I'm not a robot

Time travel is a concept that has fascinated humans for centuries. The idea of journeying through time to witness events of the past or future has been explored in literature, film, and popular culture. But where did the concept of time travel originate, and how has it evolved over time?The earliest known mention of time travel dates back to ancient Indian mythology, where the story of King Raivata Kakudmi is told. According to the legend, the king travels to the heavens with the god Brahma and returns to Earth millions of years later, only to find that everything and everyone he knew had long since perished. This tale pre-dates the concept of time travel as we know it, but it does suggest that humans have been thinking about the possibility of traveling through time for thousands of years.In the Western world, the concept of time travel can be traced back to the early science fiction novels of the 19th century. One of the first examples is The Clock that Went Backward by Edward Page Mitchell, which was published in 1881. The story features a clock that, when wound back, transports its owner back in time.Another early example is H.G. Wells The Time Machine, published in 1895. The novel follows the story of a time traveler who journeys far into the future and discovers a world where humans have evolved into two distinct species. The TimeThe dream of traveling through time is both ancient and universal. But where did humanity's fascination with time travel begin, and why is the idea so appealing?The concept of time travel moving through time the way we move through three-dimensional space may in fact be hardwired into our perception of time. Linguists have recognized that we are essentially incapable of talking about temporal matters without referencing spatial ones. "In language any language no two domains are more intimately linked than space and time," wrote Israeli linguist Guy Deutscher in his 2005 book "The Unfolding of Language." "Even if we are not always aware of it, we invariably speak of time in terms of space, and this reflects the fact that we think of time in terms of space."Deutscher reminds us that when we plan to meet a friend "around" lunchtime, we are using a metaphor, since lunchtime doesn't have any physical sides. He similarly points out that time can not literally be "long" or "short" like a stick, nor "pass" like a train, or even go "forward" or "backward" any more than it goes sideways, diagonal or down.You may like Related: Why Does Time Fly When You're Having Fun?Perhaps because of this connection between space and time, the possibility that time can be experienced in different ways and traveled through has surprisingly early roots. One of the first known examples of time travel appears in the Mahabharata, an ancient Sanskrit epic poem compiled around 400 B.C., Lisa Yaszek, a professor of science fiction studies at the Georgia Institute of Technology in Atlanta, told Live ScienceIn the Mahabharata is a story about King Kakudmi, who lived millions of years ago and sought a suitable husband for his beautiful and accomplished daughter, Revati. The two travel to the home of the creator god Brahma to ask for advice. But while in Brahma's plane of existence, they must wait as the god listens to a 20-minute song, after which Brahma explains that time moves differently in the heavens than on Earth. It turned out that "27 chatur-yugas" had passed, or more than 116 million years, according to an online summary, and so everyone Kakudmi and Revati had ever known, including family members and potential suitors, was dead. After this shock, the story closes on a somewhat happy ending in that Revati is betrothed to Balarama, twin brother of the deity Krishna.Time is fleetingTo Yaszek, the tale provides an example of what we now call time dilation, in which different observers measure different lengths of time based on their relative frames of reference, a part of Einstein's theory of relativity.Get the worlds most fascinating discoveries delivered straight to your inbox.Such time-slip stories are widespread throughout the world, Yaszek said, citing a Middle Eastern tale from the first century BCE about a Jewish miracle worker who sleeps beneath a newly-planted carob tree and wakes up 70 years later to find it has now matured and borne fruit (carob trees are notorious for how long they take to produce their first harvest). Another instance can be found in an eighth-century Japanese fable about a fisherman named Urashima Tar who travels to an undersea palace and falls in love with a princess. Tar finds that, when he returns home, 100 years have passed, according to a translation of the tale published online by the University of South Florida.In the early-modern era of the 1700 and 1800s, the sleep-story version of time travel grew more popular, Yaszek said. Examples include the classic tale of Rip Van Winkle, as well as books like Edward Belamy's utopian 1888 novel "Looking Backwards," in which a man wakes up in the year 2000, and the H.G. Wells 1899 novel "The Sleeper Awakes," about a man who slumbers for centuries and wakes to a completely transformed London.Related: Science Fiction or Fact: Is Time Travel Possible?In other stories from this period, people also start to be able to move backward in time. In Mark Twains 1889 satire "A Connecticut Yankee in King Arthur's Court," a blow to the head propels an engineer back to the reign of the legendary British monarch. Objects that can send someone through time begin to appear as well, mainly clocks, such as in Edward Page Mitchell's 1881 story "The Clock that Went Backwards" or Lewis Carrol's 1889 children's fantasy "Sylvie and Bruno," where the characters possess a watch that is a type of time machine.The explosion of such stories during this era might come from the fact that people were "beginning to standardize time, and orient themselves to clocks more frequently," Yaszek said.Time after timeWells provided one of the most enduring time-travel plots in his 1895 novella "The Time Machine," which included the innovation of a craft that can move forward and backward through long spans of time. "This is when were getting steam engines and trains and the first automobiles," Yaszek said. "I think its no surprise that Wells suddenly thinks: 'Hey, maybe we can use a vehicle to travel through time.'"Because it is such a rich visual icon, many beloved time-travel stories written after this have included a striking time machine, Yaszek said, referencing The Doctor's blue police box the TARDIS in the long-running BBC series "Doctor Who," and "Back to the Future"'s silver luxury speedster, the DeLorean.More recently, time travel has been used to examine our relationship with the past, Yaszek said, in particular in pieces written by women and people of color. Octavia Butler's 1979 novel "Kindred" about a modern woman who visits her pre-Civil-War ancestors is "a marvelous story that really asks us to rethink black and white relations through history," she said. And a contemporary web series called "Send Me" involves an African-American psychic who can guide people back to antebellum times and witness slavery."I'm really excited about stories like that," Yaszek said. "They help us re-see history from new perspectives."Time travel has found a home in a wide variety of genres and media, including comedies such as "Groundhog Day" and "Bill and Ted's Excellent Adventure" as well as video games like Nintendo's "The Legend of Zelda:Majora's Mask" and the indie game "Braid."Yaszek suggested that this malleability and ubiquity speaks to time travel tales' ability to offer an escape from our normal reality. "They let us imagine that we can break free from the grip of linear time," she said. "And somehow get a new perspective on the human experience, either our own or humanity as a whole, and I think that feels so exciting to us."That modern people are often drawn to time-machine stories in particular might reflect the fact that we live in a technological world, she added. Yet time travel's appeal certainly has deeper roots, interwoven into the very fabric of our language and appearing in some of our earliest imaginings."I think it's a way to make sense of the otherwise intangible and inexplicable, because it's hard to grasp time," Yaszek said. "But this is one of the final frontiers, the frontier of time, of life and death. And we're all moving forward, we're all traveling through time."Originally published on Live Science.Time travel has long been a popular topic in science fiction, but the concept has also captured the imaginations of scientists and philosophers alike. From H.G. Wells' "The Time Machine" to modern-day movies like "Back to the Future" and "Interstellar," time travel continues to captivate audiences.But where did the idea of time travel come from, and how has it evolved over time?Let's take a journey through the history of time travel.Ancient Mythology: The concept of time travel can be traced back to ancient mythology. The Greek myth of Chronos, the god of time, and his son, the god of love Eros, provides one of the earliest accounts of time manipulation. According to the myth, Eros shoots Chronos with an arrow, causing him to fall in love with a mortal woman and lose his sense of time.Science Fiction: The idea of time travel as we know it today began to emerge in the 19th century with the publication of H.G. Wells' "The Time Machine" in 1895. In the novel, the protagonist builds a machine that can travel through time, taking him to a future world where humans have evolved into two separate species.Einstein's Theory of Relativity: In the early 20th century, Albert Einstein's theory of relativity provided a scientific basis for the idea of time travel. According to the theory, time is not a fixed concept, but rather a relative one that depends on an observer's position and speed.Quantum Physics: In the 20th century, quantum physics also contributed to the development of the concept of time travel. The theory of quantum mechanics suggests that particles can exist in multiple states simultaneously, leading to the possibility of parallel universes and alternate timelines.Popular Culture: Time travel continues to be a popular theme in popular culture, with numerous books, movies, and TV shows exploring the concept. Some of the most well-known examples include the "Doctor Who" TV series, the "Back to the Future" movies, and Christopher Nolan's "Interstellar."While time travel remains a theoretical concept, advances in science and technology continue to bring us closer to the possibility of manipulating time. From the theories of Einstein and quantum physics to the development of wormholes and the exploration of black holes, the concept of time travel remains a fascinating subject of both science and science fiction.The idea of time travel has been around for centuries, and has captured the imaginations of people around the world. Whether in ancient mythology, science fiction, or modern popular culture, time travel continues to inspire us to explore the mysteries of the universe and the boundaries of human knowledge.Hypothetical travel into the past or futureFor other uses, see Time Travel (disambiguation).The first page of The Time Machine published by HeinemannTime travel is the hypothetical activity of traveling into the past or future. Time travel is a concept in philosophy and fiction, particularly science fiction. In fiction, time travel is typically achieved through the use of a device known as a time machine. The idea of a time machine was popularized by H. G. Wells's 1895 novel The Time Machine.[1]It is uncertain whether time travel to the past would be physically possible. Such travel, if at all feasible, may give rise to questions of causality. Forward time travel, outside the usual sense of the perception of time, is an extensively observed phenomenon and is well understood within the framework of special relativity and general relativity. However, making one body advance or delay more than a few milliseconds compared to another body is not feasible with current technology. As for backward time travel, it is possible to find solutions in general relativity that allow for it, such as a rotating black hole. Traveling to an arbitrary point in spacetime has very limited support in theoretical physics, and is usually connected only with quantum mechanics or wormholes.Statue of Rip Van Winkle in Irvington, New YorkSome ancient myths depict a character skipping forward in time. In Hindu mythology, the Vishnu Purana mentions the story of King Raivata Kakudmi, who travels to heaven to meet the creator Brahma and is surprised to learn when he returns to Earth that many ages have passed.[2][3] The Buddhist Pli Canon mentions the relativity of time. The Payasi Sutta tells of one of the Buddha's chief disciples, Kumara Kassapa, who explains to the skeptic Payasi that time in the Heavens passes differently than on Earth.[4] The Japanese tale of "Urashima Tar",[5] first described in the Manyoshu, tells of a young fisherman named Urashima-no-ko () who visits an undersea palace. After three days, he returns home to his village and finds himself 300 years in the future, where he has been forgotten, his house is in ruins, and his family has died.[6] One tradition in Judaism has Moses transported by God to the study hall of Rabbi Akiva, where he is perplexed by the later evolution of the faith. Another Talmudic story concerns Honi HaMe'agel, a miracle-working sage of the 1st century BC, who was a historical character to whom various myths were attached. While traveling one day, Honi saw a man planting a carob tree and asked him about it. The man explained that the tree would take 70 years to bear fruit, and that he was planting it not for himself but for the generations to follow him. Later that day, Honi sat down to rest but fell asleep for 70 years; when he awoke, he saw a man picking fruit from a fully mature carob tree. Asked whether he had planted it, the man replied that he had not, but that his grandfather had planted it for him.[7][8]In Christian tradition, there is a similar story of "the Seven Sleepers of Ephesus", which recounts a group of early Christians who hid in a cave circa 250 AD, to escape the persecution of Christians during the reign of the Roman emperor Decius. They fell into a sleep and woke some 200 years later during the reign of Theodosius II, to discover that the Empire had become Christian.[9][10] This Christian story is recounted by Islam and appears in a Sura of the Quran, Sura Al-Kahf.[11] The version recalls a group of young monotheists escaping from persecution within a cave and emerging hundreds of years later. This narrative describes divine protection and time suspension.[12][13][14] Another similar story in the Islamic tradition is of Uzair (usually identified with the Biblical Ezra) whose grief at the Destruction of Jerusalem by the Babylonians was so great that God took his soul and brought him back to life after Jerusalem was reconstructed. He rode on his revived donkey and entered his native place. But the people did not recognize him, nor did his household, except the maid, who was now an old blind woman. He prayed to God to cure her blindness and she could see again. He meets his son who recognized him by a mole between his shoulders and was older than he was.[15][16]Further information: Time travel in fictionTime travel themes in science fiction and the media can be grouped into three categories: immutable timeline; mutable timeline; and alternate histories, as in the interacting-many-worlds interpretation.[17][18][19] The non-scientific term 'timeline' is often used to refer to all physical events in history, so that where events are changed, the time traveler is described as creating a new timeline.[20]Early science fiction stories feature characters who sleep for years and awaken in a changed society, or are transported to the past through supernatural means. Among them L'An 2440, rve s'il en ft jamais (The Year 2440: A Dream If Ever There Was One, 1770) by Louis-Sbastien Mercier, Rip Van Winkle (1819) by Washington Irving, Looking Backward (1888) by Edward Bellamy, and When the Sleeper Awakes (1899) by H. G. Wells. Prolonged sleep is used as a means of time travel in these stories.[21] The date of the earliest work about backwards time travel is uncertain. The Chinese novel A Supplement to the Journey to the West (c.1640) by Dong Yue features magical mirrors and jade gateways that connect various points in time. The protagonist Sun Wukong travels back in time to the "World of the Ancients" (Qin dynasty) to retrieve a magical bell and then travels forward to the "World of the Future" (Song dynasty) to find an emperor who has been exiled in time. However, the time travel is taking place inside an illusory dream world created by the villain to distract and entrap him.[22] Samuel Madden's Memoirs of the Twentieth Century (1733) is a series of letters from British ambassadors in 1997 and 1998 to diplomats in the past, conveying the political and religious conditions of the future.[23]:9596 Because the narrator receives these letters from his guardian angel, Paul Alkon suggests in his book Origins of Futuristic Fiction that "the first time-traveler in English literature is a guardian angel".[23]:85 Madden does not explain how the angel obtains these documents, but Alkon asserts that Madden "deserves recognition as the first to toy with the rich idea of time-travel in the form of an artifact sent backward from the future to be discovered in the present".[23]:9596 In the science fiction anthology Far Boundaries (1951), editor August Derleth claims that an early short story about time travel is An Anachronism; or, Missing One's Coach, written for the Dublin Literary Magazine[24] by an anonymous author in the June 1838 issue.[25]:3 While the narrator waits under a tree for a coach to take him out of Newcastle upon Tyne, he is transported back in time over a thousand years. He encounters the Venerable Bede in a monastery and explains to him the developments of the coming centuries. However, the story never makes it clear whether these events are real or a dream.[25]:1138 Another early work about time travel is The Forebears of Kalimeros: Alexander, son of Philip of Macedon by Alexander Veltman published in 1836.[26]Mr. and Mrs. Fezziwig dance in a vision shown to Scrooge by the Ghost of Christmas Past. Charles Dickens's A Christmas Carol (1843) has early depictions of mystical time travel in both directions, as the protagonist, Ebenezer Scrooge, is transported to Christmases past and future. Other stories employ the same template, where a character naturally goes to sleep, and upon waking up finds themself in a different time.[27] A clearer example of backward time travel is found in the 1861 book Paris avant les hommes (Paris before Men) by the French botanist and geologist Pierre Boitard, published posthumously. In this story, the protagonist is transported to the prehistoric past by the magic of a "lame demon" (a French pun on Boitard's name), where he encounters a Plesiosaur and an apelike ancestor and is able to interact with ancient creatures.[28] Edward Everett Hale's "Hands Off" (1881)[29] tells the story of an unnamed being, possibly the soul of a person who has recently died, who interferes with ancient Egyptian history by preventing Joseph's enslavement. This may have been the first story to feature an alternate history created as a result of time travel.[30]:54Main article: Time machine (device)One of the first stories to feature time travel by means of a machine is "The Clock that Went Backward" by Edward Page Mitchell,[31] which appeared in the New York Sun in 1881. However, the mechanism borders on fantasy. An unusual clock, when wound, runs backwards and transports people nearby back in time. The author does not explain the origin or properties of the clock.[30]:55 Enrique Gaspar y Rimbau's El Anacronpete (1887) may have been the first story to feature a vessel engineered to travel through time.[32][33] Andrew Sawyer has commented that the story "does seem to be the first literary description of a time machine noted so far", adding that "Edward Page Mitchell's story The Clock That Went Backward (1881) is usually described as the first time-machine story, but I'm not sure that a clock quite counts".[34] H. G. Wells' The Time Machine (1895) popularized the concept of time travel by mechanical means.[35]Some solutions to Einstein's equations for general relativity suggest that suitable geometries of spacetime or specific types of motion in space might allow time travel into the past and future if these geometries or motions were possible.[36]:499 In technical papers, physicists discuss the possibility of closed timelike curves, which are world lines that form closed loops in spacetime, allowing objects to return to their own past. There are known to be solutions to the equations of general relativity that describe spacetimes which contain closed timelike curves, such as Gdel spacetime, but the physical plausibility of these solutions is uncertain.[37]Any theory that would allow backward time travel would introduce potential problems of causality.[38] The classic example of a problem involving causality is the "grandfather paradox," which postulates travelling to the past and intervening in the conception of one's ancestors (causing the death of an ancestor before conception being frequently cited). Some physicists, such as Novikov and Deutsch, suggested that these sorts of temporal paradoxes can be avoided through the Novikov self-consistency principle or a variation of the many-worlds interpretation with interacting worlds.[39]Time travel to the past is theoretically possible in certain general relativity spacetime geometries that permit traveling faster than the speed of light, such as cosmic strings, traversable wormholes, and Alcubierre drives.[40][41]:33130 The theory of general relativity does suggest a scientific basis for the possibility of backward time travel in certain unusual scenarios, although arguments from semiclassical gravity suggest that when quantum effects are incorporated into general relativity, these loopholes may be closed.[42] These semiclassical arguments led Stephen Hawking to formulate the chronology protection conjecture, suggesting that the fundamental laws of nature prevent time travel,[43] but physicists cannot come to a definitive judgment on the issue without a theory of quantum gravity to join quantum mechanics and general relativity into a completely unified theory.[44][45]:150The theory of general relativity describes the universe under a system of field equations that determine the metric, or distance function, of spacetime. There exist exact solutions to these equations that include closed time-like curves, which are world lines that intersect themselves; some point in the causal future of the world line is also in its causal past, a situation that can be described as time travel. Such a solution was first proposed by Kurt Gdel, a solution known as the Gdel metric, but his (and others') solution requires the universe to have physical characteristics that it does not appear to have,[36]:499 such as rotation and lack of Hubble expansion. Whether general relativity forbids closed time-like curves for all realistic conditions is still being researched.[46]Main article: WormholeWormholes are a hypothetical warped spacetime permitted by the Einstein field equations of general relativity.[47]:100 A proposed time-travel machine using a traversable wormhole would hypothetically work in the following way: One end of the wormhole is accelerated to some significant fraction of the speed of light, perhaps with some advanced propulsion system, and then brought back to the point of origin. Alternatively, another way is to take one entrance of the wormhole and move it to within the gravitational field of an object that has higher gravity than the other entrance, and then return it to a position near the other entrance. For both these methods, time dilation causes the end of the wormhole that has been moved to have aged less, or become "younger", than the stationary end as seen by an external observer; however, time connects differently through the wormhole than outside it, so that synchronized clocks at either end of the wormhole will always remain synchronized as seen by an observer passing through the wormhole, no matter how the two ends move around.[36]:502 This means that an observer entering the "younger" end would exit the "older" end at a time when it was the same age as the "younger" end, effectively going back in time as seen by an observer from the outside. One significant limitation of such a time machine is that it is only possible to go as far back in time as the initial creation of the machine;[36]:503 in essence, it is more of a path through time than it is a device that itself moves through time, and it would not allow the technology itself to be moved backward in time.According to current theories on the nature of wormholes, construction of a traversable wormhole would require the existence of a substance with negative energy, often referred to as "exotic matter". More technically, the wormhole spacetime requires a distribution of energy that violates various energy conditions, such as the null energy condition along with the weak, strong, and dominant energy conditions. However, it is known that quantum effects can lead to small measurable violations of the null energy condition,[47]:101 and many physicists believe that the required negative energy may actually be possible due to the Casimir effect in quantum physics.[48] Although early calculations suggested that a very large amount of negative energy would be required, later calculations showed that the amount of negative energy can be made arbitrarily small.[49]In 1993, Matt Visser argued that the two mouths of a wormhole with such an induced clock difference could not be brought together without inducing quantum field and gravitational effects that would either make the wormhole collapse or the two mouths repel each other.[50] Because of this, the two mouths could not be brought close enough for causality violation to take place. However, in a 1997 paper, Visser hypothesized that a complex "Roman ring" (named after Tom Roman) configuration of an N number of wormholes arranged in a symmetric polygon could still act as a time machine, although he concludes that this is more likely a flaw in classical quantum gravity theory rather than proof that causality violation is possible.[51]Another approach involves a dense spinning cylinder usually referred to as a Tipler cylinder, a GR solution discovered by Willem Jacob van Stockum[52] in 1936 and Kornel Lanczos[53] in 1924, but not recognized as allowing closed timelike curves[54]:21 until an analysis by Frank Tipler in 1974.[55] If a cylinder is infinitely long and spins fast enough about its long axis, then a spaceship flying around the cylinder on a spiral path could travel back in time (or forward, depending on the direction of its spiral). However, the density and speed required is so great that ordinary matter is not strong enough to construct it. A more fundamental objection to time travel schemes based on rotating cylinders or cosmic strings has been put forward by Stephen Hawking, who proved a theorem showing that according to general relativity it is impossible to build a time machine of a special type (a "time machine with the compactly generated Cauchy horizon") in a region where the weak energy condition is satisfied, meaning that the region contains no matter with negative energy density (exotic matter). Solutions such as Tipler's assume cylinders of infinite length, which are easier to analyze mathematically, and although Tipler suggested that a finite cylinder might produce closed timelike curves if the rotation rate were fast enough,[54]:169 he did not prove this. But Hawking points out that because of his theorem, "it can't be done with positive energy density everywhere! I can prove that to build a finite time machine, you need negative energy."[45]:96 This result comes from Hawking's 1992 paper on the chronology protection conjecture, which Hawking states as "The laws of physics do not allow the appearance of closed timelike curves."[43]Main article: Quantum mechanics of time travelWhen a signal is sent from one location and received at another location, then as long as the signal is moving at the speed of light or slower, the mathematics of simultaneity in the theory of relativity show that all reference frames agree that the transmission-event happened before the reception-event. When the signal travels faster than light, it is received before it is sent, in all reference frames.[56] The signal could be said to have moved backward in time. This hypothetical scenario is sometimes referred to as a tachyonic antitelephone.[57]Quantum-mechanical phenomena such as quantum teleportation, the EPR paradox, or quantum entanglement might appear to create a mechanism that allows for faster-than-light (FTL) communication or time travel, and in fact some interpretations of quantum mechanics such as the Bohm interpretation presume that some information is being exchanged between particles instantaneously in order to maintain correlations between particles.[58] This effect was referred to as "spooky action at a distance" by Einstein.Nevertheless, the fact that causality is preserved in quantum mechanics is a rigorous result in modern quantum field theories, and therefore modern theories do not allow for time travel or FTL communication. In any specific instance where FTL has been claimed, more detailed analysis has proven that to get a signal, some form of classical communication must also be used.[59] The no-communication theorem also gives a general proof that quantum entanglement cannot be used to transmit information faster than classical signals.A variation of Hugh Everett's many-worlds interpretation (MWI) of quantum mechanics provides a resolution to the grandfather paradox that involves the time traveler arriving in a different universe than the one they came from; it's been argued that since the traveler arrives in a different universe's history and not their own history, this is not "genuine" time travel.[60] The accepted many-worlds interpretation suggests that all possible quantum events can occur in mutually exclusive histories.[61] However, some variations allow different universes to interact. This concept is most often used in science-fiction, but some physicists such as David Deutsch have suggested that a time traveler should end up in a different history than the one he started from.[62][63] On the other hand, Stephen Hawking has argued that even if the MWI is correct, we should expect each time traveler to experience a single self-consistent history, so that time travelers remain within their own world rather than traveling to a different one.[64] The physicist Allen Everett argued that Deutsch's approach "involves modifying fundamental principles of quantum mechanics; it certainly goes beyond simply adopting the MWI". Everett also argues that even if Deutsch's approach is correct, it would imply that any macroscopic object composed of multiple particles would be split apart when traveling back in time through a wormhole, with different particles emerging in different worlds.[39]Certain experiments carried out give the impression of reversed causality, but fail to show it under closer examination.The delayed-choice quantum eraser experiment performed by Marlan Scully involves pairs of entangled photons that are divided into "signal photons" and "idler photons", with the signal photons emerging from one of two locations and their position later measured as in the double-slit experiment. Depending on how the idler photon is measured, the experimenter can either learn which of the two locations the signal photon emerged from or "erase" that information. Even though the signal photons can be measured before the choice has been made about the idler photons, the choice seems to retroactively determine whether or not an interference pattern is observed when one correlates measurements of idler photons to the corresponding signal photons. However, since interference can be observed only after the idler photons are measured and they are correlated with the signal photons, there is no way for experimenters to tell what choice will be made in advance just by looking at the signal photons, only by gathering classical information from the entire system; thus causality is preserved.[65]The experiment of Lijun Wang might also show causality violation since it made it possible to send packages of waves through a bulb of caesium gas in such a way that the package appeared to exit the bulb 62 nanoseconds before its entry, but a wave package is not a single well-defined object but rather a sum of multiple waves of different frequencies (see Fourier analysis), and the package can appear to move faster than light or even backward in time even if none of the pure waves in the sum do so. This effect cannot be used to send any matter, energy, or information faster than light,[66] so this experiment is understood not to violate causality either.The physicists Gnter Nimtz and Alfons Stahlhofen, of the University of Koblenz, claim to have violated Einstein's theory of relativity by transmitting photons faster than the speed of light. They say they have conducted an experiment in which microwave photons traveled "instantaneously" between a pair of prisms that had been moved up to 3ft (0.91m) apart, using a phenomenon known as quantum tunneling. Nimtz told New Scientist magazine: "For the time being, this is the only violation of special relativity that I know of." However, other physicists say that this phenomenon does not allow information to be transmitted faster than light. Aephraim M. Steinberg, a quantum optics expert at the University of Toronto, Canada, uses the analogy of a train traveling from Chicago to New York, but dropping off train cars at each station along the way, so that the center of the train moves forward at each stop; in this way, the speed of the center of the train exceeds the speed of any of the individual cars.[67]Shengwang Du claims in a peer-reviewed journal to have observed single photons' precursors, saying that they travel no faster than c in a vacuum. His experiment involved slow light as well as passing light through a vacuum. He generated two single photons, passing one through rubidium atoms that had been cooled with a laser (thus slowing the light) and passing one through a vacuum. Both times, apparently, the precursors preceded the photons' main bodies, and the precursor traveled at c in a vacuum. According to Du, this implies that there is no possibility of light traveling faster than c and, thus, no possibility of violating causality.[68]Many have argued that the absence of time travelers from the future demonstrates that such technology will never be developed, suggesting that it is impossible. This is analogous to the Fermi paradox related to the absence of evidence of extraterrestrial life. As the absence of extraterrestrial visitors does not categorically prove they do not exist, so the absence of time travelers fails to prove time travel is physically impossible; it might be that time travel is physically possible but is never developed or is cautiously used. Carl Sagan once suggested the possibility that time travelers could be here but are disguising their existence or are not recognized as time travelers.[44] Some versions of general relativity suggest that time travel might only be possible in a region of spacetime that is warped a certain way,[clarification needed] and hence time travelers would not be able to travel back to earlier regions in spacetime, before this region existed. Stephen Hawking stated that this would explain why the world has not already been overrun by "tourists from the future".[64]Advertisement placed in a 1980 edition of Artforum, advertising the KronONauts eventSeveral experiments have been carried out to try to entice future humans, who might invent time travel technology, to come back and demonstrate it to people of the present time. Events such as Perth's Destination Day, MIT's Time Traveler Convention and Stephen Hawking's Reception For Time Travellers heavily publicized permanent "advertisements" of a meeting time and place for future time travelers to meet.[69][70] In 1982, a group in Baltimore, Maryland, identifying itself as the Krononauts, hosted an event of this type welcoming visitors from the future.[71][72]These experiments only stood the possibility of generating a positive result demonstrating the existence of time travel, but have failed so farno time travelers are known to have attended either event. Some versions of the many-worlds interpretation can be used to suggest that future humans have traveled back in time, but have traveled back to the meeting time and place in a parallel universe.[73]Main article: Time dilationTransversal time dilation. The blue dots represent a pulse of light. Each pair of dots with light "bouncing" between them is a clock. For each group of clocks, the other group appears to be ticking more slowly, because the moving clock's light pulse has to travel a larger distance than the stationary clock's light pulse. That is so, even though the clocks are identical and their relative motion is perfectly reciprocal.There is a great deal of observable evidence for time dilation in special relativity[74] and gravitational time dilation in general relativity,[75][76][77] for example in the famous and easy-to-replicate observation of atmospheric muon decay.[78][79][80] The theory of relativity states that the speed of light is invariant for all observers in any frame of reference; that is, it is always the same. Time dilation is a direct consequence of the invariance of the speed of light.[80] Time dilation may be regarded in a limited sense as "time travel into the future": a person may use time dilation so that a small amount of proper time passes for them, while a large amount of proper time passes elsewhere. This can be achieved by traveling at relativistic speeds or through the effects of gravity.[81]For two identical clocks moving relative to each other without accelerating, each clock measures the other to be ticking slower. This is possible due to the relativity of simultaneity. However, the symmetry is broken if one clock accelerates, allowing for less proper time to pass for one clock than the other. The twin paradox describes this: one twin remains on Earth, while the other undergoes acceleration to relativistic speed as they travel into space, turn around, and travel back to Earth; the traveling twin ages less than the twin who stayed on Earth, because of the time dilation experienced during their acceleration. General relativity treats the effects of acceleration and the effects of gravity as equivalent, and shows that time dilation also occurs in gravity wells, with a clock deeper in the well ticking more slowly; this effect is taken into account when calibrating the clocks on the satellites of the Global Positioning System, and it could lead to significant differences in rates of aging for observers at different distances from a large gravity well such as a black hole.[41]:33130A time machine that utilizes this principle might be, for instance, a spherical shell with a diameter of five meters and the mass of Jupiter. A person at its center will travel forward in time at a rate four times slower than that of distant observers. Squeezing the mass of a large planet into such a small structure is not expected to be within humanity's technological capabilities in the near future.[41]:76140 With current technologies, it is only possible to cause a human traveler to age less than companions on Earth by a few milliseconds after a few hundred days of space travel.[82]Main article: Philosophy of space and timePhilosophers have discussed the philosophy of space and time since at least the time of ancient Greece; for example, Parmenides presented the view that time is an illusion. Centuries later, Isaac Newton supported the idea of absolute time, while his contemporary Gottfried Wilhelm Leibniz maintained that time is only a relation between events and it cannot be expressed independently. The latter approach eventually gave rise to the spacetime of relativity.[83]Many philosophers have argued that relativity implies eternalism, the idea that the past and future exist in a real sense, not only as changes that occurred or will occur to the present.[84] Philosopher of science Dean Rickles disagrees with some qualifications, but notes that "the consensus among philosophers seems to be that special and general relativity are incompatible with presentism".[85] Some philosophers view time as a dimension equal to spatial dimensions, that future events are "already there" in the same sense different places exist, and that there is no objective flow of time; however, this view is disputed.[86]Presentism is a school of philosophy that holds that the future and the past exist only as changes that occurred or will occur to the present, and they have no real existence of their own. In this view, time travel is impossible because there is no future or past to travel to.[84] Keller and Nelson have argued that even if past and future objects do not exist, there can still be definite truths about past and future events, and thus it is possible that a future truth about a time traveler deciding to travel back to the present date could explain the time traveler's actual appearance in the present;[87] these views are contested by some authors.[88]Main article: Grandfather paradoxA common objection to the idea of traveling back in time is put forth in the grandfather paradox or the argument of auto-infanticide.[89] If one were able to go back in time, inconsistencies and contradictions would ensue if the time traveler were to change anything; there is a contradiction if the past becomes different from the way it is.[90][91] The paradox is commonly described with a person who travels to the past and kills their own grandfather, prevents the existence of their father or mother, and therefore their own existence.[44] Philosophers question whether these paradoxes prove time travel impossible. Some philosophers answer these paradoxes by arguing that it might be the case that backward time travel could be possible but that it would be impossible to actually change the past in any way,[92] an idea similar to the proposed Novikov self-consistency principle in physics.According to the philosophical theory of compossibility, what can happen, for example in the context of time travel, must be weighed against the context of everything relating to the situation. If the past is a certain way, it's not possible for it to be any other way. What can happen when a time traveler visits the past is limited to what did happen, in order to prevent logical contradictions.[93]The Novikov self-consistency principle, named after Igor Dmitrievich Novikov, states that any actions taken by a time traveler or by an object that travels back in time were part of history all along, and therefore it is impossible for the time traveler to "change" history in any way. The time traveler's actions may be the cause of events in their own past though, which leads to the potential for circular causation, sometimes called a predestination paradox,[94] ontological paradox,[95] or bootstrap paradox.[95][96] The term bootstrap paradox was popularized by Robert A. Heinlein's story "By His Bootstraps".[97] The Novikov self-consistency principle proposes that the local laws of physics in a region of spacetime containing time travelers cannot be any different from the local laws of physics in any other region of spacetime.[98]The philosopher Kelley L. Ross argues in "Time Travel Paradoxes"[99] that in a scenario involving a physical object whose world-line or history forms a closed loop in time there can be a violation of the second law of thermodynamics. Ross uses the film Somewhere in Time as an example of such an ontological paradox, where a watch is given to a person, and 60 years later the same watch is brought back in time and given to the same character. Ross states that entropy of the watch will increase, and the watch carried back in time will be more worn with each repetition of its history. The second law of thermodynamics is understood by modern physicists to be a statistical law, so decreasing entropy and non-increasing entropy are not impossible, just improbable. Additionally, entropy statistically increases in systems which are isolated, so non-isolated systems, such as an object, that interact with the outside world, can become less worn and decrease in entropy, and it's possible for an object whose world-line forms a closed loop to be always in the same condition in the same point of its history.[41]:23In 2005, Daniel Greenberger and Karl Svozil proposed that quantum theory gives a model for time travel where the past must be self-consistent.[100][101]Claims of time travelTime travel claims and urban legendsParapsychologyCultureTime capsuleFictionTime travel in fictionList of time travel works of fictionTime viewerMeetingsTime Traveler ConventionHawking's time traveller partyScienceKrasnikov tubeRetrocausalityRing singularityTemporal paradoxWheelerFeynman absorber theoryTime perceptionCryonicsSuspended animationTime perceptionTime Travel: A History book by James Gleick^ Cheng, John (2012). 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When was time travel first thought of. Who was the first to time travel. First mention of time travel in history. Has time travel been invented.