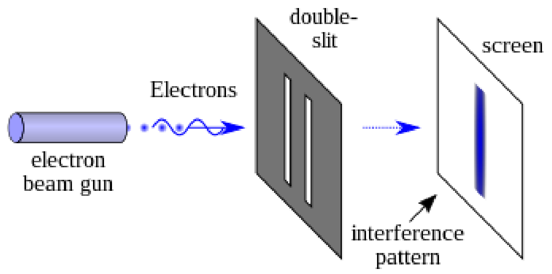




# Outline

- Problem Statement
  - The electron double slit experiment
  - Special Relativity: speed of light constrains actions
  - Information (algorithms and data) plus scans of surrounding space
  - Stephen Wolfram: The Ruliad (Rule of Rules)
- Pilot wave theory of quantum mechanics: De Broglie/Bohm/et al
- Ron Cowen: Observations on Information
- Modern Information Theory
  - Claude Shannon 1948: Binary Digit, Entropy, Communication
  - Alan Turing 1940: Turing Machine Model of Computation
  - John von Neumann 1950: Processing, Storage, Input/Ouput, Switch Fabric
- Stephen Wolfram
  - Sentience
  - Consciousness
- Viktor Frankel: Meaning in Life

# Electron Double Slit Experiment




- Video with Dr Quantum
- In modern physics, the **double-slit experiment** demonstrates that light and matter can satisfy the seemingly-incongruous classical definitions for both waves *and* particles, which is considered evidence for the fundamentally probabilistic nature of quantum mechanics.
- This type of experiment was first performed by Thomas Young in 1801, as a demonstration of the wave behavior of visible light.[ At that time it was thought that light consisted of *either* waves *or* particles.
- With the beginning of modern physics, about a hundred years later, it was realized that light could in fact show *both* wave *and* particle characteristics. In 1927, Davisson and Germer and, independently George Paget Thomson and Alexander Reid demonstrated that electrons show the same behavior, which was later extended to atoms and molecules.
- Thomas Young's experiment with light was part of classical physics long before the development of quantum mechanics and the concept of wave–particle duality. He believed it demonstrated that Christiaan Huygens' wave theory of light was correct, and his experiment is sometimes referred to as Young's experiment[ or Young's slits.
- The experiment can be done with entities much larger than electrons and photons, although it becomes more difficult as size increases. The largest entities for which the double-slit experiment has been performed were molecules that each comprised 2000 atoms (whose total mass was 25,000 atomic mass units

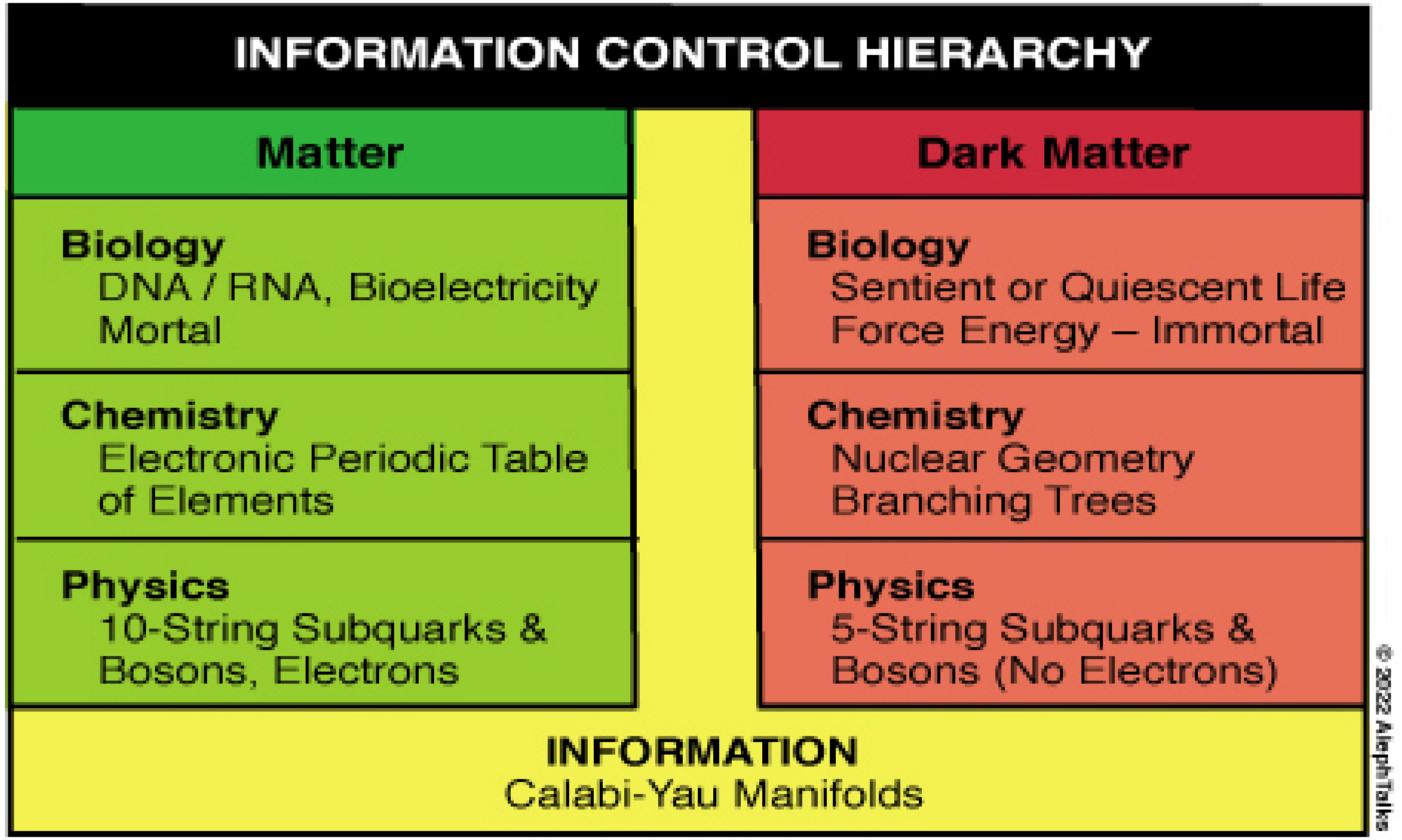
# Special Relativity

- Basic coordinate system for space-time is (x,y,z,ict)
- In physics, the **special theory of relativity**, or **special relativity** for short, is a scientific theory of the relationship between space and time. In Albert Einstein's 1905 treatment, the theory is presented as being based on just two postulates:
  - The laws of physics are invariant (identical) in all inertial frames of reference (that is, frames of reference with no acceleration).
  - The speed of light in vacuum is the same for all observers, regardless of the motion of light source or observer.
- When distances are positive, they are separate in space, or space like.
- When distances are negative, they are separated in time, or time like.

# Pilot Wave Theory of Quantum Mechanics

- In theoretical physics, the **pilot wave theory**, also known as **Bohmian mechanics**, was the first known example of a hidden-variable theory, presented by Louis de Broglie in 1927. Its more modern version, the de Broglie–Bohm theory, interprets quantum mechanics as a deterministic theory, avoiding troublesome notions such as wave–particle duality, instantaneous wave function collapse, and the paradox of Schrödinger's cat. To solve these problems, the theory is inherently nonlocal.
- The de Broglie–Bohm pilot wave theory is one of several interpretations of (non-relativistic) quantum mechanics.
- An extension to the relativistic case with spin has been developed since the 1990s.
- See this summary and critique of Bohmian mechanics

# Ronald Cowen: Information Observations



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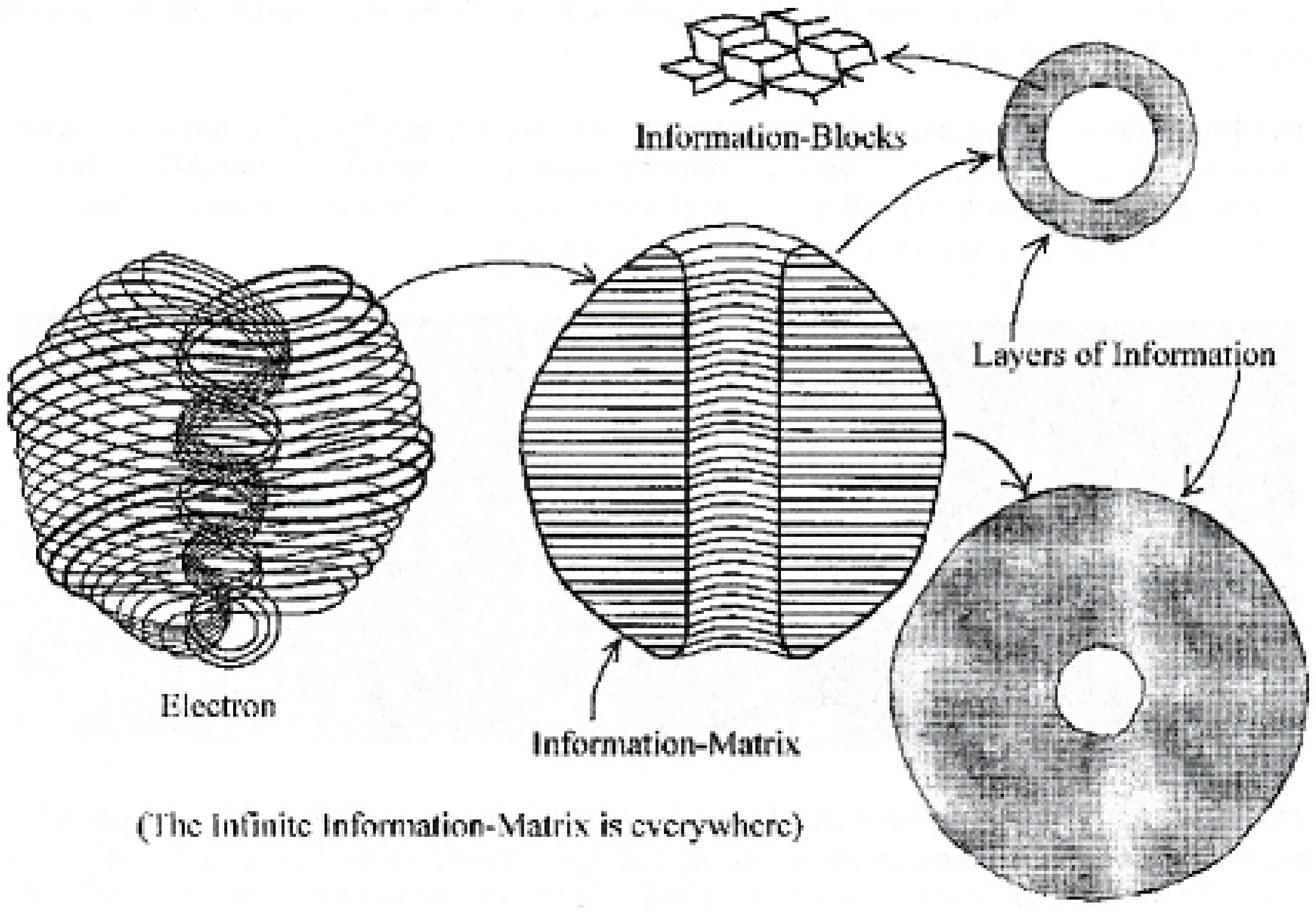

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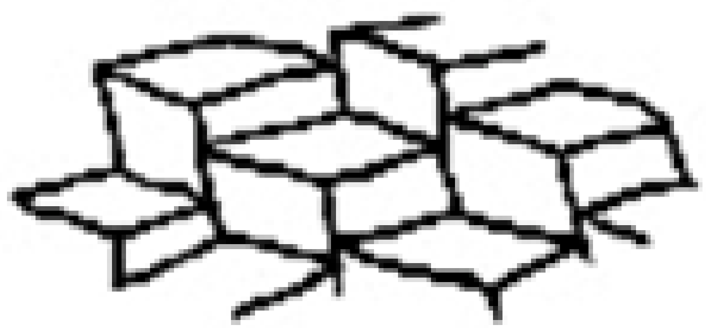
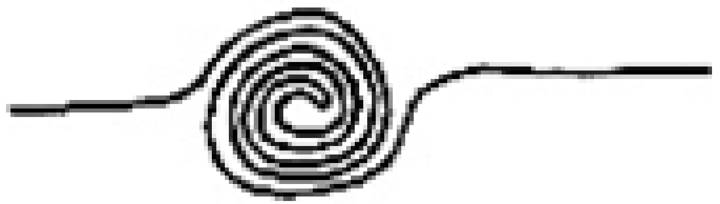


Information Blocks

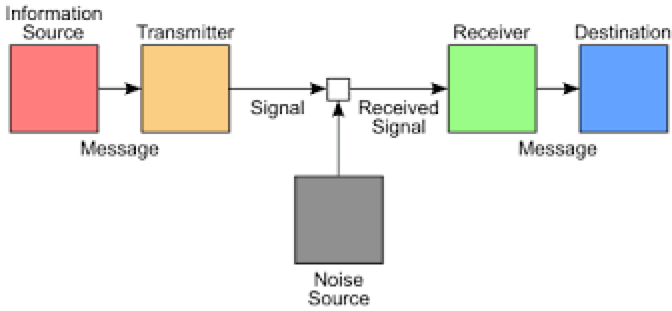
**Wave on Surface of Information Block**



**Different Wave on Surface of Information Block**

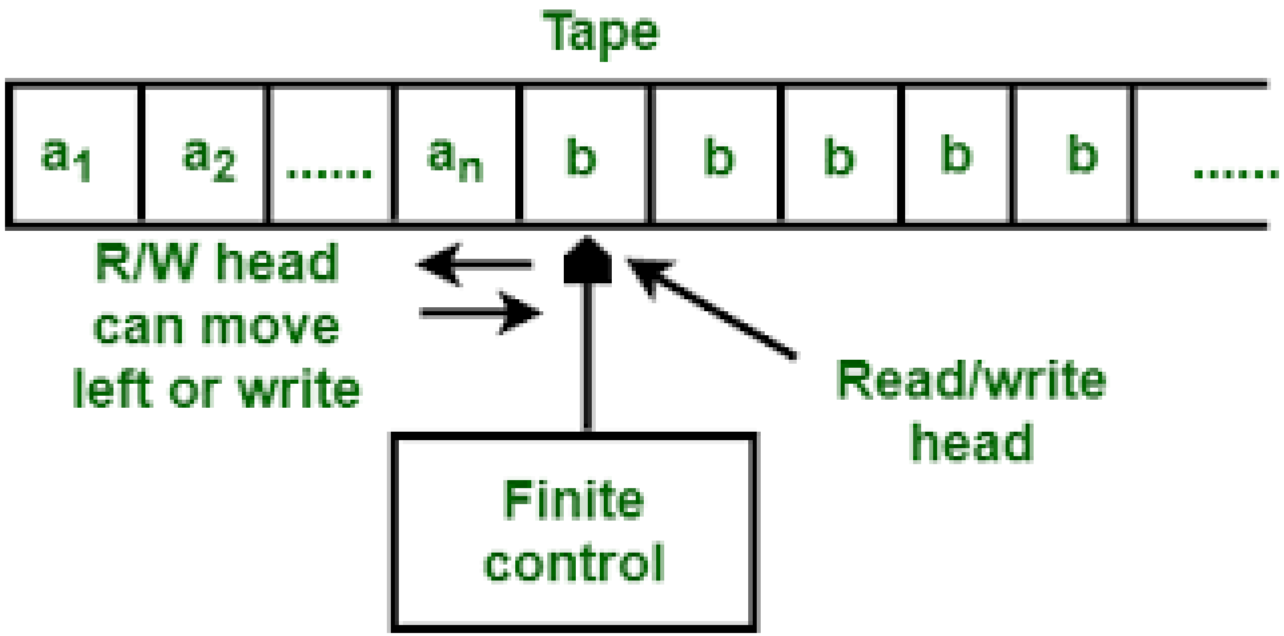
# Claude Shannon

- Encoding of analog information into binary digits (bits)
  - Source  symbol encoding to get as few bits as possible
  - Channel encoding to increase likelihood of successful transmission
  - Channel decoding to increase likelihood of successful reception
  - Source decoding to get estimate of original symbol
- Entropy
  - Information increases the more uncertain the outcome
  - If I know I get a zero, or I know I get a one, little information



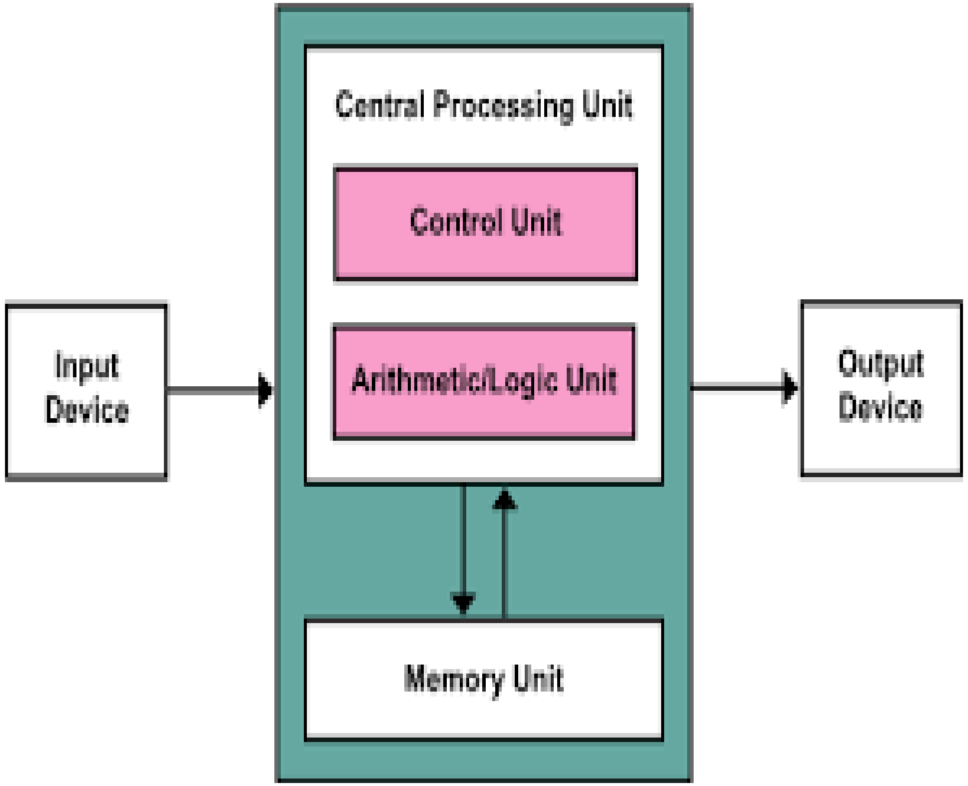
# Alan Turing

- Universal machine for processing information



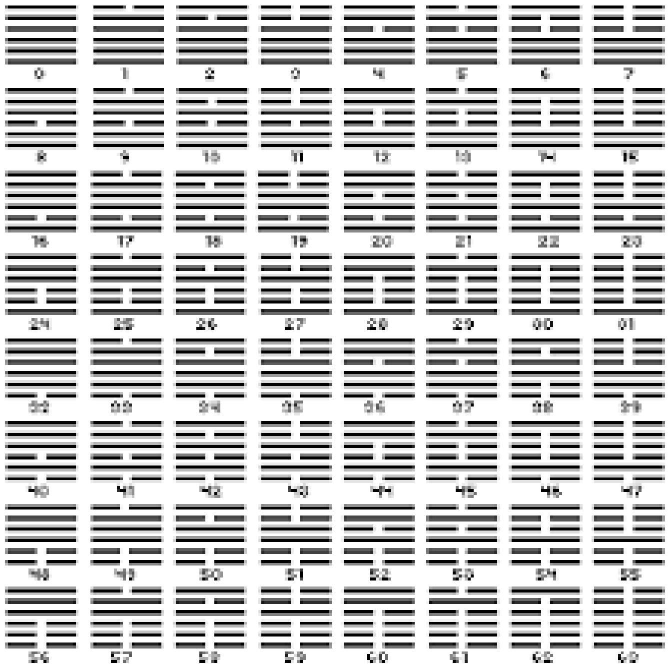
# John von Neumann

- Input/output
- Processing
- Storage
- Switch Fabric




# I-Ching

The ***I Ching*** or ***Yi Jing*** (Chinese: 易經, Mandarin: [î tɕíŋ] ⓘ), usually translated as ***Book of Changes*** or ***Classic of Changes***, is an ancient Chinese divination text that is among the oldest of the Chinese classics. The *I Ching* was originally a divination manual in the Western Zhou period (1000–750 BC). Over the course of the Warring States and early imperial periods (500–200 BC), it transformed into a cosmological text with a series of philosophical commentaries known as the "Ten Wings".



# Sentience vs Consciousness

- **Sentience** is the ability to experience feelings and sensations. The word was first coined by philosophers in the 1630s for the concept of an ability to feel, derived from Latin *sentiens* (feeling), to distinguish it from the ability to think (*reason*). In modern Western philosophy, sentience is the ability to experience sensations. In different Asian religions, the word "sentience" has been used to translate a variety of concepts. In science fiction, the word "sentience" is sometimes used interchangeably with "sapience", "self-awareness", or "consciousness".
- **Consciousness**, at its simplest, is awareness of internal and external existence. However, its nature has led to millennia of analyses, explanations and debate by philosophers, theologians, and all of science. Opinions differ about what exactly needs to be studied or even considered consciousness. In some explanations, it is synonymous with the mind, and at other times, an aspect of mind. In the past, it was one's "inner life", the world of introspection, of private thought, imagination and volition.Today, it often includes any kind of cognition, experience, feeling or perception. It may be awareness, awareness of awareness, or self-awareness either continuously changing or not. The disparate range of research, notions and speculations raises a curiosity about whether the right questions are being asked.

# Eastern Tao Views on Sentience

- Eastern religions including Hinduism, Buddhism, Sikhism, and Jainism recognise non-humans as sentient beings.The term *sentient beings* is translated from various Sanskrit terms (*jantu, bahu jana, jagat, sattva*) and "conventionally refers to the mass of living things subject to illusion, suffering, and rebirth (Saṃsāra)".
- In some forms of Buddhism plants, stones and other inanimate objects are considered to be 'sentient'.
- In Jainism many things are endowed with a soul, *jīva*, which is sometimes translated as 'sentience'.Some things are without a soul, *ajīva*, such as a chair or spoon.There are different rankings of *jīva* based on the number of senses it has. Water, for example, is a sentient being of the first order, as it is considered to possess only one sense, that of touch.
- In Jainism and Hinduism, this is related to the concept of ahimsa, non-violence toward other beings.
- Sentience in Buddhism is the state of having senses. In Buddhism, there are six senses, the sixth being the subjective experience of the mind. Sentience is simply awareness prior to the arising of Skandha. Thus, an animal qualifies as a sentient being. According to Buddhism, sentient beings made of pure consciousness are possible. In Mahayana Buddhism, which includes Zen and Tibetan Buddhism, the concept is related to the Bodhisattva, an enlightened being devoted to the liberation of others. The first vow of a Bodhisattva states, "Sentient beings are numberless; I vow to free them."

# Stephen Wolfram: Ruliad

- TEDTalk How to Think Computationally about AI, the Universe, and Everything
- Stephen Wolfram was born in London in 1959 to Hugo and Sybil Wolfram, both German Jewish refugees to the United Kingdom.
- Wolfram was educated at Eton College, but left prematurely in 1976. As a young child, Wolfram had difficulties learning arithmetic. He entered St. John's College, Oxford, at age 17 and left in 1978 without graduating to attend the California Institute of Technology the following year, where he received a PhD in particle physics in 1980.Wolfram's thesis committee was composed of Richard Feynman, Peter Goldreich, Frank J. Sciulli and Steven Frautschi, and chaired by Richard D. Field.

# Stephen Wolfram: Ruliad

- Wolfram, at the age of 15, began research in applied quantum field theory and particle physics and published scientific papers in peer-reviewed scientific journals including *Nuclear Physics B*, *Australian Journal of Physics*, *Nuovo Cimento*, and *Physical Review D*.
- Working independently, Wolfram published a widely cited paper on heavy quark production at age 18 and nine other papers.
- Wolfram's work with Geoffrey C. Fox on the theory of the strong interaction is still used in experimental particle physics.
- Following his PhD, Wolfram joined the faculty at Caltech and became the youngest recipient of a MacArthur Fellowship in 1981, at age 21.

# Stephen Wolfram: Ruliad

- In 1983, Wolfram left for the School of Natural Sciences of the Institute for Advanced Study in Princeton. By that time, he was no longer interested in particle physics. Instead, he began pursuing investigations into cellular automata,[citation needed] mainly with computer simulations. He produced a series of papers systematically investigating the class of elementary cellular automata, conceiving the Wolfram code, a naming system for one-dimensional cellular automata, and a classification scheme for the complexity of their behaviour.
- He conjectured that the Rule 110 cellular automaton might be Turing complete, which a research assistant to Wolfram, Matthew Cook, later proved correct.[ Wolfram sued Cook and temporarily blocked publication of the work on Rule 110 for allegedly violating a non-disclosure agreement until Wolfram could publish the work in his controversial book *A New Kind of Science*.Wolfram's cellular-automata work came to be cited in more than 10,000 papers.[23]
- In the mid-1980s, Wolfram worked on simulations of physical processes (such as turbulent fluid flow) with cellular automata on the Connection Machine alongside Richard Feynman[28] and helped initiate the field of complex systems.[citation needed] In 1984, he was a participant in the Founding Workshops of the Santa Fe Institute, along with Nobel laureates Murray Gell-Mann, Manfred Eigen, and Philip Warren Anderson, and future laureate Frank Wilczek.
- In 1986, he founded the Center for Complex Systems Research (CCSR) at the University of Illinois at Urbana–Champaign.
- In 1987, he founded the journal *Complex Systems*.

# Stephen Wolfram:
# Computer Symbolic Manipulation

- Wolfram led the development of the computer algebra system SMP (*Symbolic Manipulation Program*) in the Caltech physics department during 1979–1981. A dispute with the administration over the intellectual property rights regarding SMP—patents, copyright, and faculty involvement in commercial ventures—eventually led him to resign from Caltech.SMP was further developed and marketed commercially by Inference Corp. of Los Angeles during 1983–1988.
- In 1986, Wolfram left the Institute for Advanced Study for the University of Illinois at Urbana–Champaign, where he had founded their Center for Complex Systems Research, and started to develop the computer algebra system Mathematica, which was first released on 23 June 1988, when he left academia.
- In 1987, he founded Wolfram Research, which continues to develop and market the program.

# Stephen Wolfram:
# A New Kind of Science

- From 1992 to 2002, Wolfram worked on his controversial book *A New Kind of Science*, which presents an empirical study of simple computational systems.
- Additionally, it argues that for fundamental reasons these types of systems, rather than traditional mathematics, are needed to model and understand complexity in nature. Wolfram's conclusion is that the universe is discrete in its nature, and runs on fundamental laws which can be described as simple programs. He predicts that a realization of this within scientific communities will have a revolutionary influence on physics, chemistry, biology, and a majority of scientific areas in general, hence the book's title.
- The book was met with skepticism and criticism that Wolfram took credit for the work of others and made conclusions without evidence to support them.

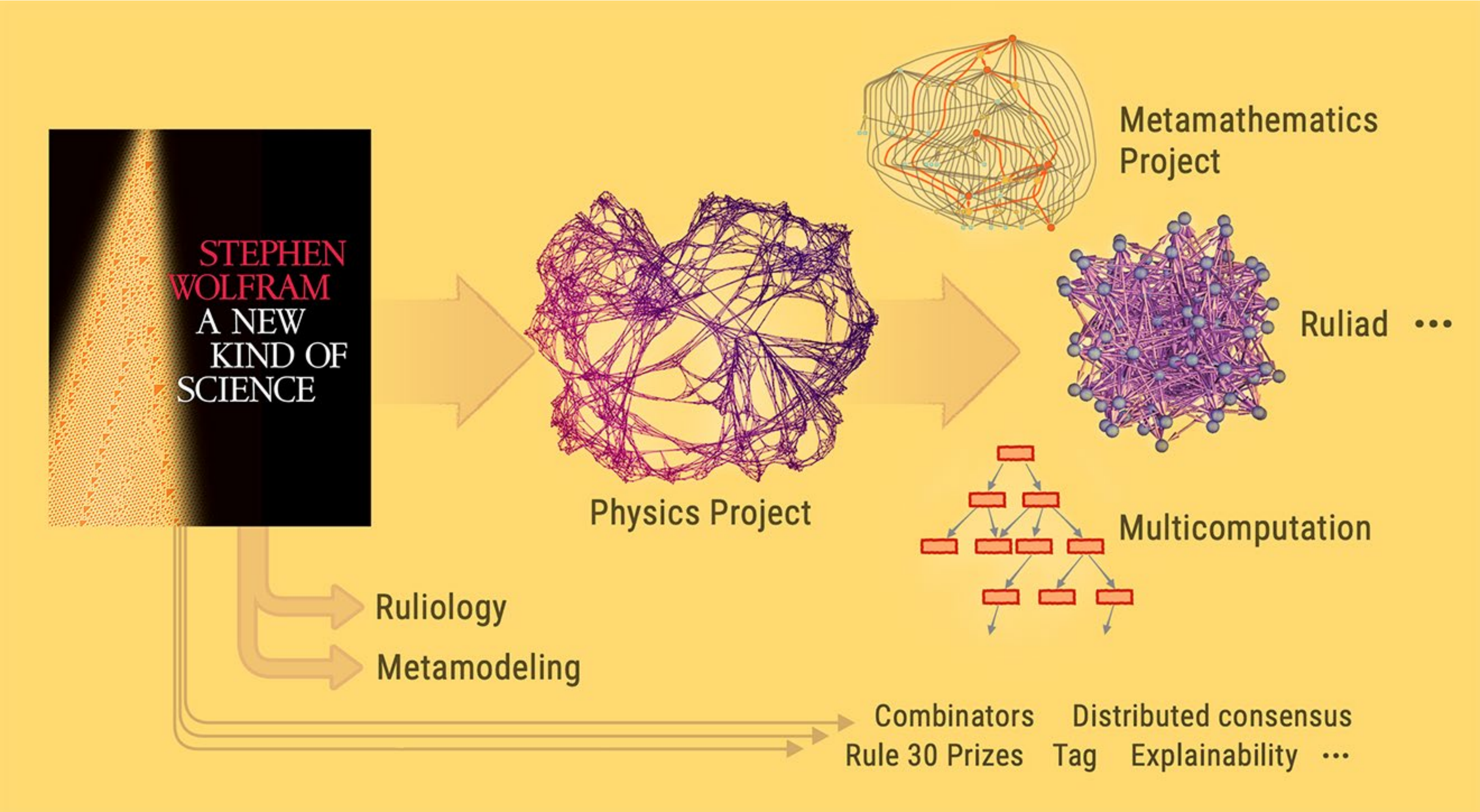
# Stephen Wolfram: Wolfram Alpha/Wolfram Language

- In March 2009, Wolfram announced Wolfram Alpha, an answer engine. WolframAlpha later launched in May 2009, and a paid-for version with extra features launched in February 2012 that was met with criticism for its high price that was later dropped from $50.00 to $2.00.The engine is based on natural language processing and a large library of rules-based algorithms. The application programming interface allows other applications to extend and enhance Wolfram Alpha.
- In March 2014, at the annual South by Southwest (SXSW) event, Wolfram officially announced the Wolfram Language as a new general multi-paradigm programming language,[40] though it was previously available through Mathematica and not an entirely new programming language. The documentation for the language was pre-released in October 2013 to coincide with the bundling of Mathematica and the Wolfram Language on every Raspberry Pi computer with some controversy because of the proprietary nature of the Wolfram Language.[41] While the Wolfram Language has existed for over 30 years as the primary programming language used in Mathematica, it was not officially named until 2014, and is not widely used.

# Stephen Wolfram: Wolfram Physics Project

- In April 2020, Wolfram announced the "Wolfram Physics Project" as an effort to reduce and explain all the laws of physics within a paradigm of a hypergraph that is transformed by minimal rewriting rules that obey the Church-Rosser property.
- The effort is a continuation of the ideas he originally described in ***A New Kind of Science***. Wolfram claims that "From an extremely simple model, we're able to reproduce special relativity, general relativity and the core results of quantum mechanics."
- Physicists are generally unimpressed with Wolfram's claim, and state that Wolfram's results are non-quantitative and arbitrary.

# Stephen Wolfram:
# The Making of the Ruliad

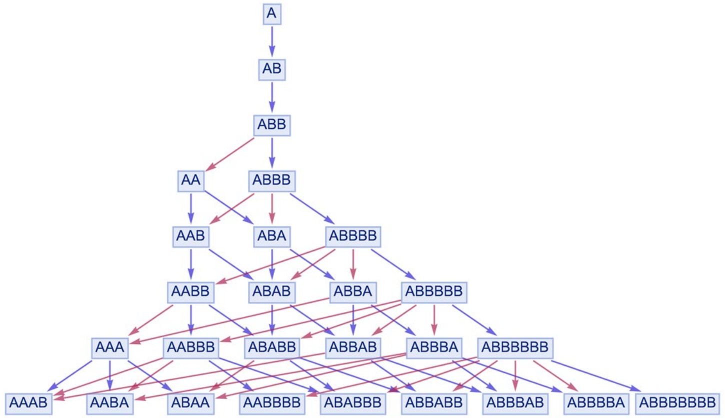



# Stephen Wolfram: Ruliad

- Think of it as the entangled limit of everything that is computationally possible: the result of following all possible computational rules in all possible ways. It's yet another surprising construct that's arisen from our Physics Project. And it's one that I think has extremely deep implications—both in science and beyond.
- In many ways, the ruliad is a strange and profoundly abstract thing. But it's something very universal—a kind of ultimate limit of all abstraction and generalization. And it encapsulates not only all formal possibilities but also everything about our physical universe—and everything we experience can be thought of as sampling that part of the ruliad that corresponds to our particular way of perceiving and interpreting the universe.
- In the language of our Physics Project, it's the ultimate limit of all rulial multiway systems. And as such, it traces out the entangled consequences of progressively applying all possible computational rules.

# Ruliad Example

- Here is an example of an [ordinary multiway system]() based on the string replacement rules {A → AB, BB → A} (indicated respectively by blueish and reddish edges):




At each step, the rules are applied in all possible ways to each state. Often this generates multiple new states, leading to branching in the graph. But, importantly, there can also be merging—from multiple states being transformed to the same state.

# Western View on Sentience

- Sentience is the ability to experience feelings and sensations.
- The word was first coined by philosophers in the 1630s for the concept of an ability to feel, derived from Latin sentiens (feeling), to distinguish it from the ability to think (reason).
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- Some writers differentiate between the mere ability to perceive sensations, such as light or pain, and the ability to perceive emotions, such as fear or grief. The subjective awareness of experiences by a conscious individual are known as qualia in Western philosophy.

# Stephen Wolfram: Consciousness

- People will ask “So what does this mean about consciousness?” And I’ll say “that’s a slippery topic”. And I’ll start talking about the sequence: life, intelligence, consciousness.
- I’ll ask “What is the abstract definition of life?” We know about the case of life on Earth, with all its RNA and proteins and other implementation details. But how do we generalize? What is life generally? And I’ll argue that it’s really just computational sophistication, which the Principle of Computational Equivalence says happens all over the place.
- I’ll talk about intelligence. And I’ll argue it’s the same kind of thing. We know the case of human intelligence. But if we generalize, it’s just computational sophistication—and it’s ubiquitous. And so it’s perfectly reasonable to say that “the weather has a mind of its own”; it just happens to be a mind whose details and “purposes” aren’t aligned with our existing human experience.

# Stephen Wolfram: Consciousness

- I’ve always implicitly assumed that consciousness is just a continuation of the same story: something that, if thought about in enough generality, is just a feature of computational sophistication, and therefore quite ubiquitous.
- But from our Physics Project—and particularly from thinking about its implications for the foundations of quantum mechanics—I’ve begun to realize that at its core consciousness is actually something rather different.
- Yes, its implementation involves computational sophistication. But its essence is not so much about what can happen as about having ways to integrate what’s happening to make it somehow coherent and to allow what we might see as “definite thoughts” to be formed about it.

# Stephen Wolfram: Consciousness

- And rather than consciousness being somehow beyond “generalized intelligence” or general computational sophistication, I now instead see it as a kind of “step down”—as something associated with simplified descriptions of the universe based on using only bounded amounts of computation.
- At the outset, it’s not obvious that a notion of consciousness defined in this way could consistently exist in our universe. And indeed the possibility of it seems to be related to deep features of the formal system that underlies physics.
- In the end, there’s a lot going on in the universe that’s in a sense “beyond consciousness”. But the core notion of consciousness is crucial to our whole way of seeing and describing the universe—and at a very fundamental level it’s what makes the universe seem to us to have the kinds of laws and behavior it does.

# Stephen Wolfram: Consciousness

- The universe in our models is full of sophisticated computation, all the way down. At the lowest level it's just a giant collection of "atoms of space", whose relationships are continually being updated according to a computational rule. And inevitably much of that process is computationally irreducible, in the sense that there's no general way to "figure out what's going to happen" except, in effect, by just running each step.
- But given that, how come the universe doesn't just seem to us arbitrarily complex and unpredictable? How come there's order and regularity that we can perceive in it? There's still plenty of computational irreducibility. But somehow there are also pockets of reducibility that we manage to leverage to form a simpler description of the world, that we can successfully and coherently make use of. And a fundamental discovery of our Physics Project is that the two great pillars of twentieth-century physics—general relativity and quantum mechanics—correspond precisely to two such pockets of reducibility.

# Stephen Wolfram: Consciousness

- There’s an immediate analog—that actually ends up being an example of the same fundamental computational phenomenon. Consider a gas, like air. Ultimately the gas consists of lots of molecules bouncing around in a complicated way that’s full of computational irreducibility.
- But it’s a central fact of statistical mechanics that if we look at the gas on a large scale, we can get a useful description of what it does just in terms of properties like temperature and pressure. And in effect this reflects a pocket of computational reducibility, that allows us to operate without engaging with all the computational irreducibility underneath.

# Stephen Wolfram: Consciousness

- How should we think about this? An idea that will generalize is that as "observers" of the gas, we're conflating lots of different microscopic configurations of molecules, and just paying attention to overall aggregate properties.
- In the language of statistical mechanics, it's effectively a story of "coarse graining". But within our computational approach, there's now a clear, computational way to characterize this. At the level of individual molecules there's an irreducible computation happening. And to "understand what's going on" the observer is doing a computation.
- But the crucial point is that if there's a certain boundedness to that computation then this has immediate consequences for the effective behavior the observer will perceive. And in the case of something like a gas, it turns out to directly imply the Second Law of Thermodynamics.
- Now we can see it as a consequence of the interplay between underlying computational irreducibility and the computational boundedness of observers. If the observer kept track of all the computationally irreducible motions of individual molecules, they wouldn't see Second Law behavior. The Second Law depends on a pocket of computational reducibility that in effect emerges only when there's a constraint on the observer that amounts to the requirement that the observer has a "coherent view" of what's going on.

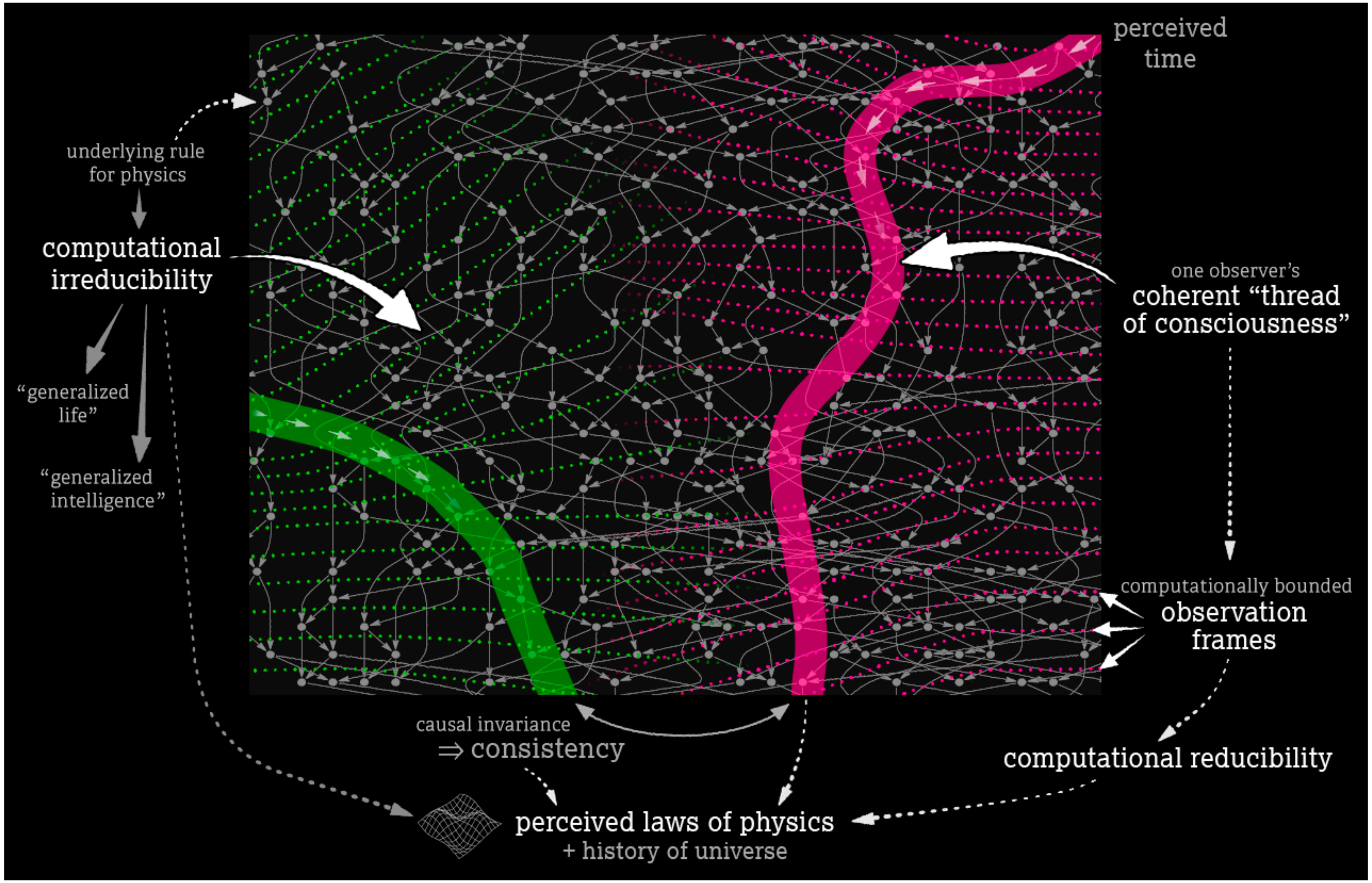
# Stephen Wolfram: Consciousness

- So what about physical space? The traditional view had been that space was something that could to a large extent just be described as a coherent mathematical object. But in our models of physics, space is actually made of an immense number of discrete elements whose pattern of interconnections evolves in a complex and computationally irreducible way.
- But it’s much like with the gas molecules. If an observer is going to form a coherent view of what’s going on, and if they have bounded computational capabilities, then this puts definite constraints on what behavior they will perceive. And it turns out that those constraints yield exactly relativity.
- In other words, for the “atoms of space”, relativity is the result of the interplay between underlying computational irreducibility and the requirement that the observer has a coherent view of what’s going on.

# Stephen Wolfram: Consciousness

- What's special about the way we humans experience the world? At some level, the very fact that we even have a notion of "experiencing" it at all is special. The world is doing what it does, we're able to meaningfully "form coherent thoughts" about the universe. And just as we can form coherent thoughts about the universe, so also we can form coherent thoughts about that small part of the universe that corresponds to our brains—or to the computations that represent the operation of our minds.
- But they seem to point to a fundamental feature of consciousness. Consciousness is not about the general computation that brains—or, for that matter, many other things—can do. It's about the particular feature of our brains that causes us to have a coherent thread of experience.
- Consciousness—like intelligence—is something of which we only have a clear sense in the single case of humans. But just as we've seen that the notion of intelligence can be generalized to the notion of arbitrary sophisticated computation, so now it seems that the notion of consciousness can be generalized to the notion of forming a coherent thread of representation for computations.

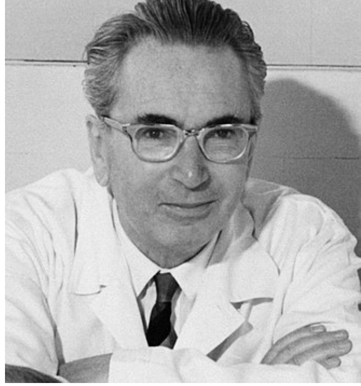
# Stephen Wolfram: Consciousness



# Consciousness

- Consciousness, at its simplest, is awareness of internal and external existence.
- However, its nature has led to millennia of analyses, explanations and debate by philosophers, theologians, and all of science. Opinions differ about what exactly needs to be studied or even considered consciousness. In some explanations, it is synonymous with the mind, and at other times, an aspect of mind. In the past, it was one's "inner life", the world of introspection, of private thought, imagination and volition.
- Today, it often includes any kind of cognition, experience, feeling or perception. It may be awareness, awareness of awareness, or self-awareness either continuously changing or not.
- The disparate range of research, notions and speculations raises a curiosity about whether the right questions are being asked.
- Examples of the range of descriptions, definitions or explanations are: simple wakefulness, one's sense of selfhood or soul explored by "looking within"; being a metaphorical "stream" of contents, or being a mental state, mental event or mental process of the brain.

# Meaning in Life: Viktor Frankl



- Viktor Emil Frankl (26 March 1905 – 2 September 1997) was an Austrian psychiatrist and Holocaust survivor, who founded logotherapy, a school of psychotherapy that describes a search for a life's meaning as the central human motivational force.
- In 1942, just nine months after his marriage, Frankl and his family were sent to the Theresienstadt concentration camp. His father died there of starvation and pneumonia. In 1944, Frankl and the surviving members of his family were transported to Auschwitz, where his mother and brother were murdered in the gas chambers. His wife Tilly died later of typhus in Bergen-Belsen. Frankl spent three years in four concentration camps.
- In 1948, Frankl earned a PhD in philosophy from the University of Vienna. His dissertation, *The Unconscious God*, examines the relationship between psychology and religion, and advocates for the use of the Socratic dialogue (self-discovery discourse) for clients to get in touch with their spiritual unconscious.
- Logotherapy is part of existential and humanistic psychology theories.
- Frankl is viewed as peer of Freud, Jung and Adler by many professionals

# Realizing Meaning in Life: Viktor Frankel

- Frankl identified three main ways of realizing meaning in life: by making a difference in the world, by having particular experiences, or by adopting particular attitudes.
- The primary techniques offered by logotherapy and existential analysis are:
  - Paradoxical intention: clients learn to overcome obsessions or anxieties by self-distancing and humorous exaggeration.
  - Dereflection: drawing the client's attention away from their symptoms, as hyper-reflection can lead to inaction.
  - Socratic dialogue and attitude modification: asking questions designed to help a client find and pursue self-defined meaning in life.
- His acknowledgement of meaning as a central motivational force and factor in mental health is his lasting contribution to the field of psychology. It provided the foundational principles for the emerging field of positive psychology. Frankl's work has also been endorsed in the Chabad philosophy of Hasidic Judaism.