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Why and How we should go to Space

On 21st Dec 2015, SpaceX finally guided a reusable rocket safely back to Earth after liftoff on Monday. Traditionally, rockets are disposed of after they detach from the spacecraft. The ability to recycle them marks a big step toward making space travel cheaper.

After three failed attempts at a rocket landing, it marks a major victory for SpaceX and CEO Elon Musk. Speaking to reporters, he said: “It’s a revolutionary moment. No one has ever brought a booster, an orbital-class booster, back intact.” Like the rest of us, Elon Musk has a handful of life goals. Unlike the rest of us, one of those life goals is to put 1,000,000 people on Mars.

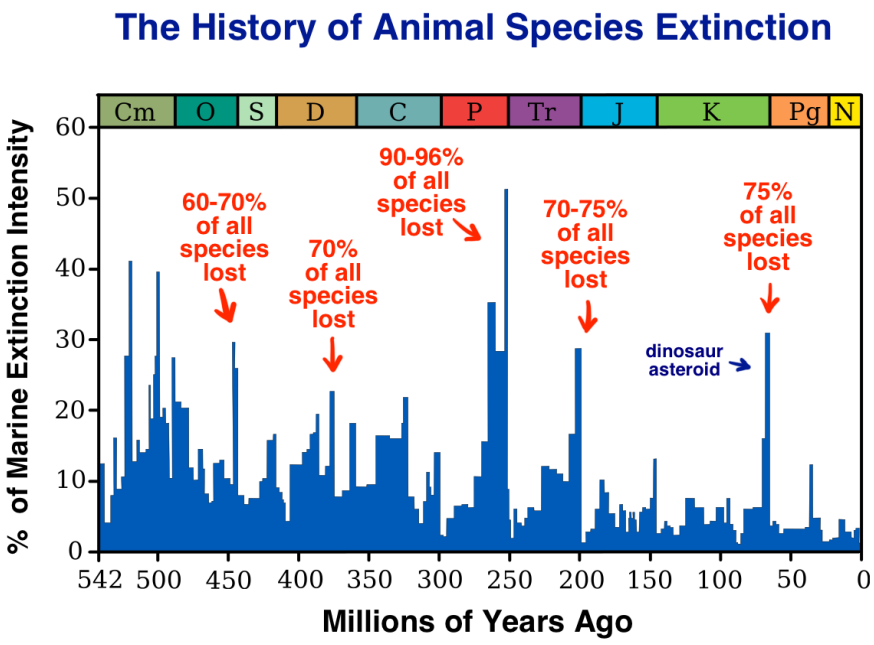
A long exposure photograph shows the SpaceX Falcon 9 lifting off from its launchpad (left) and then returning to a landing zone at Cape Canaveral

The rocket that was used, SpaceX Falcon 9, costs $300 million to develop. You might be wondering, why spend so much money on rockets? Why spend huge sums of money on Space travel in the first place? What does it have to do with me?

This first of two part article will try to explain why we should even think about travelling to Space:

The scary thing about the Universe

Species extinctions are kind of like human deaths—they're happening constantly, at a mild and steady rate. But a mass extinction event is, for species, like a war or a sweeping epidemic is for humans—an unusual event that kills off a large chunk of the population in one blow. Humans have never experienced a mass extinction event, and if one happened, there's a reasonable chance it would end the human race—either because the event itself would kill us (like a collision with a large enough asteroid), or the effects of an event would (like something that decimates the food supply or dramatically changes the temperature or atmospheric composition). The extinction graph below shows animal extinction over time (using marine extinction as an indicator). The five major extinction events are labelled and the percentage of total species lost during each one (not included on this graph is what many believe is becoming a new mass extinction, happening right now, caused by the impact of humans):



Naturally-occurring extinction events can be caused by a lot of things. The universe is a violent, hostile place and we're a group of fragile organisms living in a delicate balance of precise conditions. We're around, for now, because the universe is currently allowing us to be. Some things that might wipe us out:

- **A nearby supernova.** Supernovae, the universe's largest explosions, happen when giant stars die. If one went off within 30 light years of us—which happens about once every 250 million years—it would probably do us in.

- **A gamma-ray burst.** Gamma-ray bursts are the universe's brightest events. They occur when a massive star's core fuses into heavier and heavier elements until it eventually can't fuse anymore and the star collapses into a black hole, ejecting a two-way burst so ridiculous that it releases as much energy in a few seconds as the sun will over its 10-billion-year lifetime. Gamma-ray bursts are much rarer than supernovae, happening in each galaxy only a few times in a million years, but unlike a supernova (which happen about twice a century in a galaxy like ours), a gamma-ray burst could badly ruin our day from much farther away, anywhere in our galaxy—if it happened to be pointed in our direction. It's hypothesized that the first of the five mass extinctions on the chart above may have been caused by a gamma-ray burst.

- **A solar super flare.** Solar flares happen all the time, and the Earth's magnetic field typically shields us from them (this is what produces the Northern Lights), but we've observed in other sun-like stars the occasional super flare *millions* of times more powerful than a normal solar flare.

- **The reversal of the Earth's magnetic field.** This can happen at any time, whenever the Earth's magnetic field is craving attention—on average it happens about once every half a million years. The reversal itself isn't the problem—it's the *transition* that's dangerous. While the field is in the process of reversing, there is a stretch of time between 100 and 1,000 years long during which the magnetic field is reduced to about 5% of its normal strength. Since we rely on the magnetic field for protection, this can be devastating for life. Scientists have shown links between magnetic field reversals and mass extinction.

- **A rogue black hole.** Once in a while, one of these creeps wanders into a solar system uninvited and wreaks havoc. Even without passing close to the Earth, if one passed even as close as a billion miles from us, it would fling the Earth into a more strongly elliptical orbit, turning our summer temperatures up to about 65 °C and our winter temperatures down to around -45 °C. Not okay.

- **Aliens** As late physicist Gerard O'Neill sums it up: "Advanced western civilization has had a destructive effect on all primitive civilizations it has come into contact with, even in those cases where every attempt was made to protect and guard the primitive civilization. I don't see any reason why the same thing would not happen to us.

- **An asteroid.** We can be hit by an asteroid that's been nudged out of its normal orbit by a collision or some gravitational perturbation (probably caused by either Jupiter or a passing star).

An asteroid doesn't need to be huge to ruin everything. In 1908, a tiny, 60-meter asteroid exploded in the sky 5 to10 km over Siberia. Even from way up there, it flattened 80 million trees. If it had made it down to the Earth, it would have exploded with the force of over 1,000 Hiroshima atomic bombs. An asteroid with a diameter of only 0.8 km would kick enough dust up in the air to lower the Earth's temperature by multiple degrees for multiple years, which would have all kinds of dramatic effects. In 1989 an asteroid about this size passed through the Earth's orbit, exactly in the spot the Earth had been in six hours earlier.

The famous asteroid that made the dinosaurs sad was about 10 km in diameter. If we're hit by one of those, we'll be treated first to a searing wave of heat ten times hotter than the surface of the sun in the area near the impact site as the asteroid, racing down from the sky at 100 times the speed of a bullet, compresses the air beneath it. Then a nearly-instantaneous shockwave will ripple outwards, flattening everything for hundreds of miles in every direction. At that point, with the force of over a billion Hiroshima bombs, the blast will send a thousand cubic kilometers of rock from the asteroid and the impact site splashing upwards into space, creating a wall of black higher than the clouds in front of anyone in that part of the world. When all this rock rains back down through the atmosphere, it'll turn into thousands of huge fireballs, which will set cities and forests on fire all over the Earth. Soon, the entire Earth will be blazing hot, a chain of earthquakes will be set off, volcanoes all over will erupt, and unthinkably large tsunamis will pummel every coast. This will be followed by a worldwide cloud of dust that'll rise up and block the sun for months and maybe years, cooling the Earth considerably—and the climate won't be back to the way it is now for over 1,000 years.

All this from being hit by something that, if the Earth were the size of a three-story mansion, would be the size of a pea!

So even though it seems like we're on our safe little planet in a silent and still universe, it's actually more like being in a forest that's currently calm and peaceful—but where every once in a while, a terrifying bloodthirsty carnivore bursts out of the trees and ravages most of the life here, wiping it from existence. The mass extinction event graph above tells five horror stories from the past when our quiet Earth became the setting for an unspeakable nightmare for everything that lived here at the time. And it'll happen again—right here, where you sit. The only question is when.

Let's take a look at the 600 million-year history of animals and the mass extinction events along the way:

Looking at that timeline, we see that while there are definitely bad things looming in the future, the timescales in question are huge, so the probability of a catastrophic existential natural disaster happening in the near future is very low. How low?

To wrap our heads around it, let's surmise from the past that there's a good chance of a mass extinction event sometime in the next 50 million years, which means that there's about a 1 in 50,000 chance there will be one in the next 1,000 years. Proportionally, that's the same as someone drawing an X on the ground and telling you that it's likely that lightning will strike that one particular spot sometime in the next month. 1/50,000th of a month is about a minute, so the chances of lightning striking the spot in the next minute is the same as a mass extinction event happening on Earth in the next millennium. In other words, being on Earth over the next 1,000 years should feel as safe as standing in the lightning spot for the next

minute, knowing lightning will strike the spot sometime this month.

If a millennium is one minute in the lightning example, a human lifetime is about five seconds. So the question is, how would you feel stepping onto the X for five seconds? I wouldn't be especially thrilled to spend any time on the X, and those five seconds would probably be a little stressful—but I would also know that I'd almost definitely be fine. That's the way we should feel living on the Earth during our lives—at least as far as existential natural catastrophes are concerned.

And if you're just thinking about your own life, or even the lives of the next ten generations of your descendants, being bound to Earth is not a huge deal.

But if you care about humanity as a species, you have to think about things differently. If humans stay confined to Earth as a species forever, it's the same as a person who plans to stand right on the X for many months. Since the extinction graph above shows us that lightning strikes the X about every two months, that's not a great long-term plan—right? Maybe our technology can help us survive a few lightning strikes to the face, but it'll still be horribly unpleasant to go through it, and any single lightning strike has the potential to wipe us out.

Let's look at it another way. Let's imagine the Earth is a hard drive, and each species on Earth, including our own, is a Microsoft Excel document on the hard drive filled with trillions of rows of data. Using our shortened timescale, where 50 million years = one month, here's what we know:

- Right now, it's August of 2015
- The hard drive (i.e. the Earth) came into existence 7.5 years ago, in early 2008
- A year ago, in August of 2014, the hard drive was loaded up with Excel documents (i.e. the origin of animals). Since then, new Excel docs have been continually created and others have developed an error message and stopped opening (i.e gone extinct).

- Since August 2014, the hard drive has crashed five times—i.e. extinction events—in November 2014, in December 2014, in March 2015, April 2015, and July 2015. Each time the hard drive crashed, it rebooted a few hours later, but after rebooting, about 70% of the Excel docs were no longer there. Except the March 2015 crash, which erased 95% of the documents.

- Now it's mid-August 2015, and the homo sapiens Excel doc was created about two hours ago.

- Now—if you owned a hard drive with an extraordinarily important Excel doc on it, and you knew that the hard drive pretty reliably tended to crash every month or two, with the last crash happening five weeks ago—what's the very obvious thing you'd do?

"You'd copy the document onto a second hard drive."

That's why Elon Musk wants to put a million people on Mars.

But why develop reusable rockets?

To find out more, read Part 2 of Science Read next week!

Stephen Hawking has said:

I don't think the human race will survive the next thousand years, unless we spread into space … We face a number of threats to our survival, from nuclear war, catastrophic global warming, and genetically engineered viruses; the number is likely to increase in the future, with the development of new technologies, and new ways things can go wrong … We need to expand our horizons beyond planet Earth if we are to have a long-term future, spreading out into space, and to other stars, so a disaster on Earth would not mean the end of the human race. … Once we spread out into space and establish independent colonies, our future should be safe.

Princeton professor J. Richard Gott:

In 1970 everyone figured we'd have humans on Mars by now, but we haven't taken the opportunity. We should do it soon, because colonizing other worlds is our best

chance to hedge our bets and improve the survival prospects of our species. Sooner or later something will get us if we stay on one planet. By the time we're in trouble and wish we had that colony on Mars, it may be too late.

Find out more:

(1) http://money.cnn.com/2015/12/21/news/companies/spacex-launch-rocket-landing/

(2) http://www.theguardian.com/science/2015/dec/22/welcome-back-baby-elon-musk-celebrates-spacex-rocket-launch-and-landing

(3) SpaceX Falcon 9 1st Successful Launch/Landing on Target : https://www.youtube.com/watch?v=3G8GJQumBFs

(4) Discovery Channel - Large Asteroid Impact Simulation https://www.youtube.com/watch?v=bU1QPtOZQZU

(5) http://waitbutwhy.com/2015/08/how-and-why-spacex-will-colonize-mars.html/2