Chapter 1 : The Higgs Boson vs. Boltzmann Brains | Sean Carroll

Science expert Emerald Robinson explains what an atom is. To view over 15, other how-to, DIY, and advice videos on any topic, visit www.nxgvision.com

That which we can observe aka. And given the sheer volume of that space, one would expect that the amount of matter contained within would be similarly impressive. But interestingly enough, it is when you look at that matter on the smallest of scales that the numbers become the most mind-boggling. But looking closer, at the atomic scale, the numbers get even more inconceivable. At this level, it is estimated that the there are between to atoms in the known, observable universe. As stated already, this estimate accounts only for the observable universe which reaches 46 billion light years in any direction, and is based on where the expansion of space has taken the most distant objects observed. The history of the universe starting the with the Big Bang. Since the number of stars in a galaxy can run up to billion, then the total number of stars may very well be around 1. On average, each star can weigh about grams. Since each gram of matter is known to have about protons, or about the same number of hydrogen atoms since one hydrogen atom has only one proton , then the total number of hydrogen atoms would be roughly â€” aka. Within this observable universe, this matter is spread homogeneously throughout space, at least when averaged over distances longer than million light-years. On smaller scales, however, matter is observed to form into the clumps of hierarchically-organized luminous matter that we are all familiar with. In short, most atoms are condensed into stars, most stars are condensed into galaxies, most galaxies into clusters, most clusters into superclusters and, finally, into the largest-scale structures like the Great Wall of galaxies aka. On a smaller scale, these clumps are permeated by clouds of dust particles, gas clouds, asteroids, and other small clumps of stellar matter. Representation of the timeline of the universe over The observable matter of the Universe is also spread isotropically; meaning that no direction of observation seems different from any other and each region of the sky has roughly the same content. The Universe is also bathed in a wave of highly isotropic microwave radiation that corresponds to a thermal equilibrium of roughly 2. The hypothesis that the large-scale universe is homogeneous and isotropic is known as the cosmological principle. This states that physical laws act uniformly throughout the universe and should, therefore, produce no observable irregularities in the large scale structure. This theory has been backed up by astronomical observations which have helped to chart the evolution of the structure of the universe since it was initially laid down by the Big Bang. The current consensus amongst scientists is that the vast majority of matter was created in this event, and that the expansion of the Universe since has not added new matter to the equation. Rather, it is believed that what has been taking place for the past This is a consequence arising out of Special Relativity , in which the addition of energy to an object increases its mass incrementally. Between all the fusions and fissions, atoms are regularly converted from particles to energies and back again. Atom density is greater at left the beginning of the experiment than 80 milliseconds after the simulated Big Bang. Chen-Lung Hung Nevertheless, observed on a large-scale, the overall matter density of the universe remains the same over time. The present density of the observable universe is estimated to be very low â€” roughly 9. This mass-energy appears to consist of Thus the density of atoms is on the order of a single hydrogen atom for every four cubic meters of volume. The properties of dark energy and dark matter are largely unknown, and could be uniformly distributed or organized in clumps like normal matter. However, it is believed that dark matter gravitates as ordinary matter does, and thus works to slow the expansion of the Universe. By contrast, dark energy accelerates its expansion. Once again, this number is just a rough estimate. When used to estimate the total mass of the Universe, it often falls short of what other estimates predict. And in the end, what we see is just a smaller fraction of the whole. NASA also has the following articles on the universe, like How many galaxies are there?

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Chapter 2 : Infinite monkey theorem - Wikipedia

Round neck long sleeve dress with side slits. Garment dye and all-over print. % Organic Cotton. Made in Portugal.

Koch Hall of Human Origins. How does evolution work? To survive, living things adapt to their surroundings. Occasionally a genetic variation gives one member of a species an edge. That individual passes the beneficial gene on to its descendents. More individuals with the new trait survive and pass it on to their descendents. If many beneficial traits arise over time, a new speciesâ€”better equipped to meet the challenges of its environmentâ€”evolves. What do scientists mean when they call evolution a theory? Like gravity and plate tectonics, evolution is a scientific theory. In science, a theory is the most logical explanation for how a natural phenomenon works. It is well tested and supported by abundant evidence. It means quite the opposite from our informal use of the word theory, which implies an untested opinion or guess. As a scientific theory, evolution enables scientists to make predictions and drives investigations that lead to new kinds of observable evidence. How does evolution explain complex organisms like humans? Modern humans are the product of evolutionary processes that go back more than 3. We became human gradually, evolving new physical traits and behaviors on top of those inherited from earlier primates, mammals, vertebrates, and the very oldest living organisms. How are humans and monkeys related? Humans and monkeys are both primates. But humans are not descended from monkeys or any other primate living today. We do share a common ape ancestor with chimpanzees. It lived between 8 and 6 million years ago. But humans and chimpanzees evolved differently from that same ancestor. All apes and monkeys share a more distant relative, which lived about 25 million years ago. Did humans evolve in a straight line, one species after another? Human evolution, like evolution in other species, did not proceed in a straight line. Instead, a diversity of species diverged from common ancestors, like branches on a bush. Our species, Homo sapiens, is the only survivor. But there were many times in the past when several early human species lived at the same time. Evolution is the cornerstone of modern biology. There is no scientific controversy about whether evolution occurred or whether it explains the history of life on Earth. As in all fields of science, knowledge about evolution continues to increase through research and serious debate. For example, scientists continue to investigate the details of how evolution occurred and to refine exactly what happened at different times. How do scientists know the age of fossils? Scientists have developed more than a dozen methods for determining the age of fossils, human artifacts, and the sediments in which such evidence is found. These methods can date objects millions of years old. Read more about dating methods here. How do scientists know what past climates were like? Among the major sources of evidence are sediment cores from the ocean bottom. They preserve the fossils of tiny organisms called foraminifera. By measuring oxygen in the skeletons of these organisms, scientists can calculate fluctuations in temperature and moisture over millions of years. What has been discovered about evolution since Darwin? Since Darwin died in , findings from many fields have confirmed and greatly expanded on his ideas. Can the concept of evolution co-exist with religious faith? Some members of both religious and scientific communities consider evolution to be opposed to religion. But others see no conflict between religion as a matter of faith and evolution as a matter of science. Still others see a much stronger and constructive relationship between religious perspectives and evolution. Many religious leaders and organizations have stated that evolution is the best explanation for the wondrous variety of life on Earth. How can we reduce the conflict between religion and science? Many scientists are people of faith who see opportunities for respectful dialogue about the relationship between religion and science. Some people consider science and faith as two separate areas of human understanding that enrich their lives in different ways. This Museum encourages visitors to explore new scientific findings and decide how these findings complement their ideas about the natural world. What about the gaps in knowledge about human evolution? In science, gaps in knowledge are the driving force behind the ongoing study of the natural world and how it arose. The science of human origins is a vibrant field in which new discoveries continually add to our understanding of how we became human. You can learn about some of the most recent findings in this exhibit. How does scientific knowledge about evolution relate to cultural beliefs about our origins? Societies worldwide express their beliefs through a wide diversity of stories about how humans came into being. These stories reflect the universal curiosity people have about our origins. For millennia, they have played a vital role in helping people develop an identity and an understanding of themselves as well as of their community. This exhibit presents research and findings based on scientific methods that are distinct from these stories.

Chapter 3 : Frequently Asked Questions | The Smithsonian Institution's Human Origins Program

The infinite monkey theorem states that a monkey hitting keys at random on a typewriter keyboard for an infinite amount of time will almost surely type a given text, such as the complete works of William Shakespeare.

If the universe enters a de Sitter vacuum phase that is truly eternal, there will be a finite temperature in empty space and corresponding thermal fluctuations. Among these fluctuations will be intelligent observers, as well as configurations that reproduce any local region of the current universe to arbitrary precision. We discuss the possibility that the escape from this unacceptable situation may be found in known physics: Avoiding Boltzmann Brains in a measure-independent way requires a decay timescale of order the current age of the universe, which can be achieved if the top quark pole mass is approximately GeV. We apply some far-out-sounding ideas to very down-to-Earth physics. A room full of monkeys , hitting keys randomly on a typewriter, will eventually bang out a perfect copy of Hamlet. Assuming, of course, that their typing is perfectly random, and that it keeps up for a long time. An extremely long time indeed, much longer than the current age of the universe. So this is an amusing thought experiment, not a viable proposal for creating new works of literature or old ones. But by the conditions of the experiment, the next thing the monkey types should be perfectly random by which we mean, chosen from a uniform distribution among all allowed typographical characters , and therefore independent of what has come before. The chances that you will actually get Act II next, just because you got Act I, are extraordinarily tiny. For every one time that your monkeys type Hamlet correctly, they will type it incorrectly an enormous number of times â€" small errors, large errors, all of the words but in random order, the entire text backwards, some scenes but not others, all of the lines but with different characters assigned to them, and so forth. Given that any one passage matches the original text, it is still overwhelmingly likely that the passages before and after are random nonsense. Replace your typing monkeys with a box of atoms at some temperature, and let the atoms randomly bump into each other for an indefinite period of time. Almost all the time they will be in a disordered, high-entropy, equilibrium state. If you wait long enough, and your box is sufficiently large, you will get a person, a planet, a galaxy, the whole universe as we now know it. But given that some of the atoms fall into a familiar-looking arrangement, we still expect the rest of the atoms to be completely random. If the random motions of the atoms create a person with firm memories of the past, all of those memories are overwhelmingly likely to be false. This thought experiment was originally relevant because Boltzmann himself and before him Lucretius , Hume , etc. All of which would seemingly be little more than fodder for scholars of intellectual history, now that we know the universe is not an eternal box of gas. The observable universe, anyway, started a mere That sounds like a long time, but the time required for random fluctuations to make anything interesting is enormously larger than that. To make something highly ordered out of something with entropy S, you have to wait for a time of order eS. Since macroscopic objects have more than particles, S is at least that large. Ah, but things are a bit more complicated than that. We now know that the universe is not only expanding, but also accelerating. The simplest explanation for that â€" not the only one, of course â€" is that empty space is suffused with a fixed amount of vacuum energy, a. Only up to a point. A universe with vacuum energy accelerates forever, and as a result we are surrounded by a cosmological horizon â€" objects that are sufficiently far away can never get to us or even send signals, as the space in between expands too quickly. In other words, a universe with a cosmological constant is like a box of gas the size of the horizon which lasts forever with a fixed temperature. Which means there are random fluctuations. If we wait long enough, some region of the universe will fluctuate into absolutely any configuration of matter compatible with the local laws of physics. Atoms, viruses, people, dragons, what have you. In the overwhelming majority of times that your local environment does get created, the rest of the universe will look like a high-entropy equilibrium state in this case, empty space with a tiny temperature. All of those copies of you will think they have reliable memories of the past and an accurate picture of what the external world looks like â€" but they would be wrong. And you could be one of them. That would be bad. Discussions of the Boltzmann Brain problem typically occur in the context of speculative ideas like eternal inflation and the multiverse. This is the real world, baby. It has a Boltzmann Brain problem, and is therefore cognitively unstable, and unacceptable as a physical theory. Can we escape this unsettling conclusion? Sure, by tweaking the physics a little bit. The simplest route is to make the vacuum energy not really a constant, e. A more robust scenario would be to invoke quantum vacuum decay. Maybe the vacuum energy is temporarily constant, but there is another vacuum state out there in field space with an even lower energy, to which we can someday make a transition. What would happen is that tiny bubbles of the lower-energy configuration would appear via quantum tunneling; these would rapidly grow at the speed of light. Fine, but it seems to invoke some speculative physics, in the form of new fields and a new quantum vacuum state. The answer is â€" maybe! This is where Kim and I come in, although some of the individual pieces of our puzzle were previously put together by other authors. The first piece is a fun bit of physics that hit the news media earlier this year: The reason why this is true is a bit subtle, but it comes down to renormalization group effects. And that, Kim and I point out, has a possibility of saving us from the Boltzmann Brain problem. Note that if the energy in the other state is negative, space inside the bubbles of new vacuum will actually collapse to a Big Crunch rather than expanding. Imagine that there is another vacuum state, and that we can nucleate bubbles that create regions of that new phase. The bubbles will expand at nearly the speed of light â€" but will they ever bump into other bubbles, and complete the transition from our current phase to the new one? So given that the Higgs field might support a different quantum vacuum, we have two questions. First, is our current vacuum stable, or is there actually a lower-energy vacuum to which we can transition? Second, if there is a lower-energy vacuum, does our vacuum decay fast enough that the transition percolates, or do we get stuck with an ever-increasing amount of space in the current phase? The answers depend on the precise value of the parameters that specify the Standard Model of particle physics, and therefore determine the renormalized Higgs potential. In particular, two parameters turn out to be the most important: Happily, the answers to the two questions we are asking is our vacuum stable, and does it decay quickly enough to percolate have already been calculated by other groups: Here are the answers, plotted in the parameter space defined by the Higgs mass and the top mass. Dotted lines represent uncertainties in another parameter, the QCD coupling constant. We are interested in the two diagonal lines. If you are below the bottom line, the Higgs field is stable, and you definitely have a Boltzmann Brain problem. Whether or not there is a Boltzmann-Brain problem is then measure-dependent, see below. If you are above the top line, bubbles nucleate quite quickly, and the transition percolates just fine. However, in that region the bubbles actually nucleate too fast; the phase transition should have already happened! The most recent LHC numbers put the Higgs mass at The most recent consensus number for the top quark mass is Combining these results gives the lower of our two sets of ellipses, where we have plotted one-sigma , two-sigma, and three-sigma contours. The error bars do extend into the stable region, however. This is a discussion that is a bit outside my expertise, but a very recent paper by the CMS collaboration tries to measure the number we actually want, and comes up with much looser error bars: Naively, in that region the volume of space in our current vacuum grows without bound, and Boltzmann Brains will definitely dominate. The meat of our paper was not actually plotting a couple of curves that other people had calculated, but attempting to apply approaches to the eternal-inflation measure problem to our real-world situation. The results were a bit inconclusive. But there is at least one â€" a modified causal-patch measure with terminal vacua, if you must know â€" in which the problem is avoided. The safest place to be is on the top diagonal line in our diagram, where we have bubbles nucleating fast enough to percolate but not so fast that they should have already happened. Well, roughly, it means you should be making new bubbles approximately once per current lifetime of our universe. Don Page has done a slightly more precise estimate of 20 billion years. It means that roughly half of the lifetime of our current universe has already happened. And the transition could happen much faster â€" it could be tomorrow or next year, although the chances are quite tiny. For our purposes, avoiding Boltzmann Brains, we want the transition to happen quickly. Amusingly, most of the existing particle-physics literature on decay of the Higgs field seems to take the attitude that we should want it to be completely stable â€" otherwise the decay of the Higgs will destroy the universe! All of this, of course, assumes there is no new physics at higher energies that would alter our calculations, which seems an unlikely assumption. So the alternatives are: A no-lose scenario, really.

Chapter 4 : Quantum Monkeys | www.nxgvision.com

There are approximately 7 x 10 27 atoms in the average human body. This is the estimate for a 70 kg adult human male. This is the estimate for a 70 kg adult human male. Generally, a smaller person would contain fewer atoms; a larger person would contain more atoms.

The first theorem is shown similarly; one can divide the random string into nonoverlapping blocks matching the size of the desired text, and make Ek the event where the kth block equals the desired string. If there were as many monkeys as there are atoms in the observable universe typing extremely fast for trillions of times the life of the universe, the probability of the monkeys replicating even a single page of Shakespeare is unfathomably small. Ignoring punctuation, spacing, and capitalization, a monkey typing letters uniformly at random has a chance of one in 26 of correctly typing the first letter of Hamlet. In the case of the entire text of Hamlet, the probabilities are so vanishingly small as to be inconceivable. The text of Hamlet contains approximately , letters. The average number of letters that needs to be typed until the text appears is also 3. To put it another way, for a one in a trillion chance of success, there would need to be , universes made of atomic monkeys. For example, the immortal monkey could randomly type G as its first letter, G as its second, and G as every single letter thereafter, producing an infinite string of Gs; at no point must the monkey be "compelled" to type anything else. There is nothing special about such a monotonous sequence except that it is easy to describe; the same fact applies to any nameable specific sequence, such as "RGRGRG" repeated forever, or "a-b-aa-bb-aaa-bbb If the hypothetical monkey has a typewriter with 90 equally likely keys that include numerals and punctuation, then the first typed keys might be "3. The probability that randomly typed keys will consist of the first 99 digits of pi including the separator key , or any other particular sequence of that length, is much lower: The same applies to the event of typing a particular version of Hamlet followed by endless copies of itself; or Hamlet immediately followed by all the digits of pi; these specific strings are equally infinite in length, they are not prohibited by the terms of the thought problem, and they each have a prior probability of 0. In fact, any particular infinite sequence the immortal monkey types will have had a prior probability of 0, even though the monkey must type something. This is an extension of the principle that a finite string of random text has a lower and lower probability of being a particular string the longer it is though all specific strings are equally unlikely. This probability approaches 0 as the string approaches infinity. At the same time, the probability that the sequence contains a particular subsequence such as the word MONKEY, or the 12th through th digits of pi, or a version of the King James Bible increases as the total string increases. This probability approaches 1 as the total string approaches infinity, and thus the original theorem is correct. Correspondence between strings and numbers[edit] In a simplification of the thought experiment, the monkey could have a typewriter with just two keys: The infinitely long string thusly produced would correspond to the binary digits of a particular real number between 0 and 1. A countably infinite set of possible strings end in infinite repetitions, which means the corresponding real number is rational. Examples include the strings corresponding to one-third â€¦ , five-sixths â€¦ and five-eighths â€¦. Only a subset of such real number strings albeit a countably infinite subset contains the entirety of Hamlet assuming that the text is subjected to a numerical encoding, such as ASCII. Meanwhile, there is an uncountably infinite set of strings which do not end in such repetition; these correspond to the irrational numbers. These can be sorted into two uncountably infinite subsets: However, the "largest" subset of all the real numbers are those which not only contain Hamlet, but which contain every other possible string of any length, and with equal distribution of such strings. These irrational numbers are called normal. Because almost all numbers are normal, almost all possible strings contain all possible finite substrings. Hence, the probability of the monkey typing a normal number is 1. The same principles apply regardless of the number of keys from which the monkey can choose; a key keyboard can be seen as a generator of numbers written in base Statistical mechanics[edit] In one of the forms in which probabilists now know this theorem, with its "dactylographic" [i. His "monkeys" are not actual monkeys; rather, they are a metaphor for an imaginary way to produce a large, random sequence of letters. Borel said that if a million monkeys typed ten hours a day, it was extremely unlikely that their output would exactly equal all the books of the richest libraries of the world; and yet, in comparison, it was even more unlikely that the laws of statistical mechanics would ever be violated, even briefly. If I let my fingers wander idly over the keys of a typewriter it might happen that my screed made an intelligible sentence. If an army of monkeys were strumming on typewriters they might write all the books in the British Museum. The chance of their doing so is decidedly more favourable than the chance of the molecules returning to one half of the vessel. On the contrary, it was a rhetorical illustration of the fact that below certain levels of probability, the term improbable is functionally equivalent to impossible. Explaining the views of Leucippus , who held that the world arose through the random combination of atoms, Aristotle notes that the atoms themselves are homogeneous and their possible arrangements only differ in shape, position and ordering. In On Generation and Corruption , the Greek philosopher compares this to the way that a tragedy and a comedy consist of the same "atoms", i. He who believes this may as well believe that if a great quantity of the one-and-twenty letters, composed either of gold or any other matter, were thrown upon the ground, they would fall into such order as legibly to form the Annals of Ennius. I doubt whether fortune could make a single verse of them. By , the idiom was "that a half-dozen monkeys provided with typewriters would, in a few eternities, produce all the books in the British Museum. Everything would be in its blind volumes. They left a computer keyboard in the enclosure of six Celebes crested macaques in Paignton Zoo in Devon in England for a month, with a radio link to broadcast the results on a website. He concluded that monkeys "are not random generators. They were quite interested in the screen, and they saw that when they typed a letter, something happened. There was a level of intention there. This attribution is incorrect. This story suffers not only from a lack of evidence, but the fact that in the typewriter itself had yet to emerge. For example, Doug Powell argues as a Christian apologist that even if a monkey accidentally types the letters of Hamlet, it has failed to produce Hamlet because it lacked the intention to communicate. His parallel implication is that natural laws could not produce the information content in DNA. The chance of the target phrase appearing in a single step is extremely small, yet Dawkins showed that it could be produced rapidly in about 40 generations using cumulative selection of phrases. The random choices furnish raw material, while cumulative selection imparts information. As Dawkins acknowledges, however, the weasel program is an imperfect analogy for evolution, as "offspring" phrases were selected "according to the criterion of resemblance to a distant ideal target. The weasel program is instead meant to illustrate the difference between non-random cumulative selection, and random single-step selection. A different avenue for exploring the analogy between evolution and an unconstrained monkey lies in the problem that the monkey types only one letter at a time, independently of the other letters. Hugh Petrie argues that a more sophisticated setup is required, in his case not for biological evolution but the evolution of ideas: In order to get the proper analogy, we would have to equip the monkey with a more complex typewriter. It would have to include whole Elizabethan sentences and thoughts. It would have to include Elizabethan beliefs about human action patterns and the causes, Elizabethan morality and science, and linguistic patterns for expressing these. Then, perhaps, we might allow the monkey to play with such a typewriter and produce variants, but the impossibility of obtaining a Shakespearean play is no longer obvious. What is varied really does encapsulate a great deal of already-achieved knowledge. Collingwood argued in that art cannot be produced by accident, and wrote as a sarcastic aside to his critics, Any reader who has nothing to do can amuse himself by calculating how long it would take for the probability to be worth betting on. Any of us can do the same, as can printing presses and photocopiers. Indeed, we are told, if infinitely many monkeys It is the same text, and it is open to all the same interpretations Gracia , the question of the identity of texts leads to a different question, that of author. If a monkey is capable of typing Hamlet, despite having no intention of meaning and therefore disqualifying itself as an author, then it appears that texts do not require authors. Possible solutions include saying that whoever finds the text and identifies it as Hamlet is the author; or that Shakespeare is the author, the monkey his agent, and the finder merely a user of the text. These solutions have their own difficulties, in that the text appears to have a meaning separate from the other agents: Nonetheless, it has inspired efforts in finite random text generation. For example, it produced this partial line from Henry IV, Part 2 , reporting that it took "2,, million billion billion billion monkey-years" to reach 24 matching characters: Due to processing power limitations, the program used a probabilistic model by using a random number generator or RNG instead of actually generating random text and comparing it to Shakespeare. When the simulator "detected a match" that is, the RNG generated a certain value or a value within a certain range , the simulator simulated the match by generating matched text. If instead of simply generating random characters one restricts the generator to a meaningful vocabulary and conservatively following grammar rules, like using a context-free grammar , then a random document generated this way can even fool some humans at least on a cursory reading as shown in the experiments with SCIgen , snarXiv , and the Postmodernism Generator. Testing of random-number generators[edit] Main article: Diehard tests Questions about the statistics describing how often an ideal monkey is expected to type certain strings translate into practical tests for random-number generators ; these range from the simple to the "quite sophisticated". Computer-science professors George Marsaglia and Arif Zaman report that they used to call one such category of tests "overlapping m- tuple tests" in lectures, since they concern overlapping m-tuples of successive elements in a random sequence. But they found that calling them "monkey tests" helped to motivate the idea with students. They published a report on the class of tests and their results for various RNGs in Infinite monkey theorem in popular culture The infinite monkey theorem and its associated imagery is considered a popular and proverbial illustration of the mathematics of probability, widely known to the general public because of its transmission through popular culture rather than through formal education. Burns shows Homer "a room with a thousand monkeys on a thousand typewriters. Soon they will have written the greatest novel known to man!

Chapter 5 : What Is An Atom? â€“ Monkeysee Videos

Trousers with elastic waistband, ruffle and pockets. Garment dye. 97% Organic Cotton 3%EA. Made in Portugal.

Atomism The idea that matter is made up of discrete units is a very old idea, appearing in many ancient cultures such as Greece and India. The word "atom" Greek: In the early s, John Dalton used the concept of atoms to explain why elements always react in ratios of small whole numbers the law of multiple proportions. For instance, there are two types of tin oxide: This means that g of tin will combine either with This common pattern in chemistry suggested to Dalton that elements react in multiples of discrete units â€" in other words, atoms. In the case of tin oxides, one tin atom will combine with either one or two oxygen atoms. For example, he found that water absorbs carbon dioxide far better than it absorbs nitrogen. Brownian motion In , botanist Robert Brown used a microscope to look at dust grains floating in water and discovered that they moved about erratically, a phenomenon that became known as " Brownian motion ". This was thought to be caused by water molecules knocking the grains about. In , Albert Einstein proved the reality of these molecules and their motions by producing the first statistical physics analysis of Brownian motion. Thomson measured the mass of cathode rays , showing they were made of particles, but were around times lighter than the lightest atom, hydrogen. Therefore, they were not atoms, but a new particle, the first subatomic particle to be discovered, which he originally called " corpuscle " but was later named electron, after particles postulated by George Johnstone Stoney in He also showed they were identical to particles given off by photoelectric and radioactive materials. Thomson was given the Nobel Prize in Physics for this work. Thus he overturned the belief that atoms are the indivisible, ultimate particles of matter. This became known as the plum pudding model. Discovery of the nucleus Main article: Geiger-Marsden experiment In , Hans Geiger and Ernest Marsden , under the direction of Ernest Rutherford , bombarded a metal foil with alpha particles to observe how they scattered. To explain this, Rutherford proposed that the positive charge of the atom is concentrated in a tiny nucleus at the center of the atom. Thomson created a technique for isotope separation through his work on ionized gases , which subsequently led to the discovery of stable isotopes. This model is obsolete. Bohr model In the physicist Niels Bohr proposed a model in which the electrons of an atom were assumed to orbit the nucleus but could only do so in a finite set of orbits, and could jump between these orbits only in discrete changes of energy corresponding to absorption or radiation of a photon. Until these experiments, atomic number was not known to be a physical and experimental quantity. That it is equal to the atomic nuclear charge remains the accepted atomic model today. Groups of electrons were thought to occupy a set of electron shells about the nucleus. As this spin direction is initially random, the beam would be expected to deflect in a random direction. Instead, the beam was split into two directional components, corresponding to the atomic spin being oriented up or down with respect to the magnetic field. A consequence of using waveforms to describe particles is that it is mathematically impossible to obtain precise values for both the position and momentum of a particle at a given point in time; this became known as the uncertainty principle , formulated by Werner Heisenberg in Thus, the planetary model of the atom was discarded in favor of one that described atomic orbital zones around the nucleus where a given electron is most likely to be observed. The chemist Francis William Aston used this instrument to show that isotopes had different masses. The atomic mass of these isotopes varied by integer amounts, called the whole number rule. Isotopes were then explained as elements with the same number of protons, but different numbers of neutrons within the nucleus. Instead, his chemical experiments showed barium as a product. The standard model of particle physics was developed that so far has successfully explained the properties of the nucleus in terms of these sub-atomic particles and the forces that govern their interactions. Subatomic particle Though the word atom originally denoted a particle that cannot be cut into smaller particles, in modern scientific usage the atom is composed of various subatomic particles. The constituent particles of an atom are the electron , the proton and the neutron ; all three are fermions. However, the hydrogen-1 atom has no neutrons and the hydron ion has no electrons. Under ordinary conditions, electrons are bound to the positively charged nucleus by the attraction created from opposite electric charges. If an atom has more or fewer electrons than its atomic number, then it becomes respectively negatively or positively charged as a whole; a charged atom is called an ion. Electrons have been known since the late 19th century, mostly thanks to J. Thomson ; see history of subatomic physics for details. The number of protons in an atom is called its atomic number. Ernest Rutherford observed that nitrogen under alpha-particle bombardment ejects what appeared to be hydrogen nuclei. By he had accepted that the hydrogen nucleus is a distinct particle within the atom and named it proton. In the Standard Model of physics, electrons are truly elementary particles with no internal structure. However, both protons and neutrons are composite particles composed of elementary particles called quarks. There are two types of quarks in atoms, each having a fractional electric charge. Neutrons consist of one up quark and two down quarks. This distinction accounts for the difference in mass and charge between the two particles. The protons and neutrons, in turn, are held to each other in the nucleus by the nuclear force , which is a residuum of the strong force that has somewhat different range-properties see the article on the nuclear force for more. The gluon is a member of the family of gauge bosons , which are elementary particles that mediate physical forces. Atomic nucleus The binding energy needed for a nucleon to escape the nucleus, for various isotopes All the bound protons and neutrons in an atom make up a tiny atomic nucleus , and are collectively called nucleons. The radius of a nucleus is approximately equal to 1. The nucleons are bound together by a short-ranged attractive potential called the residual strong force. At distances smaller than 2. Within a single element, the number of neutrons may vary, determining the isotope of that element. The total number of protons and neutrons determine the nuclide. The number of neutrons relative to the protons determines the stability of the nucleus, with certain isotopes undergoing radioactive decay. Fermions obey the Pauli exclusion principle which prohibits identical fermions, such as multiple protons, from occupying the same quantum state at the same time. Thus, every proton in the nucleus must occupy a quantum state different from all other protons, and the same applies to all neutrons of the nucleus and to all electrons of the electron cloud. As a result, atoms with matching numbers of protons and neutrons are more stable against decay. However, with increasing atomic number, the mutual repulsion of the protons requires an increasing proportion of neutrons to maintain the stability of the nucleus, which slightly modifies this trend of equal numbers of protons to neutrons. The number of protons and neutrons in the atomic nucleus can be modified, although this can require very high energies because of the strong force. Nuclear fusion occurs when multiple atomic particles join to form a heavier nucleus, such as through the energetic collision of two nuclei. For example, at the core of the Sun protons require energies of 3â€"10 keV to overcome their mutual repulsionâ€"the coulomb barrier â€"and fuse together into a single nucleus. The nucleus can also be modified through bombardment by high energy subatomic particles or photons. If this modifies the number of protons in a nucleus, the atom changes to a different chemical element. This deficit is part of the binding energy of the new nucleus, and it is the non-recoverable loss of the energy that causes the fused particles to remain together in a state that requires this energy to separate. For heavier nuclei, the binding energy per nucleon in the nucleus begins to decrease. That means fusion processes producing nuclei that have atomic numbers higher than about 26, and atomic masses higher than about 60, is an endothermic process. These more massive nuclei can not undergo an energy-producing fusion reaction that can sustain the hydrostatic equilibrium of a star. Atomic orbital and Electron configuration A potential well, showing, according to classical mechanics , the minimum energy V x needed to reach each position x. Classically, a particle with energy E is constrained to a range of positions between x1 and x2. The electrons in an atom are attracted to the protons in the nucleus by the electromagnetic force. This force binds the electrons inside an electrostatic potential well surrounding the smaller nucleus, which means that an external source of energy is needed for the electron to escape. The closer an electron is to the nucleus, the greater the attractive force. Hence electrons bound near the center of the potential well require more energy to escape than those at greater separations. Electrons, like other particles, have properties of both a particle and a wave. The electron cloud is a region inside the potential well where each electron forms a type of three-dimensional standing wave â€"a wave form that does not move relative to the nucleus. This behavior is defined by an atomic orbital , a mathematical function that characterises the probability that an electron appears to be at a particular location when its position is measured. The three 2p orbitals each display a single angular node that has an orientation and a minimum at the center. Play media How atoms are constructed from electron orbitals and link to the periodic table Each atomic orbital corresponds to a particular energy level of the electron. The electron can change its state to a higher energy level by absorbing a photon with sufficient energy to boost it into the new quantum state. Likewise, through spontaneous emission , an electron in a higher energy state can drop to a lower energy state while radiating the excess energy as a photon. These characteristic energy values, defined by the differences in the energies of the quantum states, are responsible for atomic spectral lines. For example, it requires only Atoms that have either a deficit or a surplus of electrons are called ions. Electrons that are farthest from the nucleus may be transferred to other nearby atoms or shared between atoms. By this mechanism, atoms are able to bond into molecules and other types of chemical compounds like ionic and covalent network crystals. Isotope , Stable isotope , List of nuclides , and List of elements by stability of isotopes By definition, any two atoms with an identical number of protons in their nuclei belong to the same chemical element. Atoms with equal numbers of protons but a different number of neutrons are different isotopes of the same element. For example, all hydrogen atoms admit exactly one proton, but isotopes exist with no neutrons hydrogen-1 , by far the most common form, [55] also called protium , one neutron deuterium , two neutrons tritium and more than two neutrons. The known elements form a set of atomic numbers, from the single proton element hydrogen up to the proton element oganesson. However, only 90 of these nuclides are stable to all decay, even in theory. Another bringing the total to have not been observed to decay, even though in theory it is energetically possible. These are also formally classified as "stable". An additional 34 radioactive nuclides have half-lives longer than 80 million years, and are long-lived enough to be present from the birth of the solar system. This collection of nuclides are known as primordial nuclides.

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Atomic Biology: is the name we are giving to the study of the enormous amount of super-intelligent physical work that is essential for finding, sorting, selecting, counting, grasping, and precisely placing and fastening all the right numbers of the right atoms required for constructing, sustaining, growing, maintaining, and repairing all living cells and entities.

A Talk with Seth Lloyd [5. Huxley said, "I would rather be descended from a humble ape than from a great gentleman who uses considerable intellectual gifts in the service of falsehood. Seth Lloyd is an Edgy guy. In fact he likes to work "at the very edge of this information processing revolution". I take that personally, because most of what I do on a day-to-day basis is to try to coax little super-conducting circuits to give up their secrets". His seminal work in the fields of quantum computation and quantum communicationsâ€"including proposing the first technologically feasible design for a quantum computer. Electronic and optical methods of storing, processing, and communicating information have advanced exponentially over the last half-century. In the s, Gordon Moore, the ex-president of Intel, pointed out that the components of computers were halving in size every year or two, and consequently, the power of computers was doubling at the same rate. As a result these machines that we make, these human artifacts, are on the verge of becoming more powerful than human beings themselves in terms of raw information processing power. If you count the elementary computational events that occur in the brain or in the computerâ€"bits flipping, synapses firingâ€"the computer is likely to overtake the brain in terms of bits flipped per second in the next couple of decades. Software evolves much more slowly than hardware, and indeed much current software seems to be designed to junk up the beautiful machines that we build. The situation is like the Cambrian explosion, a rapid increase in the power of hardware. Who is smarter, humans or computers, is a question that will get sorted out some million years hence, maybe; maybe sooner. My guess would be that it will take hundreds or thousands of years until we actually get software that we could reasonably regard as useful and sophisticated. Most of what I do in my everyday life is to work at the very edge of this information processing revolution. Much of what I say to you today comes from my experience in building quantum computers, computers where you store bits of information on individual atoms. About ten years ago I came up with the first method for physically constructing a computer in which every quantumâ€"every atom, electron, and photonâ€"inside a system stores and processes information. I take that personally, because most of what I do on a day-to-day basis is to try to coax little super-conducting circuits to give up their secrets. For instance, he invention of moveable type and the printing has had a much greater impact on human society so far than the electronic revolution. There have been many information processing revolutions. One of my favorites is the invention of the so-called Arabicâ€"actually Babylonianâ€"numbers, in particular, zero. This amazing invention, very useful in terms of processing and registering information, came from the ancient Babylonians and then moved to India. It came to us through the Arabs, which is why we call it the Arabic number system. The invention of zero allows us to write the number 10 as one zero. This apparently tiny step is in fact an incredible invention that has given rise to all sorts of mathematics, including the bitsâ€"the "binary digits"â€"of the digital computing revolution. Another information processing revolution is the invention of written language. Another of my favorites is the first sexual revolution; that is, the discovery of sex by a living organism. Being from a mechanical engineering department, I would say that when you evolve only by mutation, you have an engineering conflict: In particular, the two prerequisites for lifeâ€"evolve, but maintain the integrity of the genome â€"collide. However, if you have sexual selection, then you can combine genes from different genomes and get lots of variation without, in principal, ever having to have a mutation. Of course, you still have mutations, but you get a huge amount of variation for free. I wrote a paper a few years ago that compared the evolutionary power of human beings to that of bacteris. The point of comparison was the number of bits per second of new genetic combinations that a population of human beings generated, compared with the number generated by a culture of bacteria. A culture of bacteria in a swimming pool of seawater has about a trillion bacteria, reproducing once every thirty minutes. Compare this with the genetic power of a small town with a few thousand people in New Englandâ€"say Peyton Placeâ€"reproducing every thirty years. Despite the huge difference in population, Peyton Place can generate as many new genetic combinations as the culture of bacteria a billion times more numerous. In daytime TV the sexual recombination and selection happens much faster, of course. Sexual reproduction is a great revolution. The discovery, however it came about, that information can be stored and processed genetically and that this could be used to encode functions inside an organism that can reproduce is an incredible revolution. It happened four to five billion years ago on Earth, maybe earlier if one believes that life developed elsewhere and then was transported here. At any rate, since the universe is only We forgot to talk about the human brain or should I say, my brain forgot to talk about the brain? Electronic information processing, for instance, comes out of the notion of written language, of having zeroes and ones, the idea that you can make machines to copy and transmit information. A printing press is not so useful without written language. And what are brains for but to help you have sex? Music came from the ability to make sound, and the ability to make sound evolved for the purpose of having sex. You either need vocal chords to sing with or sticks to beat on a drum with. To make sound, you need a physical object. Every information processing revolution requires either living systems, electromechanical systems, or mechanical systems. For every information processing revolution, there is a technology. OK, so life is the big one, the mother of all information processing revolutions. But what revolution occurred that allowed life to exist? I would claim that, in fact, all information processing revolutions have their origin in the intrinsic computational nature of the universe. The first information processing revolution was the Big Bang. Information processing revolutions come into existence because at some level the universe is constructed of information. It is made out of bits. Of course, the universe is also made out of elementary particles, unknown dark energy, and lots of other things. Whenever two elementary particles bounce off of each other, those bits flip. The notion that the universe is, at bottom, processing information sounds like some radical idea. They showed that, in fact, the universe is fundamentally about information. They, of course, called this information entropy, but if you look at their scientific discoveries through the lens of twentieth century technology, what in fact they discovered was that entropy is the number of bits of information registered by atoms. My claim is that this intrinsic ability of the universe to register and process information is actually responsible for all the subsequent information processing revolutions. How do we think of information these days? The contemporary scientific view of information is based on the theories of Claude Shannon. When Shannon came up with his fundamental formula for information he went to the physicist and polymath John von Neumann and said, "What shall I call this? The founders of information theory were very well aware that the formulas they were using had been developed back in the 19th century to describe the motions of atoms. When Shannon talked about the number of bits in a signal that can be sent down a communications channel, he was using the same formulas to describe it that Maxwell and Boltzmann used to describe the amount of information, or the entropy, required to describe the positions and momenta of a set of interacting particles in a gas. What is a bit of information? When you buy a computer you ask how many bits its memory can register. A bit comes from a distinction between two different possibilities. Anything that has two distinct states registers a bit of information. At the elementary particle level a proton can have two distinct states: Each proton registers one bit of information. In fact, the proton registers a bit whether it wants to or not, or whether this information is interpreted or not. It registers a bit merely by the fact of existing. A proton possesses two different states and so registers a bit. We exploit the intrinsic information processing ability of atoms when building quantum computers, because many of our quantum computers consist of arrays of protons interacting with their neighbors, each of which stores a bit. Each proton would be storing a bit of information whether we were asking them to flip those bits or not. Similarly, if you have a bunch of atoms zipping around, they bounce off each other. The atoms come together, and they bounce off each other, and then they move apart again. When the atoms collide, their bits flip. The number of bits registered by each atom is well known and has been quantified ever since Maxwell and Boltzmann. Each particleâ€"for instance each of the molecules in this roomâ€"registers something on the order of 30 or 40 bits of information as it bounces around. This feature of the universeâ€"that it registers and processes information at its most fundamental levelâ€"is scientifically uncontroversial, in the sense that it has been known for years and is the accepted dogma of physics. My claim is that this intrinsic information processing ability of the universe is responsible for the remainder of the information processing revolutions we see around us, from life up to electronic computers. Let me repeat the claim: More technically, the universe is a gigantic information processor that is capable of universal computation. That is the definition of a computer. If he were here Marvin Minsky would say, "Ed Fredkin and Konrad Zuse back in the s claimed that the universe was a computer, a giant cellular automaton. He and Ed Fredkin at MIT came up with this idea that the universe might be a gigantic type of computer called a cellular automaton. This is an idea that has since been developed by Stephen Wolfram. The idea that the universe is some kind of digital computer is, in fact, an old claim as well. Thus, my claim that the universe computes is an old one dating back at least half a century. This claim could actually be substantiated from a scientific perspective. One could prove, by looking at the basic laws of physics, that the universe is or is not a computer, and if so, what kind of computer it is. We have very good experimental evidence that the laws of physics support computation. I own a computer, and it obeys the laws of physics, whatever those laws are. We know the universe supports computation, at least on a macroscopic scale. My claim is that the universe supports computation at its most tiny scale.

Chapter 7 : Atoms Quotes - BrainyQuote

Atoms are the basic, smallest stable units of matter. They are composed of subatomic particles called protons, neutrons, and electrons.

Chapter 8 : www.nxgvision.com - Chemistry Study Guide -CHAPTER 3 : ATOMIC STRUCTURE

When the atoms bounce off each other the string of bits changes because the atoms' momentum changes. When the atoms collide, their bits flip. The number of bits registered by each atom is well known and has been quantified ever since Maxwell and Boltzmann.

Chapter 9 : August KekulÃ© - Wikipedia

Those green lines are the actual atomic bonds inside a molecule. This isn't an artist's impression: That's an atomic force microscope (AFM) image of electron density. The green bars are the joints between atoms, the scaffold supporting everything. The red cells are the void between atoms in even the most solid material.