



INTRODUCTION

THE ONLY REASON  
FOR TIME IS SO  
EVERYTHING  
DOESN'T HAPPEN  
AT ONCE.

Albert Einstein

WHAT IS TIME?

For the dictionary, time is «*the system of those sequential relations that any event has to any other, as past, present, or future; indefinite and continuous duration regarded as that in which events succeed one another.*» For most of us, time is the duration between events; something we cannot see, yet live through on an everyday experience. Time is a constant. One second here is one second there, and although we perceive time at different rates depending on our mood and situation, the underlying framework says time does not bend or break.


However, the science of time does not fully obey that notion.

The following map can be interpreted and overlapped with the various following theories and experiments. Are the nodes events in time? Are they parallel universes? Are they particles or strings, contained within every single atom within the universe? Or, are they just dots?



ABSOLUTE TIME

TIME MOVES  
AT THE RATE  
OF ONE SECOND  
PER SECOND.



Some of the earliest philosophers queried what time was. Was it real? Did it exist? What happens before and after the present moment? Plato and Plotinus related time to motion: that time is the means we use to measure motion, and motion or change is the measure of time (respectively). Saint Augustine asked «*What then is time? If no one asks me, I know what it is. If I wish to explain it to him who asks, I do not know.*» For all the questions, there were very few answers, and for the answers, they were contradictory.

THE FIRST SOLID SCIENTIFIC THEORY OF TIME came from Isaac Newton's law of universal gravitation, first published in 1687. It stated that **time is a constant for all observers** in the universe – no matter where you are, what you're in, or how fast you're traveling – and is the backdrop for which all physical phenomena occur. Again, one second is equal to one second and events happen sequentially.

Absolute, true and mathematical time, of itself, and from its own nature flows equably without regard to anything external, and by another name is called duration: relative, apparent and common time, is some sensible and external (whether accurate or unequal) measure of duration by the means of motion, which is commonly used instead of true time ...

Newton, *In Philosophiae Naturalis Principia Mathematica*.

The theory also states that light and gravity are instantaneous; that is, that light and gravity from the sun and distant stars reach us immediately. It also postulates that the force of gravity is the pull of one object on another. While for the most part Newton's mathematical equations of gravity were very accurate (and blasphemous at the time, as they did not corroborate with the church's views), there were problems with Newton's theory that would soon be found and solved.



GENERAL RELATIVITY

PUT YOUR HAND  
ON A HOT STOVE  
FOR A MINUTE,  
AND IT SEEMS LIKE  
AN HOUR. SIT WITH  
A PRETTY GIRL  
FOR AN HOUR,  
AND IT SEEMS  
LIKE A MINUTE.  
THAT'S RELATIVITY.

Albert Einstein

IN 1915, ALBERT EINSTEIN published his work on general relativity, which combined the work of his previous special relativity and Newton's law of universal gravitation. The largest impact of the work stated that time is not a constant: that it is malleable, bendable, and not separable from space. That the fourth dimension of time is inextricably woven into the three dimensions of space. Therefore it is not *space* and *time*, but *spacetime*: they are interpenetrating!

In contrast to Newton's law on gravitational pull, Einstein proposed that gravity was the effect of mass warping spacetime. It was not the effect of one object dominating another, but one object bending and distorting the fabric of spacetime so much that the other object was essentially caught in the distortion. Einstein also stated that since mass bends the fabric of spacetime, mass and therefore gravity bend time itself. The higher a gravitational force – or subsequently faster an acceleration of a particle or object – the more bent and slower time moves. This is called time dilation.

For a quick visual example of bending spacetime, imagine a trampoline. The surface of the trampoline is spacetime. As children stand on the trampoline, their mass warps the fabric thus creating the bend we experience as gravity and time dilation. The heavier the children, the more they bend spacetime.

Einstein's special relativity is founded upon ***the speed of light – 299 792 458 meters a second – being absolute***, and that nothing is faster. That means it doesn't matter if you're standing still or running at 99 percent the speed of light, light will always travel at the same speed. This has several different effects on time.

First, it defies the Newtonian idea that everything happens instantaneously. ***Since everything is limited to a top speed, there is a delay between every cause and effect.*** It takes eight minutes for light from the sun to reach us on Earth, and it takes light from the nearest star we can see – Proxima Centauri – four lightyears to reach us. (A lightyear is the distance light travels in one year. Proxima Centauri is 37 trillion kilometers away.) The speed of light limits our knowledge in relation to time, both on cosmic (solar systems, planets, galaxies) and personal scales (the delay between specific causes and effects.) Since light has a defined speed, one event can only effect other events within a certain range.

Second, ***if one was able to travel at the speed of light itself, time would stand still.*** However, it would take an infinite amount of energy to propel someone that fast, so it's impossible. On the other hand, time dilation increases the more an observer accelerates toward the speed of light. This is observable in what is called the Twins Paradox:

Twins, Adam and Braden, are born. Adam is put immediately on a space ship and sent traveling constantly at 90 percent the speed of light to a nearby star. For Adam, time moves at a relative rate to his frame of reference, as does Braden's. After Adam has traveled for what to him is 5 years, he lands back on Earth. To their surprise, Braden has aged more and faster than Adam. Over 40 years have passed on Earth, compared to Adam's 5 years! This happens because, as stated in general relativity, time moves slower around larger masses and with accelerated objects. Adam's acceleration was greater than Earth's gravitational pull exerted on Braden, and therefore time moved slower for him.

# THOUGHT EXPERIMENT 1

IMAGINE A ROCKET SHIP OUT IN SPACE. For convenience, imagine that the rocket ship is so long that light takes one second to traverse it from top to bottom. Finally, suppose there is an observer at the ceiling of the rocket ship and another at the floor, each with identical clocks that tick once each second.

Suppose the ceiling observer waits for the clock to tick, and then immediately sends a light signal down to the floor observer. The ceiling observer does this once more the next time the clock ticks. According to this setup, each signal travels for one second and then is received by the floor observer. So just as the ceiling observer sends two light signals a second apart, the floor observer receives two, one second apart.

How would this situation differ if the rocket ship were resting on earth, under the influence of gravity, instead of floating freely out in space? According to Newton's theory, gravity has no effect on this situation. If the observer on the ceiling sends signals one second apart, the observer will receive them one second apart. But the principle of equivalence does not make the same prediction. We can see what happens, that principle tells us, by considering the effect of uniform acceleration instead of the effect of gravity. This is an example of the way Einstein used the principle of equivalence to create his new theory of gravity.

So let's now suppose the rocket ship is accelerating. (We will imagine that it is accelerating slowly, so we don't approach the speed of light!) Since the rocket ship is moving upward, the first signal will have less distance to travel than before, and so will arrive sooner than one second later. If the rocket ship

were moving at a constant speed, the second signal would arrive exactly the same amount of time sooner, so the time between the two signals would remain one second. But due to the acceleration, the rocket ship will be moving even faster when the second signal is sent than it was when the first signal was sent, so the second signal will have even less distance to traverse than the first and will arrive in even less time. The observer on the floor will therefore measure less than one second between the signals, disagreeing with the ceiling observer, who claims to have sent them exactly one second apart.

This is probably not startling in the case of the accelerating rocket ship – after all, we just explained it! But remember, the principle of equivalence says that it also applies to a rocket ship at rest in a gravitational field. That means that even if the rocket ship is not accelerating but, say, is sitting on a launching pad on earth's surface, if the ceiling observer sends signals toward the floor at intervals of one each second (according to his clock), the floor observer will receive the signals at shorter intervals (according to his clock). That is startling!

Stephen Hawking, *A Briefer History of Time*



QUANTUM MECHANICS •

IN INFINITE SPACE,  
EVEN THE MOST  
UNLIKELY EVENTS  
MUST TAKE PLACE  
SOMEWHERE.

Max Tegmark

WHILE EINSTEIN'S THEORY of general relativity works on macro scales, quantum mechanics explains what happens on microscopic scales: protons, electrons, neutrons, quarks, photons and the likes. (However accurate general relativity and quantum mechanics are, they are completely incompatible when mixed!) Although quantum mechanics is able to predict events accurately to a degree better than one part in ten billion, all the math is based on probabilities. That is, ***the probability that a particular particle will be in that state at that exact location at that time.*** That means that even though there is a near 100 percent likelihood that an outcome will occur, there is also a chance that it will be different. The result is only known when an observation of the particle is made.

When measuring and pinpointing specific particles with quantum mechanics, it is impossible to determine both the location and velocity of the particle. The more you know of one, the less you know of the other. Therefore, that is why quantum mechanics is based on the probability the particle will be here going there. The results look much like a bell curve: the highest and most likely probability in the center and everything else petering out from there. It is said if you could know the exact location and velocity of every particle in a controlled environment, you would know and could predict the future of all the particles involved. However, not even the fastest computers in the world can begin to crack such a complex system as this, even in a small system.

#### ***How does quantum mechanics infer with time? Interestingly.***

Since quantum mechanics deals with probabilities, and the outcome of that probability is realized only when observed, then it is said that all probabilities are true until an observa-

tion is made. This has been verified in experiments where one particle (a neutron or a photon) can be made to follow two completely different paths at the same time, as long as no attempt is made to observe the particle. ***The one particle is in two different places until it is observed,*** and then the observation causes the probabilities to collapse, and for only one path to become 'real'. This has a weird side note that is also true for you and your body. There is a probability that a piece of you (an atom or particle) could not be in your body at any one time. That is, a piece of you could be in Tahiti right now.

There are also events in space and time that are so small they aren't specifically measurable, where new matter is created and destroyed in *Planck* time. These quantum fluctuations are made when two particles – a particle and an anti-particle – are created out of nothing and then seemingly annihilate one another in a flash of energy. These are called ***virtual particles,*** and come into existence for  $10^{-21}$  seconds. They are constantly being created and destroyed everywhere: from the depths of outer space to inside your brain. They even momentarily exist inside pure vacuums, which means there is no such thing as absolutely nothing.

Another – perhaps more interesting – aspect of quantum mechanics is within the mathematical calculations, there is no inherent direction of time: the equations are equally valid both forwards and backwards. That means that at the quantum level, if an event happened backwards in time it would not break any rules of quantum mechanics. And since everything is based on probabilities, there is a beyond miniscule chance that a broken glass on the floor could repair itself, if all probabilities were realized at the same moment. ***Quantum mechanics is time symmetric.***



STRING THEORY

STRING THEORY  
IS 21<sup>ST</sup> CENTURY  
PHYSICS THAT FELL  
ACCIDENTALLY  
INTO THE 20<sup>TH</sup>  
CENTURY.

Edward Whitten

WHILE STRING THEORY may not be viewed as a solid scientific explanation of the universe – as it does not provide any verifiable experiments – it is one of the most interesting emerging theories in physics. It tries to unite the theories of general relativity and quantum mechanics – the universes of the macro and micro – by explaining that everything is made from tiny one-dimensional strings. Smaller than atoms, smaller than protons and electrons, smaller than quarks, there are ***tiny vibrating strings of energy that form every aspect of everything***. The strings are so small, that if an atom (normally around  $10^{-8}$  centimeters) were the size of our solar system, a single string would be the size of a tree on our planet. This is one of the reasons string theory is not universally accepted: strings are too small to begin to measure. Each string is made up of pure energy, and only differentiates itself by the frequency of its vibration, much like playing a cello.

While string theory does not provide any new insights into how time works or what time is, it has some different consequences of how our world – and time – interact.

String theory – and all subsidiary theories – hypothesize that ***we live in a world with not four dimensions, but eleven*** (perhaps even more). The extra seven dimensions, which are all thought to be space dimensions (but no one is exactly sure) are sustained at a subatomic *Planck* scale of around  $10^{-33}$  centimeters. Some postulate that there could be another time dimension wrapped up in the strings, but this is considered highly unlikely.

String theory suggests that our universe, as well as all other universes, are on thin planes called membranes. Basically, each membrane is stacked side by side, like a loaf of bread. The membrane keeps all the universes separate, but pose interesting hypothetical situations that will be talked about later, especially when they touch and overlap.



**BEGINNING OF TIME**

IS THERE TIME,  
IF THERE IS NO  
ONE TO OBSERVE  
OR MEASURE IT?

Aristotle

## Was there time before there was consciousness? Was there time before any matter? Was there time before the Big Bang?

NO ONE KNOWS FOR SURE WHEN TIME STARTED. Consciousness has a unique way of tracking time: even bacteria have internal clocks. Human consciousness has its own set of time: divided, broken apart, fractured, and quantified into equal parts for us to judge and measure. The universe has its own time – or non-time – in the present moment. So, when did time start?

Most physicists agree that ***time started with the Big Bang***. If there was some time – any time – before the Big Bang, it would not be measurable. The time frame before ours could be infinite. It would have no effect on our current time, and would therefore be meaningless. So we start with the Big Bang.

***The Big Bang was something out of nothing***. Arguably, a stream of quantum fluctuations that exploded and expanded into what we know as the universe today. Yet, even with all the evidence that shows the Big Bang started the universe, physicists do not know exactly how it started, what it looked like, or what its properties were at the very beginning. Relativity and quantum mechanics can explain what happened in the Big Bang down to  $10^{-37}$  seconds, but beyond that both theories break down and cannot explain any further. The

equations get wonky and temperature and energy reach infinite, which doesn't work so well in math equations.

How the Big Bang came about is up for argument. A singularity, quantum fluctuation, colliding parallel membranes, black holes, a creator...

String theory hypothesizes that – if you remember the membrane bread loaf metaphor – the Big Bang started when our membrane collided with another membrane. This collision sparked the expansion and inflation and release of energy as is required for the Big Bang, and may have collided with this other membrane more than once – meaning more Big Bangs. Even more disturbing, if the theory is right, is that ***these collisions may happen again in the future***, or already have happened and we have not felt the effects yet as they have not reached us, as effects from events have a defined speed.

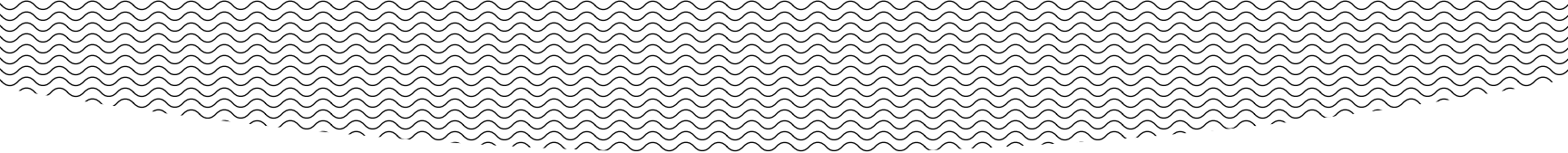
Some physicists have theorized that ***there is one universe, and multiple universes popping up in this one universal plane*** (however *universes* start.) Given enough time and expansion, these *universes* would eventually interact with one another, with galaxies potentially colliding. This might be even stranger if the theories of string theory are correct, and some *universes* have different dimensions than ours. I wonder how that would work.



COSMIC TIME

NO MATTER  
HOW FAST LIGHT  
TRAVELS IT FINDS  
THE DARKNESS  
HAS ALWAYS GOT  
THERE FIRST, AND  
IS WAITING FOR IT.

Terry Pratchett



MEASURING FROM THE BIG BANG, our universe is over 13.7 billion years old (in comparison, the Earth is 4.54 billion years old, and modern Homosapiens 200 000 years old.) The observable universe – that is, the size of the universe we can see, remembering light can only travel at a finite speed so there are parts of the universe so far away the light from them hasn't reached us yet – is around 93 billion light years in diameter, meaning ***we can only see things 46.5 billion light years away***, or  $4.4 \times 10^{23}$  kilometers away. No one is certain if the universe is finite in size, or infinitely big.

Since light can only travel at that finite speed, and hence limits the rate of our knowledge, we are effectively living in the cosmic past. ***Everything we see is the past***, and that expands more drastically as the distance between us and the observed increases. As stated earlier, what we see happening on the sun actually happened eight minutes ago, Proxima Centaura four years ago, and everything else in the night sky longer ago than that. Stars that we see as intact now may have already died out, and black spaces in the sky may have stars that have formed there that we cannot see yet. ***We are living outer space's history.***

This mode of thinking is true too of extra terrestrial life. We have been searching for life, sending out signals that travel at the speed of light, for the past 70 years or so. That gives us a 35 light year radius for outside life to contact us and immediately send back a signal. Not a very large distance in comparison to our 46.5 billion light year radial universe. And, if we were to observe other life in some far distant planet, it would effectively be their past and we would have no idea if they were now extinct, and vice versa.



END OF TIME

THE END  
HAS NO END.

The Strokes

TO CONTINUE DOWN THE PATH we have already established, **time will end when the universe ends**. But, the universe may not end, so time may not end. There are two possible established outcomes for our universe: an open and a closed model. **Either the universe will continue to expand forever, or it will reach a specific size and eventually collapse back in on itself.** They both depend on what is called critical density.

Critical density is the average density of matter in the universe so that gravitational pull would be able to stop the expansion of the universe. Critical density is measured to be around  $(1 \text{ to } 2) \times 10^{-26}$  kilograms per meter cubed – around 100 times greater than the average density we can calculate today. However, there is thought to be dark matter and dark energy that would put the density of the universe near the critical density required to stop the expansion.

If the density is what we can observe now, the universe will expand the way it has been expanding since its inception: continual exponential growth. Everything will continue moving away from one another, forever.

If the density is extremely near but not at the critical density – which is now believed to be most accurate – the universe will slow its expansion, but never come to a complete stop.

If the universe has critical density, it will slowly stop expanding, come to a halt, and then **start collapsing back in on itself.** This would hypothetically end with the universe collapsing back into a singularity, around  $10^{-33}$  centimeters across, and most likely would start a new Big Bang and a new frame of time. Therefore, time would never really end, just start a new reference point over and over again.

**How will time end if time ends at all? Does time end with the death of consciousness? Does time end with the end of the universe, if there is one?**

A diagram illustrating a black hole. It features a central white dot representing the singularity, surrounded by three concentric dashed white circles representing the event horizon and other gravitational boundaries. The text "BLACK HOLES" is centered within the innermost dashed circle.

BLACK HOLES

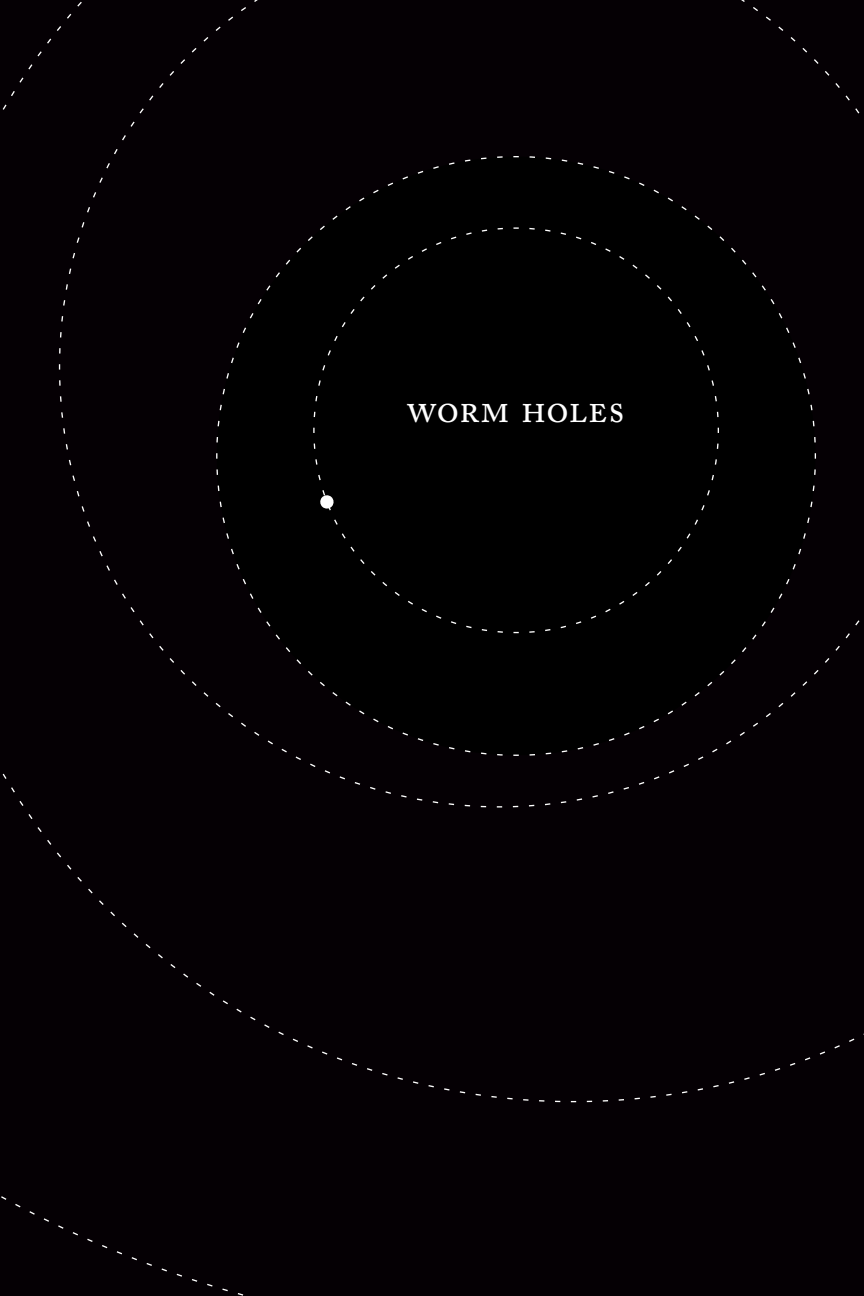
BLACK HOLES ARE  
EVENTS IN TIME,  
NOT SPACE.

A BLACK HOLE'S GRAVITATIONAL DENSITY IS SO STRONG, not only does light not escape the pull, but at the core of a black hole time stands still. *It warps time to infinity.*

A black hole is an infinitely small point with an infinite density called a singularity, but due to its gravitational pull it has massive effects to its surrounding area. Black holes are even thought to be at the center of some galaxies. The surrounding region of a black hole's gravitational pull – the edge of no return – is called an event horizon. Once an object or particle enters the event horizon of a black hole, it cannot escape – *the black hole's escape velocity is greater than the speed of light.* However, where an event horizon begins is undetectable, so the only way one would know they're in one is when they try to escape and see it's futile. Take the following example:

There are two observers standing in space outside of a black hole and outside of its event horizon. Observer *A* stands still, and observer *B* starts moving towards the black hole. They send signals (traveling at the speed of light) back and forth to each other one second apart. *A* sends to *B*, which is received in one second, and *B* sends one back to *A*, and is received in one second. As observer *B* starts to move towards the event horizon, the gravitational pull on him and his signals increases. Observer *A* sends a signal to *B*, which is received in one second, and *B* sends one back to *A*, which now takes two seconds to get to *A*. This continues as *B* moves closer to the event horizon: *B* receives *A*'s signals in one second, and *A* receives *B*'s signals in increasing time intervals. This continues until *B* hits the event horizon. Once *B* crosses the event horizon, *A* will not receive any more signals, no matter how many signals *B* sends. None of the signals will be able to escape the gravitational pull of the black hole, and neither will observer *B*. *B*, however, will continue to get *A*'s signals if he sends them.


Several interesting aspects of this example are that observer *B* will not feel any time dilation. To his frame of reference, the signals he is sending back to *A* only take one second. Although, once he crosses over the event horizon, *the force of the gravity will stretch and 'spaghettify' him* and he would be crushed to death. Also, observer *A* would see observer *B* slow down as he approaches the event horizon, but never actually cross over. This is because the reflected light it would take to see observer *B* would never be able to escape the event horizon.



WORM HOLES

WAIT A MINUTE,  
DOC. ARE YOU  
TELLING ME THAT  
YOU BUILT A TIME  
MACHINE... OUT OF  
A DELOREAN?

Marty McFly, *Back to the Future*




WORM HOLES ARE HIGHLY THEORETICAL, highly speculative, highly controversial aspects of time and space. They are founded in general relativity, where Einstein proposed that spacetime was not a flat surface, but was actually curvable and bendable: that its shape could change. Wormholes can exploit this as a way of time travel.

A wormhole is the bending over of spacetime with a tunnel or connection between two parts of space. It is essentially ***a tearing and a shortcut through space and time***. It does not propose that one travels faster than the speed of light – as that would defy the laws of general relativity – but that one can traverse a smaller amount of spacetime faster than it takes light to travel the non-worm holed distance of spacetime. It would ***allow for almost instantaneous travel*** between two points in space – and maybe in time.

Some physicists propose that, if they could create and control wormholes, they would be able to manipulate them in certain ways as to be able to ***travel into the past or the future***. The future is more theoretically applicable, because travel into the past would cause major problems with causality.

Causality is the relation of cause and effect: you turn the dial on the stove and the element gets hot. If you do not turn the dial, the element does not get hot. The cause precedes the effect. With the case of time travel and worm holes, some wrenches get thrown in when thinking about causality. The weirdest one comes from Robert Heinlein in his short story *All You Zombies*, which is explained on the next map.

Some physicists have proposed certain ways of avoiding paradoxes and causalities, such as the time traveller ending up in a parallel timeline, where they change the course of events in that universe, not their original universe. This view holds that history is an unchangeable constant.



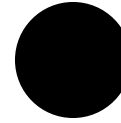
# THOUGHT EXPERIMENT 2

A BABY GIRL is mysteriously dropped off at an orphanage in Cleveland in 1945. 'Jane' grows up lonely and dejected, not knowing who her parents are, until one day in 1963 she is attracted to a drifter. She falls in love with him. But just when things are finally looking up for Jane, a series of disasters strike. First, she becomes pregnant by the drifter, who then disappears. Second, during the complicated delivery, doctors find that Jane has both sets of sex organs, and to save her life, they are forced to surgically convert 'her' to a 'him.' Finally, a mysterious stranger kidnaps her baby from the hospital.

Reeling from these disasters, rejected by society, scorned by fate, 'he' becomes a write, a drunkard and drifter. Now Jane has lost her parents, her lover, her child and she becomes a he.

Years later, in 1970, he stumbles into a lonely bar, called *Pop's Place*, and spills out his pathetic story to an elderly bartender. The sympathetic bartender offers the drifter the chance to avenge the stranger who left him (her) pregnant and abandoned, on the condition that he join the *Time Travelers Corps*. Both of them enter a time machine, and the bartender drops off the drifter in 1963.

The drifter is strangely attracted to a young orphan woman, who subsequently becomes pregnant.



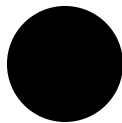
The bartender then goes forward 9 months, kidnaps the baby girl from the hospital, and drops off the baby in an orphanage back in 1945.

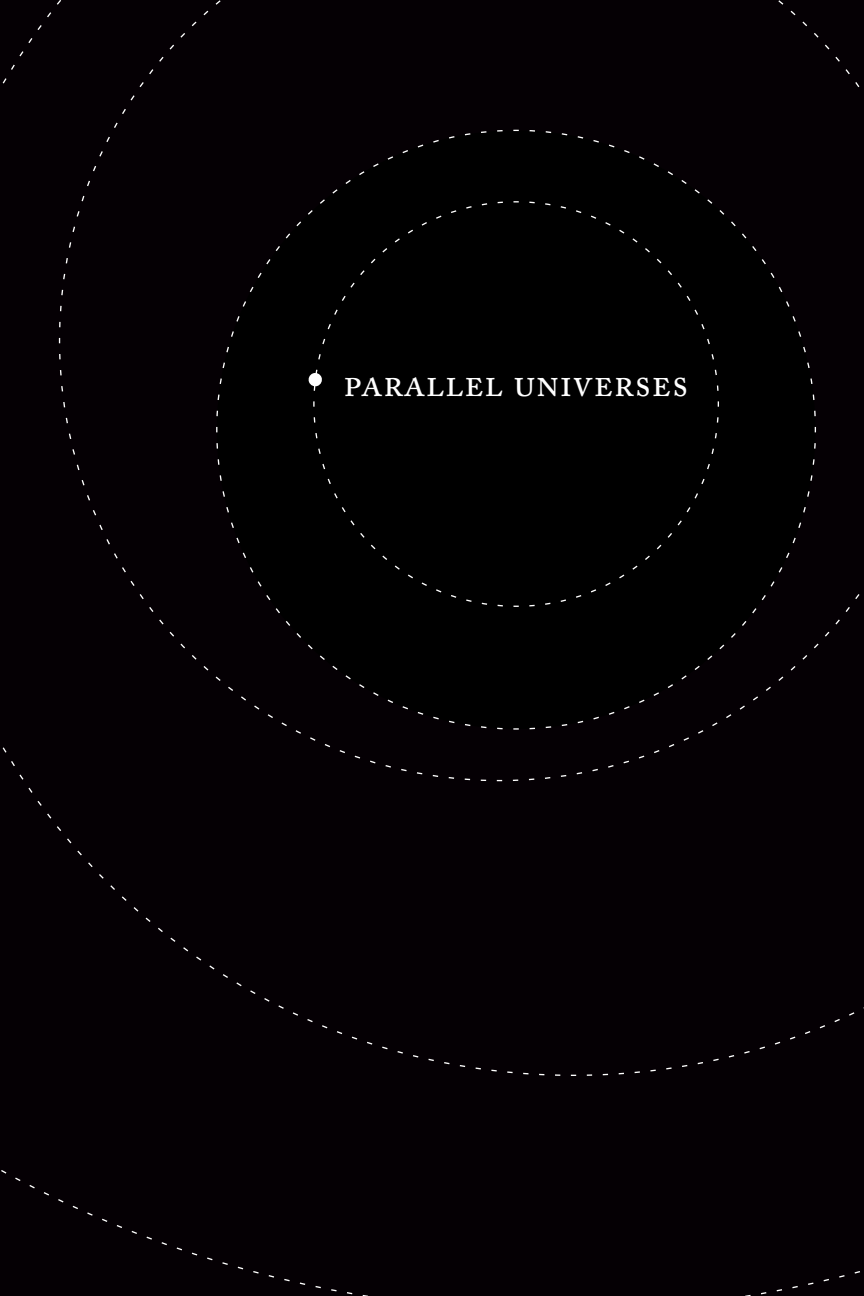
Then the bartender drops off the thoroughly confused drifter in 1985, to enlist in the *Time Travelers Corps*.

The drifter eventually gets his life together, becomes a respected and elderly member of the *Time Travelers Corps*, and then disguises himself as a bartender and has his most difficult mission: a date with destiny, meeting a certain drifter at *Pop's Place* in 1970.

The question is: Who is Jane's mother, father, grandfather, grand mother, son, daughter, granddaughter, and grandson? The girl, the drifter, and the bartender, of course, are all the same person. These paradoxes can made your head spin, especially if you try to untangle Jane's twisted parentage. If we draw Jane's family tree, we find that all the branches are curled inward back on themselves, as in a circle. We come to the astonishing conclusion that she is her own mother and father! She is an entire family tree unto herself.

Robert Heinlein, *All You Zombies*





PARALLEL UNIVERSES

THERE ARE  
PROBABLY  
OTHER PARALLEL  
UNIVERSES IN OUR  
LIVING ROOM.

Michio Kaku

OUR TIME MAY NOT BE THE ONLY TIME. Various theories have been raised and given rise to the idea of parallel universes, both linearly and all around us.

String theory has its membrane theory: that we are contained in thin layers called membranes that are stacked like slices in loaves of bread. They touch, correspond, interact, and even pass energy between them. It is also proposed that some universes may have started differently than ours, and contain a different set or even more dimensions than ours. Could you imagine 5 spacial dimensions and 2 time dimensions?

Quantum theory has its multiple world interpretation. It states that for every quantum event – for every probability that a particle will be this or there – it is recognized in one universe or another. ***If a quantum event has 50 probable outcomes, there would be 50 universes branched out for that one quantum event.*** If you extrapolate this over the course of everything, there would be ***an infinite number of universes.*** We would be located on just one where specific quantum events keep happening. Our universe would not be so special.

Black holes are also thought to be creators of parallel universes. They are theorized to spawn *baby universes* inside of them from all the matter they absorb. Some physicists even go as far to say they take the genetics (physical laws) of their ‘parent’ universes, and evolve just the way humans evolved from apes: one mutation at a time. This would also create shifting parent/baby prehistories. Our universe – like us humans – would just be a ***fortunate genetic mutation.***

Parallel universes also offer an explanation to déjà vues. It may have happened that you experienced that same phenomenon that caused the déjà vu in a parallel universe. Somehow, you and your other parallel self shared that experience, or your consciousness crossed over, or specific causal lines crossed, or string membranes crossed momentarily, or...



TIME DIRECTIONS

TIME GOES,  
YOU SAY? AH NO!  
ALAS, TIME STAYS,  
WE GO.

Henry Austin Dobson

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IN THE THREE SPACIAL DIMENSIONS, you can move in both directions: forwards-backwards, side-to-side, and up-and-down. However, in time, you can only move in one direction. Even though the laws of quantum mechanics – one of the most trusted physics theories – do not distinguish a direction of time. So what makes time – or the appearance of time – move unidirectionally?

There are two main theories regarding the direction of time, and what makes it seem to go in only one direction: the thermodynamic arrow of time and the cosmological arrow of time.

The thermodynamic arrow of time, based on the second law of thermodynamics, states that in an isolated system, **entropy tends to increase with time**. Entropy is the measure of how organized or chaotic a set of particles is. Since entropy is always increasing in time – never decreasing – time will always move in the direction of the particles becoming more chaotic, which we perceive to be moving forward. Think of the example of an ice cube melting in a glass. The particles spread out, becoming more chaotic over time. **The particles never organize themselves back into an ice cube**, and therefore time is never able to move backwards.

The other main theory is based on the Big Bang, called the cosmological arrow of time. It states that time is based on the direction of expansion of the universe. Therefore, time direction is the expansion of spacetime. This is interesting, however, if you remember the closed model of the universe, the one that expands until it collapses back in on itself. Some physicists theorize that if this model is correct, and the universe starts to contract, **time could move backwards**. That is, our lives would be in reverse. This brings up some weird ideas: would we know our ‘future’? Would we be able to change what we do, or would it be fixed? If that is true, then is our future fixed now?

Another strange, hypothetical consideration, is a subatomic particle called a tachyon. **A tachyon is said to be faster than the speed of light**, which flies in the face of much of what you’ve read thus far. It defies special and general relativity, creates problems with causality, would allow escape from blackholes, and time travel, among others. With tachyons, time would have no direction. If one could use tachyons, forwards and backwards in time would be possible, and realized.



DETERMINISM

EITHER THERE WILL  
BE A SEA BATTLE  
TOMORROW, OR  
THERE WILL NOT.

Aristotle

DETERMINISM. FATE. Whatever you want to call it. Is the future fixed?

There is no real scientific evidence there is. Although, if one was to know the exact location and velocity of every particle in a controlled environment, you could predict the future of all the particles involved. If you extrapolate it to the scale of the universe, ***could one know the future of the universe?*** Impossible, but possible.

The Aristotle quote relates to quantum mechanics, and the idea that every possible outcome is realized in one universe or another. Therefore, the quote is true. ***In one universe, a sea battle will be realized, in another it won't.*** The future of both universes had been set before the causal events led that to them.

And, of course, the notion of prophets come into play. They have no scientific basis, but they deserve a mention.

