When Stars Go Dark

Transcript of show by ***Fly Science Guy Star Shows*** on October 31st, 2020.
Written by James Sanders and Rebecca Dudek.

Section 1: Introduction

Happy Halloween everybody! This time of year is fun: dressing up in scary or silly costumes and sharing spooky stories by the campfire. We all know that stories are scarier when we think they're real. That's why every good campfire story says that it's true. But with campfire stories, it can be hard -- if not impossible -- to verify. If the only source is that long ago somebody's great-great grandfather claims to have seen a beast with red glowing eyes in the forest, how can you verify that? There's no documented evidence. There was only one witness, who is no longer available to give his testimony. Unlike laboratory experiments, you can't run controlled experiments to test the repeatability of the occurrence. But with campfire stories, that's okay! It's fun to be spooked, and that's the point of it-- to have fun. That's why we enjoy watching true crime shows but don't enjoy being murdered-- it's fun as long as you know you're not in any real danger.

So when you're sitting around the campfire, and Johnny tells a story about his grandfather seeing a mythical beast in the forest, it's not important to ask Johnny to cite his sources, ensure they're all credible, ensure there are enough experts in agreement to merit a trend, and if possible, analyze the source data to verify for yourself that the story checks out. As long as everyone knows that the point of Johnny's campfire story is just to have fun, and it shouldn't be taken too seriously. It shouldn't be treated as verified science or history and you shouldn't make any major life decisions based on it.

The difference between campfire stories, and what I'll be talking about tonight, is that our goal at Fly Science Guy Star Shows is to inspire everyone to think like a scientist or a historian-- to verify the credibility of sources you get information from, to find and understand the source data yourself if possible, and to think critically, open-mindedly, and from as many different perspectives as possible when looking at that data. That is to say, everything I'll talk about tonight is verified history or science, and if you'd like to be too disturbed to close your eyes tonight, you can read about these things yourself after the show-- all our references are posted on our website.

We could have pulled an Orsen Welles and read a scary but fictional story to you, and you'd think, "If that was real, it'd be quite frightening!" (1) But unfortunately, we don't need to pretend that the world has real horrors.

Don't get me wrong-- science has made the world a better place. (Example: if you're watching this right now, and you don't have polio, you can thank science!(2)) And many people have

helped make the world a better place too. But people have also done and experienced some horrific things, both in the name of science and in the rejection of it.

In advertising this show, we did our best to emphasize that this show is for mature audiences only. I don't recommend that anyone under the age of 13 watch without parental guidance, and if you're someone who can only get through life by blocking out disturbing information, this may not be well suited for you either.

So with that said, let's start by diving into the history of Halloween.

Resources for Section 1:

1. https://en.m.wikipedia.org/wiki/The_War_of_the_Worlds_(1938_radio_drama) I know wiki gets a bad reputation, but this is the most comprehensive article I found, better explaining the whole picture than any of the news articles I read. Wiki cites their sources, so if anything seems fishy, just verify it via their sources.
2. https://www-history-com.cdn.ampproject.org/v/s/www.history.com/.amp/this-day-in-history/salk-announces-polio-vaccine?amp_js_v=a6&amp_gsa=1&usqp=mq331AQFKAGwASA%3D#aoh=16041376587225&referrer=https%3A%2F%2Fwww.google.com&amp_tf=From%20%251%24s&ampshare=https%3A%2F%2Fwww.history.com%2Fthis-day-in-history%2Fsalk-announces-polio-vaccine

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Section 2: History of Halloween

Most people don't know this, but Halloween is an astronomical holiday. It's what's called a cross-quarter day. It marks the halfway point between the autumnal equinox (the start of fall) and the winter solstice (the start of winter).

Halloween has its roots in Samhain, which was a festival of the Celtic people throughout Europe, dating as far back as 1600 BC (2). Practically speaking, Samhain was a time of feasting, when the harvest was celebrated and livestock was slaughtered so there were less to feed during the scarce winter months. In celebration, they'd have big bonfires to try to push back the coldness of winter, to bless themselves in the smoke, and to ward off hostile otherworldly beings.

It was a time when the veil between our world and the otherworld was said to be lifted, allowing souls of the departed, fairies, banshees, and other supernatural beings to walk amongst us. Now, the fairies the Celts believed in were not the dainty, sweet beings that children's film industry depicts fairies as today. To the Celts, sure, some fairies were harmless, just playing pranks on humans with no ill will, but some faeries were malicious beings who would cause harm to humans for their own amusement. They were thought to kidnap infants and replace them with identical changelings, or faery infants, instead.(9) Things like caves or fairy circles,

which are just naturally occurring circles of mushrooms, were thought to be portals through which demons and departed souls entered our world.(10) This visit caused mixed emotions among the Celts. On one hand, it was a happy time in which they could be visited by deceased family members. They'd leave food offerings for their loved ones and put fires in their hearths to warm the spirits of ancestors that visited their home.(11) But on the other hand, malevolent spirits and demons were also believed to have entered our world at this time. Some people would leave offerings of food outside their homes, in the hopes that it was appease these malevolent beings and pardon the family from any unwelcome interaction with them.(9) People would disguise themselves as otherworldly beings in attempts to fool the supernatural beings, and avoid their attention.(11) The presence of these supernatural beings were said to aid in predicting the future. As recently as the 18th century, this manifested as predicting marriage prospects for young ladies. In Scotland, ladies would take a handful of nuts, and assign each nut the name of one of her suitors.(1) The nut that burned rather than popping open was said to represent her future husband. But a less romantic interpretation is of the Druids-- or ancient celtic priests-- who were said to have predicted the future based on the sounds and motions made by human and animal sacrifices and the orientation of their remains. Diodorous of Sicily (6) (90BC to 30BC) wrote about this practice saying, "When the stricken victim has fallen, they read the future from the manner of his fall and from the twitching of his limbs, as well as from the gushing of the blood, having learned to place confidence in an ancient and long-continued practice of observing such matters." (7)

Now, it's important to note here, that much of what we know regarding the Celtic tradition of Samhain-- or the Celtic people as a whole for that matter-- comes from what was written about them by monks and Romans, and not by the Celts themselves. The celtic people did not have written language, so their history was passed through the generations through word of mouth. For Celtic history dating back to the time of Tigernmas, said to have reigned over Ireland from 1621 to 1544BC (2), it's unclear whether figures, practices, and events from that time are factual or legend.(3) Legend has it though, that on Samhain, King Tigernmas set up a stone idol of Cromm Cruach and required his people to sacrifice a first-born child to it. (4-5) On one particular Samhain, Tigernmas and three fourths of his people died during these ceremonies for unknown reasons.(12) An even earlier legend, said to have taken place from 2350BC to 1731BC, the oppressed people called Nemedians are forced by their oppressors to sacrifice two thirds of the milk, corn, and children, until they rise up against their oppressors, resulting in only 30-- out of a starting number of 60,000-- Nemedian survivors.(5,8) (That is to say, they lost that battle.)

Now, the Celts were initially spread all over Europe, but during the Roman conquests, the only place the Romans weren't able to defeat the Celts were Scotland, Ireland, and Britain,which is why Halloween in America flourished with the influx of Irish immigrants.(13) And of course, where the Romans did take over became the Holy Roman Empire. Science flourished under the Holy Roman Empire, and-- whereas in ancient times, the study of the stars, science, and their divine meaning and cause were considered one interwoven study-- eventually science and religion began to separate.

Resources for Section 2:

1. https://www.history.com/topics/halloween/history-of-halloween
2. https://en.wikipedia.org/wiki/Tigernmas
3. A concise history of ireland.Ireland. Patrick Welton Joyce. Page 55.
4. https://www.irishcentral.com/roots/history/did-the-ancient-celts-practice-human-sacrifice#:~:text=In%20all%20of%20Ireland's%20rich,killed%20as%20offerings%20to%20it.
5. https://en.wikipedia.org/wiki/Samhain
6. https://en.wikipedia.org/wiki/Diodorus_Siculus
7. Nicholas Rogers, page 14 and 15 of Halloween: From Pagan Ritual to Party Night
8. https://en.wikipedia.org/wiki/Nemed
9. https://thecelticjourney.wordpress.com/2013/04/21/faeries/#:~:text=Common%20themes%20among%20the%20Celtic,and%20mounds%20of%20the%20Otherworld.
10. https://en.wikipedia.org/wiki/Samhain#Ritual_bonfires
11. https://www.newgrange.com/samhain.htm
12. O 'Donovan's Annals of the Four Masters, 1851, i., 38 -41. Found here: https://celt.ucc.ie//published/T100005A/index.html. Also referenced here: The Irish mythological cycle and celtic mythology. Page 63.
13. https://www-history-com.cdn.ampproject.org/v/s/www.history.com/.amp/topics/ancient-history/celts?amp_js_v=a6&amp_gsa=1&usqp=mq331AQFKAGwASA%3D#aoh=16038482972498&referrer=https%3A%2F%2Fwww.google.com&amp_tf=From%20%251%24s&ampshare=https%3A%2F%2Fwww.history.com%2Ftopics%2Fancient-history%2Fcelts

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Section 3: Hypatia

In Alexandria in 400AD, science was thought of (by Christians) as pagan, anti-Christian, blasphemous.

It was in this atmosphere that a woman named Hypatia was born and rose to become a significant academic and societal influence of the time. Hypatia was an only child, and was raised by her father, Theon, himself a prominent mathematician and philosopher. This, along with his resistance against the ideas of women being less than men, led him to raise Hypatia as a son -- teaching her to read, write, and perform mathematics. She came to surpass her father in mathematics growing up, and eventually began teaching at the “School of Alexandria”. It was unheard of at the time, that a woman could be a respected academic and societal force, but Hypatia was. She wrote math textbooks, refined scientific instruments, and developed a more efficient method of long division in her time there. She was a respected and admired teacher who managed to create an atmosphere of inclusion and open-ness in her classroom, despite the unrest and violence amongst Christians, Pagans, and Jews in Alexandria at this time. Around 415AD, unrest rose when the local Christian Archbishop commanded followers to destroy anything that wasn’t Christian. A dispute between the Archbishop and a Roman governor became public about these heinous acts. The governor approached Hypatia asking for guidance, as she had made an image for herself as being wise and impartial. She advised the governor to act fairly and without zeal. Soon after, how-ever, christian monks under the

archbishop started a riot in which the governor of Rome was injured, so the governor had their leader killed. The archbishop blamed Hypatia, claiming she was a witch whose witchcraft kept the governor from Christianity (even though the governor was actually a moderate Chistian himself). When Hypatia was returning home from the university where she taught, a mob of hundreds of Christian monks in black robes, took her out of her chariot, tied her to the back of it, and dragged her through the city to a church. They then proceeded to use something hard-- some interpretations say shells, some say shards of porcelain-- scrape off all of her flesh. They then tore her limbs apart and burned her remains. And arguably the scariest part of this, is that the mob then destroyed her university, which many historians consider to be the end of the classical age, the end of knowledge, growth and exploration, as Europe would plunge into the dark ages for the next 1000 years.

Resources for Section 3:

All information in the section about Hypatia was gathered from the following sources:
https://www.britannica.com/biography/Hypatia

https://www.ancient.eu/Hypatia_of_Alexandria/

https://www.smithsonianmag.com/history/hypatia-ancient-alexandrias-great-female-scholar-10942888/

https://www.youtube.com/watch?v=n1mwZrVJ-TI

Section 4: Jack Parsons

Of course, that was a long time ago. And a usual human coping strategy when we hear about horrible things happening, is to create a division-- a distinction-- between our reality and the reality of horrible things. Distinctions like, “that was really long ago”, or “that’s really far away”. But we know it’s a delusion and that if we dared to explore, we’d find modern day realities we’d be quite uncomfortable acknowledging.

Mad scientist is a common Halloween costume. If you google real life mad scientists, you’ll mostly find past biologists doing ethically questionable experiments or mentally unstable people like Tesla who were labeled as “mad” because mental health and illness were even less understood during their lifetimes than they are today. (1)

But you’ll also find Jack Parsons, who’s in a category all his own. Jack Parsons is famous for his scientific contributions to rocketry. He was one of the founders of the Aerojet Engineering Corporation, later rebranded to Jet Propulsion Laboratory, which is a part of California Institute of Technology that NASA manages.

Now, Parsons makes the mad scientist list because of his leadership role in the sex-magic religion “Thelema” founded by Alister Crowley, who called himself “The BEAST 666.” But there are lots of instances of people doing scary things as a result of nonscientific beliefs, such as a mother who slit her daughters throats because she didn’t want them to suffer when the world was said to end in 2012. The reason we’re talking about Jack Parsons is because of his contributions to science. Nothing is black and white -- It’d be easy enough to tell you just about Parsons calling himself the Antichrist, or leading a cult that held short masses involving a priest and priestess having sexual relations while the rest of the Thelemites watched, but that’d be doing a disservice to history, because in reality, Parsons was instrumental in pushing rocket research forward when the field was incredibly stigmatized and the idea of space travel was regarded as fantasy. He’s also responsible for making developments in the use of solid fuel for rockets. Solid fuel is like a powder or a block of powder instead of a liquid fuel like gasoline. Solid fuel rockets were one time use rockets, essentially, because once you light a solid fuel rocket, it doesn't stop burning until the fuel is depleted. This is in contrast to a fuel like gasoline that goes into a combustion chamber through tubes, so if you want to stop the rocket from receiving power, you just close those tubes. Jack Parsons developed and popularized the use of a lot of these solid fuels. And we still use solid fuel rockets today by the way (one way they are still used is for missiles and to give liquid-fueled rockets that extra “umph” during takeoff).

Jack was very progressive and open-minded, which is why he was open to Alister Crowley’s Thelema in the first place.

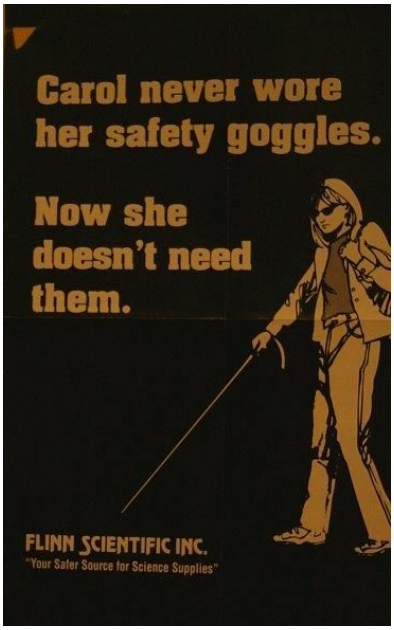
From a young age, Parsons was interested in magic, and I don’t mean like “pulling a rabbit out of a hat” magic. No, as a kid he attempted to summon Satan into his bedroom. He claimed to have succeeded, but ironically stopped because he was too frightened.

Today of course, rocketry is accepted as a science. That is, the study, observance, and search of explanations to how the physical, natural world works. But back then, space travel was considered just science fiction. So to Jack, magic and rocketry had the same appeal: they seemed impossible and were stigmatized by society as rubbish.

So we don’t need to embellish the story of Jack Parsons to make it fitting for Halloween.

Jack faced a lot of hardships throughout his life, but he never let that hold him back. As a kid, he didn’t have many friends and was bullied, but he was also very bright, and was interested in explosives. When his mom sent him to military school thinking it would be good for him, he thought otherwise, and typical Jack found an unconventional but effective solution: he got himself kicked out by literally blowing up toilets at the school.

Now, if you have a science degree, chances are you’ve seen this poster:



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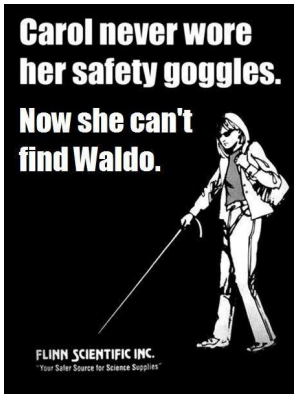
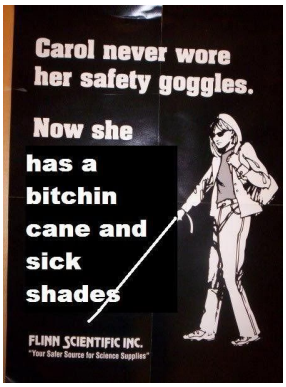
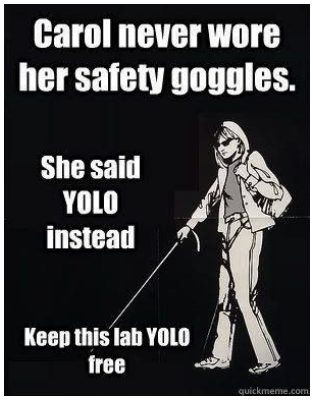
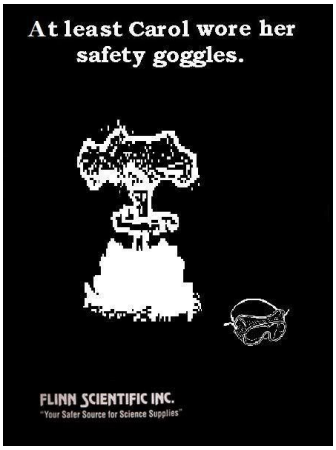
And all the memes it became:









Jack Parsons embodied why these posters exist.

Later on in his life -- Jack Parsons, his childhood best friend Ed Foreman, and CalTech student Frank Malina were given the go ahead from a CalTech professor, thanks to Frank Malina's connections with the university, to use their chemicals and equipment for research. Which led to them, on a single Saturday, killing a section of the campus lawn by spilling a tank of liquid nitrogen tetroxide, as well as flooding the science building with gaseous nitrogen tetroxide and methyl alcohol fumes that rusted all metal equipment in the building. After having to clean all the equipment in that building, CalTech gave them an area on the far side of campus as a place to perform their apparently destructive experiments. Here, they earned the nickname "Suicide Squad" because of the frequent explosions heard coming from their outdoor lab, garnering the attention of the student body, staff, and outside journalists. So frequent in fact, that his crew was

finally forced to move their experiments far from campus in the vast open desert, where there was less infrastructure for them to destroy.

During World War II, Parson's was contracted by the government to build jet propulsion for bomber planes. But toward the end of World War II came the Red Scare, where Parsons had his security clearances taken away because it came to he had hung out with people associated with the communist party prior to the war -- mostly for intellectual conversation as opposed to political affiliation. When Parsons could no longer pursue his passion for rocketry, he channeled that passion towards Thelema. Generally, the worse Jack's mental and social state, the more extreme his escapades into sex magic became.

One of the things that he was trying to do was basically create an elemental -- a being of a certain element like fire, water, or earth -- to be his lover. He performed rituals where he believed he had to climax on a series of relics while chanting, which disturbed his roommates who, while technically Thelemites, may have really just been in it for the sex orgies as this was the climate of California at the time. Ed Forman, whom also associated with this cult, claimed that during these times Jack summoned banshees -- shrieking female supernatural beings that are said to be an omen of death. I think though this was likely a bad case of tinnitus, a ringing in the ears. Forman continued to claim he heard banshees throughout his life -- not just when around Jack, and he did work with explosives that could cause hearing problems.

As part of his pursuit to summon an elemental, Parsons actually went into the desert with L. Ron Hubbard -- who later founded Scientology -- and masturbated while chanting and listening to opera music. During these times, Parsons documented his beliefs in writing. In one of his books, *The Book of Babalon*, he proclaims:

"An end to restriction and inhibition, for I, THE ANTICHRIST, am come among you preaching the Word of the BEAST 666, which is,

'There is no law beyond Do what thou wilt.'

And I, BELARION, ANTICHRIST, do lift up my voice and prophesy, and I say:

I shall bring all men to the law of the BEAST 666, and in His law I shall conquer the world.

And within seven years of this time, BABALON, THE SCARLET WOMAN HILARION will manifest among ye, and bring this my work to its fruition"

When a red haired woman in a fiery red Dress showed up to join the House of the Thelemites, Jack believed her to be the fire elemental he had summoned. The two married and after some years planned to go to Mexico to start a new life together.

Him and his beloved packed up all their belongings, and Parsons transferred the lease of his house to some friends, since it'd be no use to him while in Mexico. The day before they planned to depart, Parsons got a request from a special effects company he'd been creating explosives for. Parsons explained that all his equipment was packed up and that he was leaving the

country in a matter of hours, but the company was insistent that Parsons help them out one last time. Typical Parsons, he had all of his explosives stored in the shed of the house he was leaving behind. With his proper equipment packed up, he went to the shed and started mixing up the requested explosives in an old coffee can, a move which OSHA would be proud of for sure. The little boy, who was part of the family obtaining the lease, came to the shed to observe the mad scientist. On his way back inside, he lightheartedly said, “Don’t blow us all up Jack!” Before finishing the product, the coffee can slipped from Jack’s hand. He reached to catch it, but-- as coffee cans filled with explosives do-- when it hit the ground it blew his arm and half of his face off. Unfortunately, Jack was still alive when they found him, but he died from his injuries later that day.

So in conclusion, wear your safety goggles.

In all seriousness though, I don’t want to scare you away from science. Wear your safety goggles, and don’t mix explosives in a coffee can in your shed. And if you read our supplementary info on Jack Parsons after the show, I bet you’d find him inspiring -- ignoring personal-life and haphazard safety habits, of course. But who knows where we’d be today if he hadn’t studied rockets.

Resources for Section 4:

Real life “mad” scientists article, include Tesla and Jack Parsons: https://www.bestcollegereviews.org/10-incredible-real-life-mad-scientists/#:~:text=1.,zaniest%20scientist%20who%20ever%20lived.

Further reading on solid fuel rockets: https://en.wikipedia.org/wiki/Solid-propellant_rocket#:~:text=Solid%20rockets%20are%20still%20used,for%20their%20simplicity%20and%20reliability.

All memes are from: https://knowyourmeme.com/memes/carols-safety-goggles

All information on Jack Parsons was learned from: *Strange Angel: The Otherworldly Life of Rocket Scientist John Whiteside Parsons* by George Pendel.

Section 5: The Heat Death of the Universe

But studying the universe makes you very aware that nothing we experience is forever-- not our lives, not the human species, not life on earth, not earth itself, our solar system, any solar system, galaxies-... Through science though, not only do we know that these things will end, we also have an idea how, and after learning how everything will come to an end, you can decide for yourself if you’d prefer to live forever.

Because, even if the human race doesn’t exterminate itself or get wiped out by an asteroid like

what happened to the dinosaurs, we live on a doomed planet. If nothing else kills us, what will definitely kill us is the evolution of our sun.

Our Sun has an enormous amount of gravity, because it has so much mass-- so much stuff that makes it up. This gravity pushing in on our sun causes the nuclei-- the center parts of hydrogen gas particles -- to fuse together, making helium.

When this happens -- when hydrogen nuclei slam together and become helium -- a tremendous amount of energy is released, and that energy pushes outward against the enormous force of the sun's gravity.

But eventually, our sun is going to run out of hydrogen to burn. When that happens, there's no energy from fusion to push back against the force of the sun's gravity, so gravity gets the upper hand. It'll press in on the core of our sun -- now made of helium -- until that helium starts to fuse into other elements, which releases even more energy than hydrogen fusing into helium, so then that energy pushes back against gravity, but more so this time.

So much so in fact, that our sun's atmosphere, or envelope, grows from the outward energy of helium fusing into other stuff. At this point, our sun will be what is called a red giant. It's going to swell, engulfing Mercury, Venus, and either getting very close to Earth or engulfing earth as well. Before you let out a sigh of relief because the sun might not swallow Earth -- once the sun is that large and that close to Earth, Earth will not be habitable. Like what happened to Mars so long ago, our atmosphere will be sheared off, our oceans will boil away.

That's Earth's fate in about six-billion years, but the Earth will begin to be uninhabitable in about one-billion years. And with our current technology, there's nothing we can do about that. Now, people sometimes say to me, "A billion years is a long time; what if we come up with a way to travel to another planet by then?" But we could only avoid the inevitable for so long.

For our solar system, eventually the sun will run out of helium to fuse, but unlike when it runs out of Hydrogen and starts fusing helium, once helium is fused into heavier elements, those heavy elements won't have enough pressure in our Sun to fuse further. That means once again, there'll be no energy pushing out against the sun's gravity. The core of our sun will collapse again. It'll push inward, until the electrons at the sun's core are forced close enough together that they repel and push outward against the gravity, much like when you put two negatively charged magnets together and can feel them seem to push away from each other. The outer envelope of the sun is pushed further and further outward, creating what is called a planetary nebula-...

A roughly spherical cloud of gas and dust that surrounds the exposed core, like a quiet ghost of what used to be. The core left behind is now called a White Dwarf. This will be the fate of our sun and of any low or medium mass stars (less than 8 times the mass of our sun). But not all stars go out so quietly.

For stars that are 8 to 25 times the mass of our sun-- more mass means more gravity. When these stars run out of helium to burn, they DO have enough strength to fuse heavier elements. And when that particular star has fused the heaviest elements it can in ITS core -- then the core begins to collapse yet again. The star is so massive that the gravity is so great that it doesn't care that these electrons don't want to be close to each other. This gravity collapses the core to such an extent that these electrons are now not only forced to be near each other, but forced to be closer to protons as well.

So close that they essentially give their charges to the protons via the weak nuclear force, turning the protons into neutrons. The core becomes a dense, solid ball of neutrons called a neutron star.

Now with white dwarf stars, as I said you have radiation that overcomes the force of gravity and gradually pushes the star's envelope from the core, creating a planetary nebula. But with these more massive stars that create neutron stars as their stellar corpse, the point at which the core stops collapsing is not a soft-stop where the forces within reach an equilibrium with the force of gravity. No, instead gravity slams these neutrons together. And since you can't have two objects occupying the same space, the neutrons just get as close as they can to each other until they suddenly halt, and blast a tremendous amount of energy outward. This is what's called a core shock. Newton's third law of energy is that for every action, there is an equal and opposite reaction.

So the action of gravity slamming the neutrons together leads to the reaction of that energy having to go somewhere once the neutrons suddenly have nowhere else to go-...

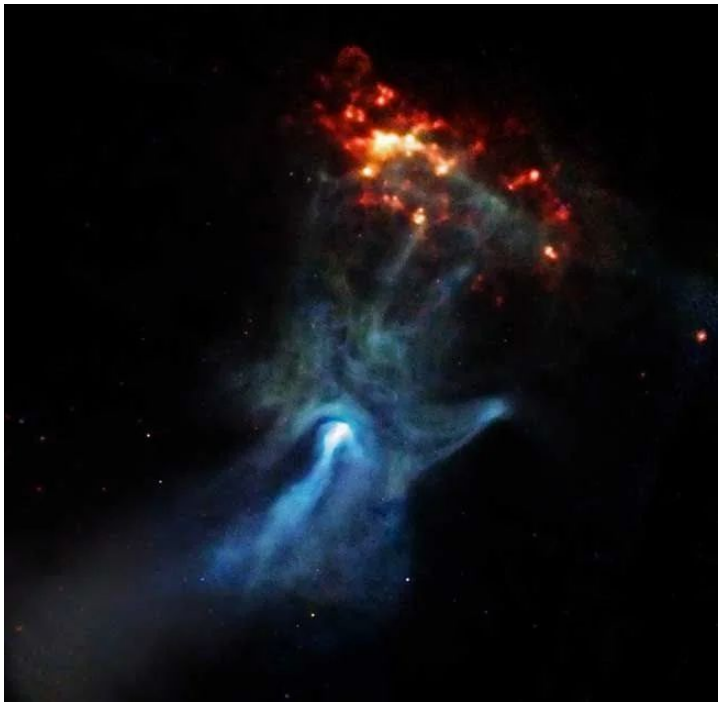
and since it can't go inward, it goes outward -- an explosion of energy called a supernova that blasts the star's envelope to smithereens, creating a much more chaotically shaped Nebula surrounding a rapidly rotating neutron star.

The shape of these nebulae are totally random-- just however the dust and gas ended up as a result of the core shock explosion-- but they can randomly end up in some pretty spooky shapes.

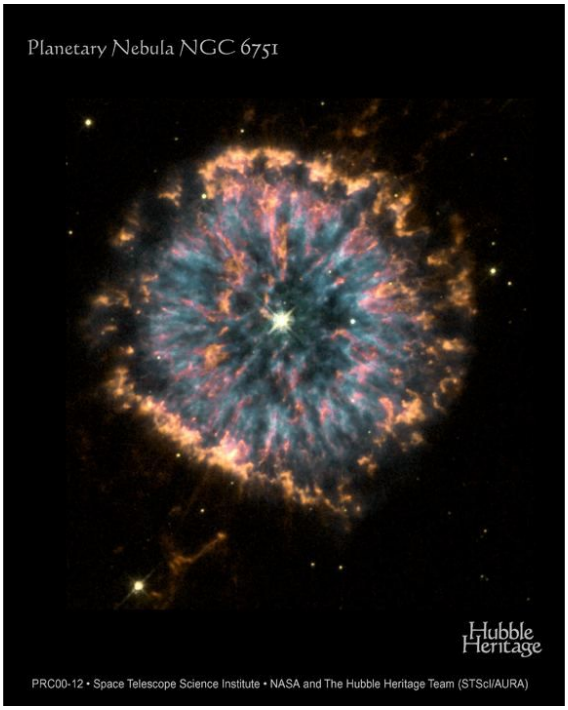
Like this nebula (SH2 136,https://apod.nasa.gov/apod/ap061031.html) that to me looks like people screaming and flailing as they're sucked into a mist.

Or this one:
(NGC 6960, https://www.space.com/23402-halloween-photos-wizard-nebula-witch-broom.html) nicknamed the "witch's broom" nebula, which was created from a supernova that occurred about 9000 years ago.

Or this one (PSR B1509-58, https://www-space-com.cdn.ampproject.org/v/s/www.space.com/amp/13264-spooky-nebulas-space-halloween-photos.html?usqp=mq331AQFKAGwASA%3D&amp_js_v=0.1#aoh=16036831625240&csi=1&referrer=https%3A%2F%2Fwww.google.com&amp_tf=From%20%251%24s&ampshare=https%3A%2F%2Fwww.space.com%2F13264-spooky-nebulas-space-halloween-photos.html)
that took the shape of a hand reaching toward its neighboring gas cloud (shown as red).



And while we're looking at nebulae, this (NGC 6751, https://hubblesite.org/contents/media/images/2000/12/956-Image.html?news=true) is actually a planetary nebula that can be found in the constellation Aquila. And while in a telescope it'd just look like a pinpoint of light, when photographed using the Hubble space telescope, it's revealed that it looks like a giant eye, watching the universe:



So for stars less than 8 times the mass of our sun, the collapse of their core yields a white dwarf and a planetary nebula. For stars 8 to 25 times the mass of our sun, the collapse of their core yields a neutron star and a supernova explosion that creates these chaotically shaped Nebula. But there are stars greater than 25 times the mass of our sun. Earlier I said that two objects cannot occupy the same place in spacetime. But with these most massive stars, their gravity is so great, that it, in a sense, *does* force these neutrons to occupy the same space. Gravity forces them to keep compressing, ripping a hole in space time-...

A black hole.

The amazing part about this is that once you push past that neutron point, we don't know of anything that would stop the collapse after that. So for all intents and purposes, as far as we're aware, black holes are collapsed stars that never stop collapsing--- they collapse infinitely, making them infinitely dense. The gravity of the black hole is so strong, that not even light can escape it, which is why it appears black.

If you were on a space mission, and one of your fellow astronauts floated away from the ship and was pulled toward a black hole, you'd see them float further and further from you, flailing for their life, until they appeared to just stop-- to freeze. That moment when you see your friend freeze is when they pass the event horizon of the black hole. The point at which you'd have to be traveling faster than the speed of light to escape. You see your friend freeze because your view of him had been the result of light reflecting off of him and entering your eyes, but once he passes the event horizon, the light reflecting off of him can not escape the black hole and reach your eyes.

He will then eerily start to turn red and translucent, slowly fading away.

But in comparison to your emotional anguish, what your friend physically experiences during this is arguably worse.

As he gets further and further into the black hole, because it has infinite density, infinite gravity, the gravity at his feet is far greater than the gravity at his head. So his body is ripped in half. Then for each of his two halves, the bottom part of each half has greater gravity than the upper part of each half, so they get broken in half again so that your friend is now in four pieces. Each of those gets ripped in half, and this keeps happening until your friend is just a stream of atoms plummeting into the black hole. And this is a very real process that creative scientists call spaghettification.

Stars form and burn, and die, they create other stars that form and burn and die. But this cycle eventually ends when there's not really anything that can be used to create new stars. When this occurs, this is the down-slope for the universe.

The first things to go will be the more massive, hotter stars. Then medium mass stars. The last stars to go will be very low-mass red dwarf stars.

These stars will live upto one-hundred-billion to one-trillion years. Almost ten-to-one-hundred-times the age of our universe now.

Once the age of red-dwarf stars ends, they will also turn into white dwarf stars-...

and the remaining light in the universe will be from these remaining white-dwarfs. Starting at this point, for the next several quadrillion years, nothing new will occur. Just the faint glow of various dead remnants of former stars, laid stagnant in our universe as they grow dimmer and dimmer.

Eventually dying out themselves, not in a bang, and hardly with a whimper.

For an uncountable amount of years -- our universe will be dark and silent. Nothing giving off visible light, nothing forming, nothing living.

Until the first black-hole dies.

Eventually the universe will radiate the occasional light of black-holes exploding. Giving off tremendous amounts of energy as they do. That is, until the final black-hole explodes.

Once the last black-hole goes. Our universe will only be left with the dark husks of black dwarf stars and anything else that didn't fall into a black hole.

It's theorized that protons, the subatomic particles that make up all matter we know, will eventually decay. They'll be the last things to decay. With this, anything left will break down, evaporate until we have a sea of elementary particles. This is the last breath of the universe. As far as we know -- nothing new will form; nothing new will die. Everything that ever existed, everything that ever happened -- what's left of the universe will show no indication that anything had ever occurred. A silent husk, of what once was.

Resources for Section 5:

I learned the information in this section from my classes at Clarion University, but to learn more about this stuff yourself, check out the following resources:

White Dwarfs:
https://imagine.gsfc.nasa.gov/science/objects/dwarfs2.html#:~:text=A%20white%20dwarf%20is%20what,core%20of%20the%20star%20remains.

Book review of *The End of Everything (Astrophysically Speaking)*:
https://www.nature.com/articles/d41586-020-02338-w#:~:text=If%20the%20Universe%20holds%20enough,any%20life%20on%20nearby%20planets.

Heat Death:
https://phys.org/news/2015-09-fate-universeheat-death-big-rip.html

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I hope you've enjoyed this show, and I hope you have a spooky but fun Halloween. One final note, since we do primarily give astronomy shows, I have to mention that this is a particularly special Halloween, because it is the first time in 46 years that there's a proper full moon on Halloween, and this won't happen again until 2039 (Resource). Hopefully you can go outside after the show for a peek at that. As I mentioned if you want to learn more about anything I've talked about tonight, head over to FlyScienceGuyStarShows.com for access to a complete list of resources. If you have any questions please feel free to comment, and I'll stick around and do my best to answer. Anything I don't know the answer to, I'll do some research and post the answer in our supplementary show info, which will be posted within the next week. Being Halloween-themed, was a bit of a different format from our regular, astronomy-based shows, but if you're interested our next show in November will be about how to shop for telescopes-- just in time for the holiday season. If you enjoyed the show and have the means to do so, we have a donation button on our website, and your donations allow us to keep doing these shows. Our mission here at Fly Science Guy Star Shows is to promote learning and understanding by making people excited to ask questions. Never stop asking questions, never be afraid to ask questions, because there is still so much out there we can learn together.

Fly Science Guy Star Shows
Mission Statement

Hello fellow stargazers, question-askers, wonderers, learners, and curious cats!

One thing that never sat well with me was when people say, "I have a stupid question." I believe that is a knee-jerk statement because society makes us feel bad for not having all of the answers. You should never feel ashamed of being curious, and you should never have to fear asking questions. The universe is full of mysteries and science is about learning, so it doesn’t make sense to be embarrassed about not having all the answers. My mission is to promote learning and understanding by changing how people feel about asking questions.

I aim to make free and accessible astronomy content that entertains and inspires you to stay curious and keep learning. I try to make the live-streams interactive by encouraging guests to ask questions, which I’ll answer during the show. If I don't know the answer to a question, I'll research the topic afterwards and post the answer (along with references and resources) on our Facebook page, and on this site.

Check out the upcoming events so you can feed your curiosity at the next show!

James Sanders, The Fly Science Guy