“Science fiction is the most important literature in the history of the world, because it's the history of ideas, the history of our civilization birthing itself. ...Science fiction is central to everything we've ever done, and people who make fun of science fiction writers don't know what they're talking about.”

― Ray Bradbury

Preface

This book, and this project, represents the end of an era, a collection of all the things I've learned in high school, and a window into the future I wish to build for myself. Both science and science fiction are things that have been ubiquitous in my world, and both are things that were fundamentally important to my high school experience. That being said, this is the best way to combine them.

For a long time, I was that kid who didn't like sci-fi movies because they weren't "scientifically accurate," and truth be told, I still have an issue with *Gravity.* I may or may not religiously follow Neil deGrasse Tyson on Twitter (and find him kind of amusing). However, there's a reason it's science *fiction.* This book is more or less meant to not only introduce people to astronomy and physics, but to *Star Trek* and *Doctor Who.* Science, and astronomy in particular, is often reserved for overly-educated academics, but most people have some intrinsic curiosity about the universe.

I find that science fiction is almost as overwhelming to get into — from the die hard fans to realizing that there's 50 years of backstories, inside jokes, and other intricacies to catch up on. Most people don't have time to watch 50 seasons of a single television program. (And if you have time to watch 50 years worth of TV shows, cartoons, and movies, please let me know where you found that time.)

This, by no means, is comprehensive, but it's good for the basics. In fact, this book is almost good enough to read to your dog (or 5 year old.)

This book lacks the typical formalities, it's often snarky. It's rather clear that I think J.J. Abrams ruined *Star Trek* with the last two movies, and that I think he's about to ruin it again with the new movie this summer. I get way too excited about the small things in these stories. I am that dork that dresses up and goes to Star Trek conventions. I couldn't make it more obvious if I wanted to.

My point here is to find a casual way to show that scientific accuracy has a place in science fiction, that is sometimes exists. Maybe science fiction is important to science as well. My end goal is to be able to share my interests in astronomy and sci-fi with you, my dear reader.

Live long and prosper. 

Acknowledgments

Science is as much about your ability and willingness to collaborate and communicate well as it is about your own ideas, education, and talent. That being said, there are so many people who have helped me along the way writing this, from purely science content to Star Trek expertise, to editing.

First and foremost, I'd like to thank my mentor, Rachel Wolf. Rachel has seen every step of this process, has answered all of my seemingly elementary questions, helped me stay on track, and helped me make sure my goals for this project were realistic. At this point, it's probably fair to assume that she thinks I'm stupid, but thanks to Rachel for tolerating me and for teaching me about not only astrophysics, but academia and research in general.

I am also eternally grateful to Mimi Fuchs for all of her help with this project. Even from Hawaii, Mimi's enthusiasm for science is unparalleled, and her willingness to share all of her knowledge has been golden throughout this process. Mimi has been the cheerleader, and she never let me give up when things were difficult or frustrating (which was most of the time; astrophysics is harder than it looks. Don't try this at home, kids.).

I'd also like to thank Rosalind Echols for her support, not only in this project, but also throughout my time at SLA. For fostering my interest in physics, for lending me a ton of books, for encouraging my interest in science fiction, for being a fellow nerd, and for being a wonderful role model for women in science.

To Dr. Derrick Pitts at The Franklin Insitute for being my mentor in astronomy throughout my entire high school career — and for his interest in this project, and for introducing me to Rachel. He took me under his wing sophomore year, and has taught me a tremendous amount about the universe and what it means to be a good scientist and educator.

And to Heaven Mendez for being my grammar editor in chief and one of my best friends. Opposites attract, and for every self proclaimed "liberal arts weenie," (read: creative writing major) there's a physics nerd by her side. Heaven is also the only person that tolerates me crying about math, physics, Spock, sexism in early Star Trek, and how cute Tribbles are.

Finally, I'd like to thank my friends and family because without them, none of this would exist. My mom encouraged my love of science from early on, and because of her, I'm now (almost) a

scientist. And to the folks at Science Leadership Academy, especially my advisor, Pia Martin for adopting me, ensuring I made it to graduation in mostly one piece, and for getting me to senior year so I could do this project.

There aren't really enough words to describe how grateful I am for all of these people and all of the things they've done for me; even the truly impactful things they've done that they haven't even realized.

Introduction

Science fiction, without

Science Fiction for People Who Are Too Cool for It

Science fiction is notorious for its nuanced worlds, full of backstories and complicated worlds that exist in fictional universes far from our own. That being said, this should serve as a brief introduction to the worlds and ideas between Doctor Who and Star Trek: The Next Generation. This is, by no means, as comprehensive as it could and should be. 50 years is a lot of ground to cover, and although interesting, it is not essential to understand every alien, backstory, philosophical question, or technology in these shows.

Doctor Who is a science fiction TV show that ran on BBC One from 1963 to 1989, when it was discontinued due to funding. The show was rebooted in 2005 by the BBC. Doctor Who is one of the longest running science fiction shows currently running, at 53 years. The show was started as an educational program(me) for children in the UK, and instead of making a documentary series for kids, they used time travel to take kids to different historical events on Earth. As an attempt to make it more educational, the first two companions of the Doctor were teachers. It was never developed as an educational series, but rather as a science fiction TV show.

The show follows a humanoid alien, known as the Doctor. The Doctor is from the planet Gallifrey, which was destroyed in a war between the Time Lords and the Daleks. The Daleks are the main enemy of the Doctor, and the reason is the fundamental philosophical difference between them:. The Daleks exist solely to destroy things and kill people, whereas the Doctor sees himself as the protector of worlds and he avoids death at all possible costs. The main question throughout the show is ‘Doctor Who?’ as no one knows what his real name is. It is believed that the Doctor changed his name after he escaped the time war because of the horrible acts and crimes he committed. Before those events, the Doctor stole a time machine, and the show follows him as he travels through time and space.

The time machine he uses is known as the TARDIS (Time and Relative Dimensions in Space). The TARDIS is meant to have a piece of technology called a Chameleon Circuit, which allowed it to blend into it’s surroundings, but this was broken escaping Gallifrey. Because of that, we see the TARDIS as a blue, 1960’s style British police phone box. It is mentioned at various points that this model of TARDIS was a museum piece when the Doctor stole it to run away from Gallifrey, but he seems to be rather fond of it anyway.

The police box is one of the most iconic images in the show, aside from the famous sonic screwdriver that the Doctor carries. The sonic screwdriver is a pen-like object that has the ability to open all things (except wood doors) and take all sorts of readings and measurements. The

design of the sonic screwdriver usually changes with different Doctors, with the exception of the 9th and 10th Doctor who have the same model, and the 12th Doctor who has sonic sunglasses. They do the same thing, but they're sunglasses and not some flashy alien looking gadget.

And since this show has been running since the 1960's, the actor who has played the Doctor has changed. Time Lords have the ability to regenerate 13 times - almost like they die and come back as the same person in a different body. To date, 12 actors have assumed the role as the Doctor. And although the Doctor could look like anyone or be anything he really wanted, he's always a skinny, white, male actor from the U.K. Every Doctor has very distinctive personality traits and fashion senses. The 5th Doctor wore a stalk of celery on his jacket, while the 11th Doctor always wore a bowtie. The 1st Doctor was older and more mature, whereas the 10th Doctor was fairly jovial and at times, childish.

One of the main characteristics of the Doctor is his love of Earth, and humanity in general. Because he is the believed to be the only living Time Lord in this dimension and universe, it is a reoccurring theme that he is extremely lonely. As a result, the Doctor always keeps human companions with him. These people travel through time and space with the Doctor as they encounter different alien worlds and time periods. These adventures take the humans to see the conflicts between Earth and alien worlds, and usually the only human that is aware of these conflicts is the Prime Minister of England, who was chosen not only to represent Earth, but the whole of humanity.

Star Trek is totally different in its ideals. Star Trek, in all of it's iterations, series, and movies, follows the bridge crew of the USS Enterprise, which is the flagship of the United Federation of Planets.

In 2160, the Earth-Romulan war ended. A year later, the allies of Earth from the war met in San Francisco met and signed an agreement to form the United Federation of Planets, which is informally referred to as the Federation. The Federation was meant to show an idealized version of the U.N., and Star Trek was almost meant to be Gene Roddenberry's political commentary of things happening in the 1960's. The main goal of this alliance was to combine resources for the purpose of science and exploration, where all members of the Federation had to agree to the Prime Directive, which states that explorers cannot interfere with the development of civilizations, even if that interference is meant well. The Prime Directive is also referred to as the 'non-interference agreement' at various points in other series.

People from Earth who were involved in the Federation were members of Starfleet, which is run like a military organization, but is meant to prepare people to serve on long-term missions in space where they will travel to other worlds and star systems within the Milky Way Galaxy. Starfleet is broken up into 3 main divisions: science, engineering, and command. Science officers wear blue shirts, command officers wear red shirts, and engineering officers wear yellow. In The Original Series, command wore yellow, whereas in The Next Generation and on, command officers wore red. Although this change was never really explained, it is believed that this change was made because more characters wearing red shirts were killed than any other on screen. That was never confirmed nor denied by the producers of Star Trek.

The crew of the Enterprise (NCC 1701-D, *TNG*) is as follows:

Captain Jean-Luc Picard (Command)
Picard is the commanding officer of the Enterprise, and the only Starfleet captain from France. Picard is well educated, often telling his crew the importance of studying art and philosophy. Starfleet uses him for negotiations with alien worlds and peace missions as he is pretty much the poster child for the mission and ideals of Starfleet. He also vehemently upholds the Prime Directive, to the point where he allows members of his crew to die before he'd violate it. Picard is the voice of reason on the show, and he is really the enforcer of ethics in the show. He doesn't allow the crew to act on behalf of their own personal interest, the interest of the crew, or even the interest of the Federation. Rather, for the best interest of the bigger picture.

Lt. Commander Data (Engineering)
Data is the only artificial life form in Starfleet. He is an android developed by Dr. Noonian Soong and his brain contains all of the current knowledge of Starfleet, as well as the ability to complete advanced calculations within seconds. Data is a bridge engineering officer as well as a primary scientific tool.

Commander William T. Riker (Command)
Will Riker is the first officers of the Enterprise, and leads all of the away teams. Although he's not a scientist himself, Riker works closely with Data, Troi, and Crusher on scientific endeavors. Riker just likes taking unnecessary risks, and the only reason he's a half decent command officer is because he's extremely personable.

Lt. Geordi LaForge (Engineering)
LaForge is the chief engineering officer after his promotion in season 2. He was originally stationed at the engineering com on the main bridge. His promotion was due to the death of Lt.

Yarr, and the promotion of Worf. LaForge is a human officer, who also happens to be blind. Because he's blind, he uses a visor to be able to "see" in a sense; he is able to pick up electromagnetic waves.

Jr. Lt. Worf (Engineering/Security)
Worf is promoted to the chief of security in the second season after the death of former security officer Natasha Yarr. Klingons hope to die in battle and are forced to commit suicide if they become too injured to return to battle. This ritual suicide poses major ethical question to the Federation, after Worf is injured in a cargo bay incident and he asks Riker to assist him in his suicide. The Klingon Empire is a former enemy of the Federation, and Worf was one of the first Klingons to serve in Starfleet because instead of joining the Federation, the Klingon Empire made peace with the Federation. They didn't even form an alliance or anything of the sorts. Worf is fiercely loyal to those he holds close, and throughout the show, his primary job is to protect the crew as they travel to alien planets.

Lt. Natasha Yarr (Security/Engineering)
For the first season, Yarr is the chief of security. Tasha was only on the show for a season, before she was killed by a slimy-like alien. Her death is the first on screen death in The Next Generation. Tasha is later brought back in the 3rd season, when the Enterprise encounters itself on a different timeline and her daughter is found on Romulus when she was acting as an ally to the Romulan people. Romulans are a Vulcan like race that is considered to be an enemy of the Federation. It is possible that she was kidnapped and taken to Romulus instead of dying like the Federation believed, where she would have a daughter and eventually betray the Romulan Empire but her ultimate fate is made rather unclear.

Chief Miles O'Brien (Engineering/Security)
O'Brien is a character in both The Next Generation and Deep Space Nine. He is the transporter chief, meaning he is responsible for operating, maintaining, and repairing the transport system. Most transporter missions are over a short distance, between low orbit around a planet and the planet's surface. Transport works by disassembling a person atom by atom and putting them back together at their destination. O'Brien also works in main engineering when he's needed. Miles is married to Kieko, who is one of the main botanists on board.

Counselor Deeana Troi (Science)
Troi is half human and half Betazoid. Betazoid is a class M, Earth-like planet where all the people are telepathic. Because Troi is only half Betazoid, she is empathic and able to sense the emotions of almost every alien race. Because of her abilities, Picard uses her as the ship's

counselor, helping in negotiations and counseling members of the crew. In most cases, being an empath is advantageous to her, but it also means that it is easier for aliens to control her mind and take over her body. There are several alien races that exist as energy forms or don't have bodies that use Deanna as a way to communicate with humans and humanoid life forms. She is also a graduate of the University of Betazoid with graduate degrees in psychology.

Dr. Beverly Crusher (Science)
Crusher is the chief medical officer on the Enterprise. Seeing as the crew is either nearly killed in a shuttle accident or attacked by aliens of some sort, she's one of the most valuable members of the crew. Crusher is not only a general doctor, but also a tap dancer and astrobiologist and researcher. For a year, she serves as the head of Starfleet Academy Medical School but returns to serve on the Enterprise with Wesley at the start of season 3. Crusher is also a good personal friend as the captain, and aside from her formal service as the chief medical officer, she also serves as a confidant and advisory to Picard.

Ensign Wesley Crusher (Command)
Wesley is the son of Dr. Crusher who took an interest in starships and science from a young age. At the beginning of the show, Picard found him annoying and tried his hardest to keep Wesley confined in his quarters. Eventually, Picard and Riker realized Wesley's potential and promoted him to 'acting ensign' in an emergency when one of the other ensigns was killed during an attack. Wesley later returns to Earth to go to Starfleet Academy in San Francisco. He is only really in the show for the first 4 seasons, but occasionally returns.

Obviously, the Federation has some enemies. The main enemies in the show are the Romulans, The Borg, and Ferengi. There are other races that the Federation is worried about, however, those 3 are the main, recurring ones in the series.

The introduction of the Borg was considered something extremely innovative to science fiction at the time, although now it is ever so slightly cliched. The Borg were humans who were assimilated to join this race of half-man, half-machine people. They functioned on a hive mind, where although they were all separate people, they shared a common knowledge and one singular mind. The Borg were programmed to assimilate people into the Borg, and at every encounter with the Federation they attempted to force the Enterprise to join them. This violated Picard's beliefs of personal liberties and freedoms, thus making them official enemies of the Federation. They do capture and assimilate Picard in season 4, but Dr. Crusher finds a way to free the captain of their technology. The only thing lost in the attack was that the Borg was able to download and process all the information from Picard's brain which was a major tactical

disadvantage to all Federation ships and out-posting. The Borg claimed that they took Picard because they wanted to find and use a well respected, intelligent, and educated human for the Borg introduction to humanity and other Federation races. Because of the single mindedness of the race, it is believed that the Borg are only violent and destructive.

Romulans are almost like Vulcans, but Vulcan is a member of the Federation. They even have the pointy elf ears. A theory suggests that Romulus was colonized by Vulcans, and they evolved after their rejection to rejoin Vulcan during the social reforms of the the Time Awakening. The Time Awakening was a time in Vulcan history where the people of the planet decided to end all wars and fighting to focus on academic study. Because of growing tensions between Romulus and Vulcan, they are enemies of the Federation.

Ferengi are generally assumed to be the most annoying aliens of the entire show. They aren't really out to destroy the Federation, rather to acquire valuable things. They're the humanoid form of capitalism. Everything in their entire culture is about business and advancing oneself financially. This, of course, contradicts the views of the Federation, because they don't engage in trading or anything of the sort.

Star Trek has many different versions, most of which have different bridge crews. In JJ Abrams' recent reboot of the series, the original cast of characters have been reintroduced. The details in this description of the show are all about *The Next Generation*, because that's where most of the examples in this book are coming from. However, there are references to both the *Enterprise* series, and *Star Trek: 2009*. The ideals and missions of the Federation don't change in either of those spin-offs, so most of the details are remarkably similar.

Crash Course in Black Holes

What are black holes?

According to Newton's laws of gravitation, the escape velocity of an object based upon the distance from the center of gravity and the mass of the object is mathematically expressed as follows:

What happens if the mass of the object becomes so condensed that $v > c$? Black holes are a region of spacetime that is so dense that nothing, not even light can escape.

How are they formed? Will the Sun eventually become a black hole?

In order to understand how stellar black holes are formed, we must first have a basic understanding of stars. Stars are held together by the balancing of two forces: the inward pull of gravity, and the outward force of emitted radiation. Stars are powered by fusion. At the core of a star, hydrogen is fused into helium, helium is fused into carbon, and the process continues as the elements in the core grow denser and denser. For smaller stars such as our own sun, they stop at oxygen and cool down.

However, for stars about 5 times as massive as our own sun, the fusion continues. Fusion is an exothermic reaction, meaning it releases more energy than it requires. These stars will fuse elements until they get to iron. No energy can be released from fusing iron. After the fusion stops, so does the emission of radiation. Without the outward forces of radiation balancing the inward pull of gravity, the star collapses.

All of the mass of the star is then condensed into a much smaller space, and the escape velocity only goes up from there. Eventually the escape velocity becomes greater than the speed of light, meaning that nothing at all will be able to escape it.

As for our own sun, no, it will not eventually form a black hole. Why? The sun is currently going through the same fusion process as any star in the universe, however, the sun isn't big enough to have the core fuse into iron. This being said, the sun will cool off into a white dwarf instead of becoming a black hole.

Are black holes real? What evidence do we have to support this? And how do we find them?

Because not even light cannot escape black holes, we cannot directly see them. However, scientists detect black holes in other ways. When matter comes near the event horizon of a black hole, it is drawn in. As matter is drawn in, it spirals around the black hole, heating up. When matter heats up like this, it emits X rays. X rays can be seen by telescopes such as Chandra. Another clue scientists use to find black holes is rapidly moving stars. As stars fall into the gravitational forces of a black hole, they move much differently than they normally do.

This being said, there is plenty of scientific evidence to suggest that black holes exist in more than just mathematical theory. In fact, it is believed that supermassive black holes may exist at the center of our galaxy.

In Star Trek: 2009, the planet Romulus is being threatened by a supernova, which could destroy their planet, and in turn, the entire race of Romulan people. Starfleet science officer, Spock, settles on a plan where he would create a 'red matter' bomb which would cause an artificial black hole. This black hole would then consume the supernova, destroying the threat. Despite the efforts of Starfleet, Romulus is eventually destroyed. However, it is later realized that Nero, the Romulan commander, is from the future. He attempts to take Spock's plan and uses it against the Vulcan people, eventually destroying their entire planet. Romulus is a spilt from Vulcan, almost in the same sense that the United States is a split from Great Britain.

So, how does a single planet become a black hole when not even our own sun is large enough to one day become a black hole? It is mentioned that Vulcan has a stronger gravitational field strength than Earth, but Vulcan is also a 'Class M' planet where humans and other humanoid species live, so the planet isn't much larger than Earth itself. (Class M is a fictional categorization of planets in which the planet can support human/humanoid life forms, has liquid water, and a breathable atmosphere.)

Hypothetically speaking, anything could become a black hole if it collapsed within its Schwarzschild radius. The Schwarzschild radius is essentially the maximum radius of a black hole -- such that if all the matter of Vulcan was condensed into this sphere, that the escape velocity from its surface would be equal to the speed of light.

The Vulcan race is one that is dedicated to science and logic throughout the entire Star Trek franchise. From TOS' poster child, Spock, to Enterprise's science officer, T'Pol, the Vulcan dedication to the spirit of scientific discovery is admirable. As of the year 2152, the Vulcan scientists discover and chart over 2,000 different black holes throughout the observable universe. It is later learned that Vulcan physiology allows them to do this, as they are immune to X ray radiation.

Throughout their voyages, the crew of the Enterprise is bound to encounter black holes. During the run of the Star Trek: Enterprise series, the crew ran into several black holes, with one case that was particularly interesting. The Enterprise received a distress call, and the nearest Vulcan ship was 9 days away. After they had laid in a course to respond and assist the ship in need, they realized that the crew was acting strange. This, of course, is later attributed to the radiation from the 'Class IV' black hole. This is a fictional classification for black holes, and what it meant was that this black hole was once part of a trinary star system. After conducting a scan. T'Pol and her commanding officer, Captain Archer, learned that the radiation would eventually be lethal to all

the non-Vulcan personnel aboard the ship, so they made the decision to dangerously navigate around the black hole, being careful to avoid getting pulled beyond the event horizon.

Crash Course in Supernovae

What is a supernova?

A supernova is an explosion of a massive star when it can no longer sustain the fusion process, thus causing it to collapse in on itself. This occurs during the final stage of a massive star's life cycle. During this catastrophic event, the star outputs about as much light as 10 billion runs, which means that supernovae are visible to the name eye. This being said, there's a tremendous output of energy in these explosions, and as a result, they don't last for very long. Live fast, die young.

How are they classified?

Why are they important? Why do scientists study them? And how?

Everyone loves a good explosion, outer space and science fiction directors included. And within the universe. nothing is permanent. Even stars must come to an end. The life of a star ends in two ways; it either burns out to become a small, feeble star or ends in a rather violent explosion we come to know a supernovae.

Because feeble stars are rather uninteresting, and Gene Roddenberry didn't care to add many to his show because it didn't look pretty with CGI, let's talk about supernovae.

To start season 3 of TNG, Picard is asked to bring as astrophysicist on board. Dr. Paul Stubbs is a Starfleet scientist who specializes in star collapse in binary star systems, and it's the Enterprise's job to bring him close enough to this astrophysical phenomena to observe it.

Towards the end of season 3 of *The Next Generation*, the Enterprise is sent to survey a star system for possible habitable planets for the Federation to colonize when they encounter an object matching their heading and speed. This, of course, causes some alarm for the crew because they weren't expecting another ship. Data later comes to realize that this object wasn't another ship, but rather a life form they'd never encountered before. As swell as it is that they found a new life form, because after all, that's their mission, the bridge received a notice from the astrophysics department that the star they were near was collapsing and about to go supernova.

This is rather problematic for several reasons. And if Picard is a half decent captain, he should probably do something about it.

First of all, the Enterprise is torn between leaving the star system where they're aware that they'll be safe, or they could stay and try to save this alien that they call 'Tin Man.' From the perspective of the command officers, attempting to save the alien would be a violation of the Prime Directive if Tin Man didn't leave the star system on it's own volition.

Secondly, from a science side, it's important to understand that even at full shield capacity, the Enterprise wouldn't survive the explosion. Stars fuse elements to make heavier elements, which is how they sustain themselves. Supernovae are responsible for the distribution of elements throughout the universe, and it's somewhat difficult to believe that the Federation designed it's flagship to be able to handle iron projectiles. The command goal should be to avoid that, or at least that's what taught at Starfleet Academy.

If we switch gears for a second to look at *Doctor Who*, they also seem to enjoy supernovae. The 11th Doctor once informed human companion Amelia Pond that he threw the instruction manual to the TARDIS in a supernova because he disagreed with the suggestions it provided him. To be fair, if you really do intend on destroying something, throwing it in a supernova isn't a bad idea. First of all, the elements being ejected from a star are extremely hot because of the amount of energy contained in a star, so the paper from the book would burn. Even if the book didn't come in contact with any of those elements, no space ship could get close enough to it to ever retrieve the book.

Science Fiction + History

Science and science fiction have gone hand in hand throughout history. One could even argue that some aspects of science fiction have served as predictions for the future. *Star Trek* had replicators before we could even think about commercially producing 3D printers, holodecks have become a reality through the development of virtual reality, and Starfleet's popular handheld computers on the bridge closely resemble the ever so popular iPad.

Doctor Who is arguably a work of fantasy, a TV show that uses time travel to explore philosophy and ethics, or a stupid children's program. On *Doctor Who*, time travel is sort of accepted as something that's both possible and rational. It's not really explained how the TARDIS works, or why the companions chose to run away with a strange alien man.

Star Trek, however, is a different game. When *TOS* came out, the fans were rather upset about warp drive. Sure, in order to advance the plot, they can't spend the whole season traveling light years between star systems. However, according to Newton's laws, if the Enterprise went from still to warp 9.8 (10 times faster than the speed of light), the entire crew would be impaled. Spock is rather useless if he's dead. All that being said, the nerds rallied together and sent a letter to the producers pointing out this obvious flaw in the science. From there, they introduced the 'inertial compensators', which at least gave a justifiably almost scientifically valid way around the dangers with warp drive.

Time travel is a cliche that spans every kind of science fiction throughout history, starting with H.G. Wells in the 1895 when he introduced and popularized the concept of time travel. Well, not really time travel, because that was something that can be found much earlier literary works of what one could consider "science fiction," but rather time machines.

All of this being said, there's time travel in both *Doctor Who* and across the whole *Star Trek* franchise. And to make things even cooler, time travel is possible, just not in the way that we see it on TV. There are no flashy machines with lots of blinking lights that take you back to the past so you can see your parents meet. There's no way that you could become Marty McFly and accidentally make sure that your parents never meet. And I hate to break it to you, but science is probably never going to find a way to make it possible for you to meet your favorite dead historical figure.

Time, as most things with physics, is relative. Well, everything is relative but the speed of light in a vacuum.

The more mass an object has, the slower is experiences time. And as an object approaches the speed of light, time also slows down. Time is passing more quickly for us the astronauts on the International Space Station than it is for the folks on Earth.

Scott Kelly and his twin brother are both NASA astronauts, except he spent a year in aboard the space station, meaning he's ever so slightly younger than his brother who spent the year in space. (Talk about sibling goals, their parents must be proud.) When the first GPS satellite was put into orbit, scientists forgot to account for this difference and they didn't work.

This being said, an interesting, though entirely hypothetical, proposal for a time machine is as follows: we build a train that circles the Earth, and said train would accelerate to near the speed of light. It's impossible to go faster than the speed of light in a vacuum; Einstein established that as the cosmic speed limit in 1915 with the publication of his theory of special relativity. For the passengers of the train, time would pass more slowly than for the rest of the world. So while they may only be on the train for a few hours, a few days may pass for the rest of the world. Strictly speaking, this would transport them into the future. Significantly less exciting than *Star Trek's* time traveling aliens, or the Doctor's time machine, but entirely possible.

Something else that's interesting about both *Doctor Who* and *Star Trek*, is that these shows have been on TV for 50 years. Between the time these shows have started, we've put men on the moon, built the International Space Station, and discovered gravity waves, thus confirming the existence of black holes. Black holes were originally pawned off by Einstein to be an error is his math because they're extremely strange and exotic objects in the field of celestial objects. The first seasons of these shows are important for a lot of reasons, in terms of culture and media but the scientific error is enough to drive the common physics nerd insane and the common film geek marvels at the high quality special effects. Nothing like low budget 1960's aliens (aka dogs wearing coats.) Black holes were only really confirmed in 2105, prior to that, it was purely evidence based speculation. This being said, the early directors of *Star Trek* made some very interesting artistic choices to show

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