

# The End of the World

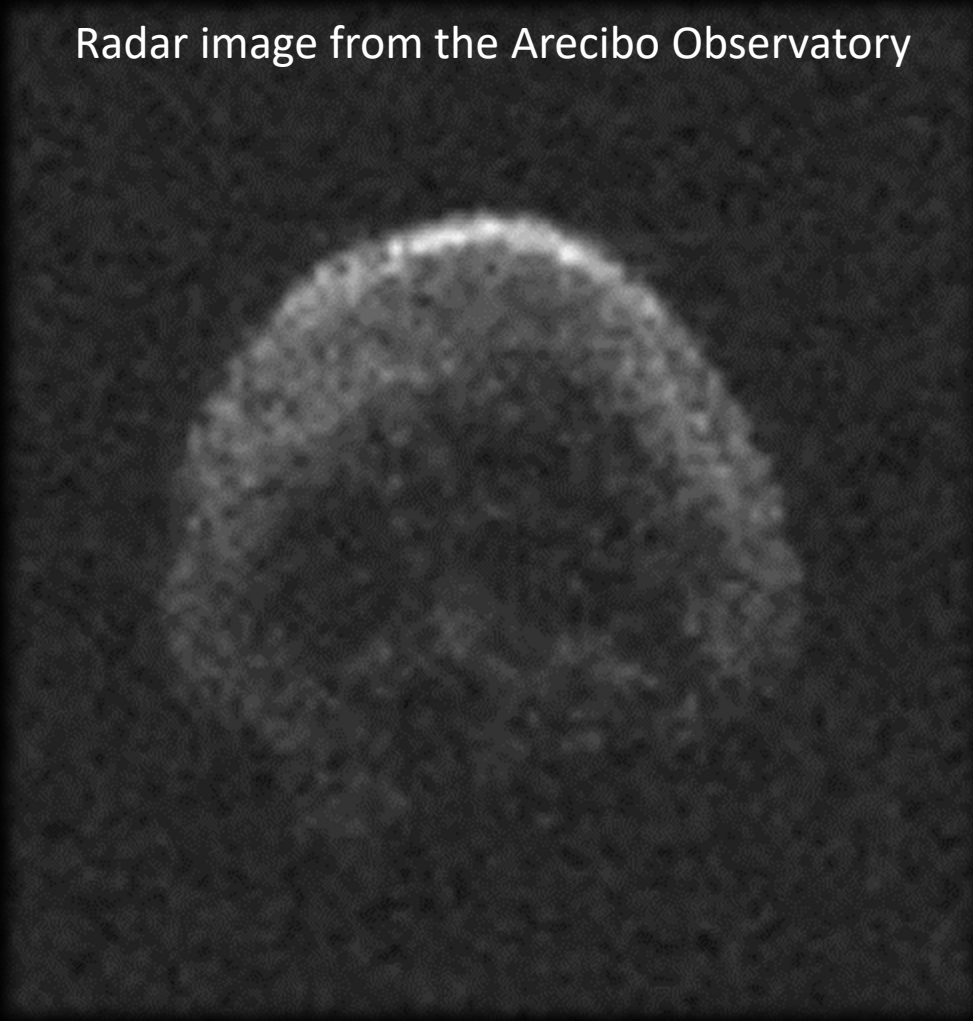


**Death from  
the Heavens**

**Asteroids,  
Existential Risk and  
Planetary Defense**

Week 8 Lecture | Professor Crews  
Religious Studies 357 W

Radar image from the Arecibo Observatory



Artist rendering of 2015 TB145

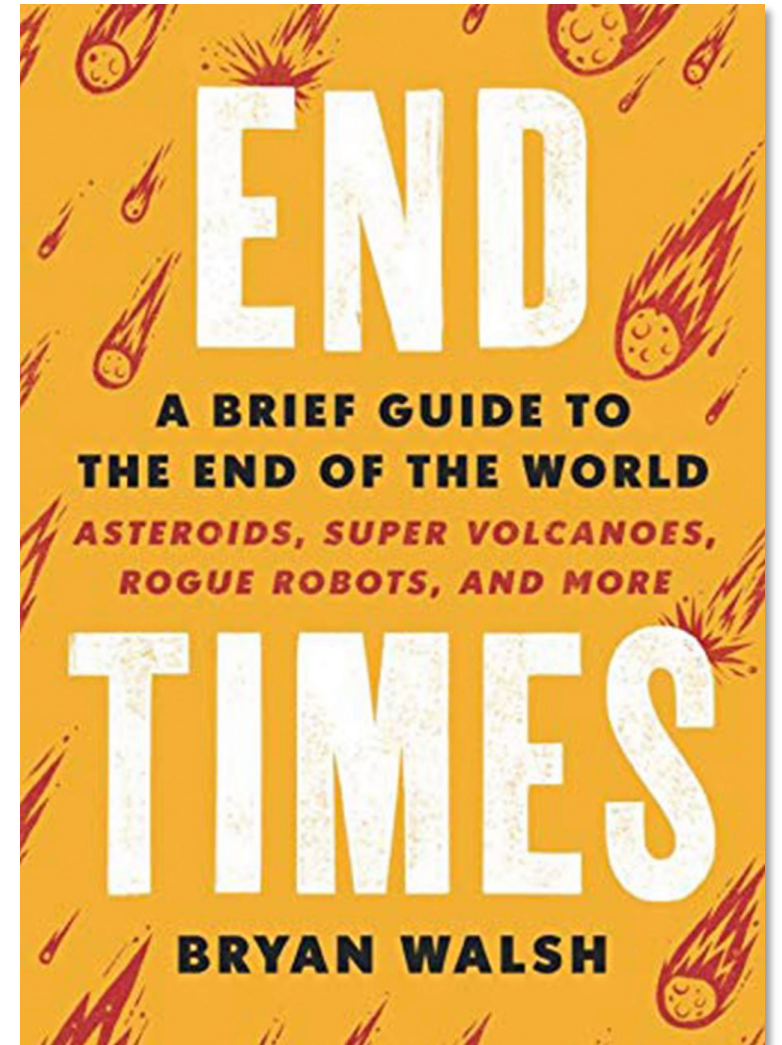


The 650-meter 2015 TB145 passed within 300,000 miles of Earth on Oct 31, 2015, putting it in the Potentially Hazardous Object category.

In *End Times: A Brief Guide to the End of the World*, author Bryan Walsh takes us through a wide range of possible end of the world scenarios, from asteroids and super volcanoes to killer robots and climate apocalypse.

Walsh is interested not only in what some of the more common end times scientific worries are, but also, how realistic these threats are and what we can do to address them. As he noted in the introduction to his book:

“If we don’t appreciate the present, it’s in part because we don’t fully understand the past— even as we make the mistake of assuming the future will be like the present... Risks that are most available to the mind are the ones that we care about, which is why so much of our regulation is driven by crisis, rather than by reason.”



## One in seven thinks end of world is coming: poll



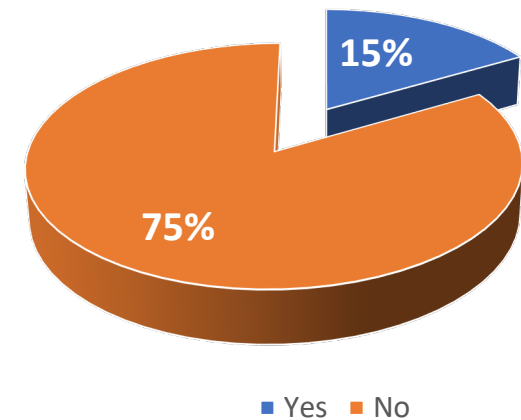
Nearly 15 percent of people worldwide believe the world will end during their lifetime and 10 percent think the Mayan calendar could signify it will happen in 2012, according to a new poll.

According to a researcher at Ipsos Global Public Affairs which conducted the Reuters poll: “Whether they think it will come to an end through the hands of God, or a natural disaster or a political event, whatever the reason, one in seven thinks the end of the world is coming.”

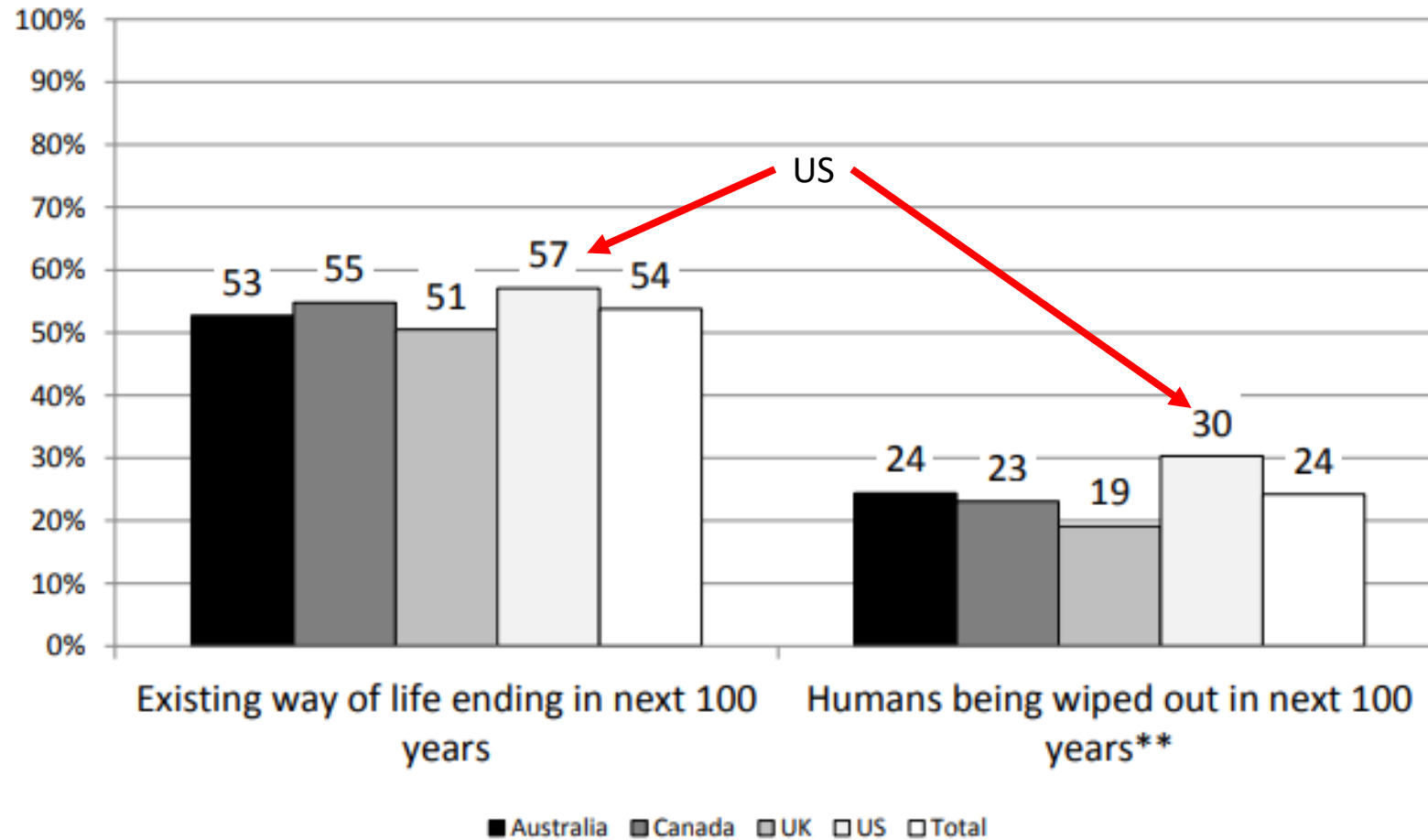
Factors for belief in an apocalypse during their lifetime, including on Dec 21, 2012, as well as those more anxious it may happen:

- People with lower education
- People with lower income
- People under 35

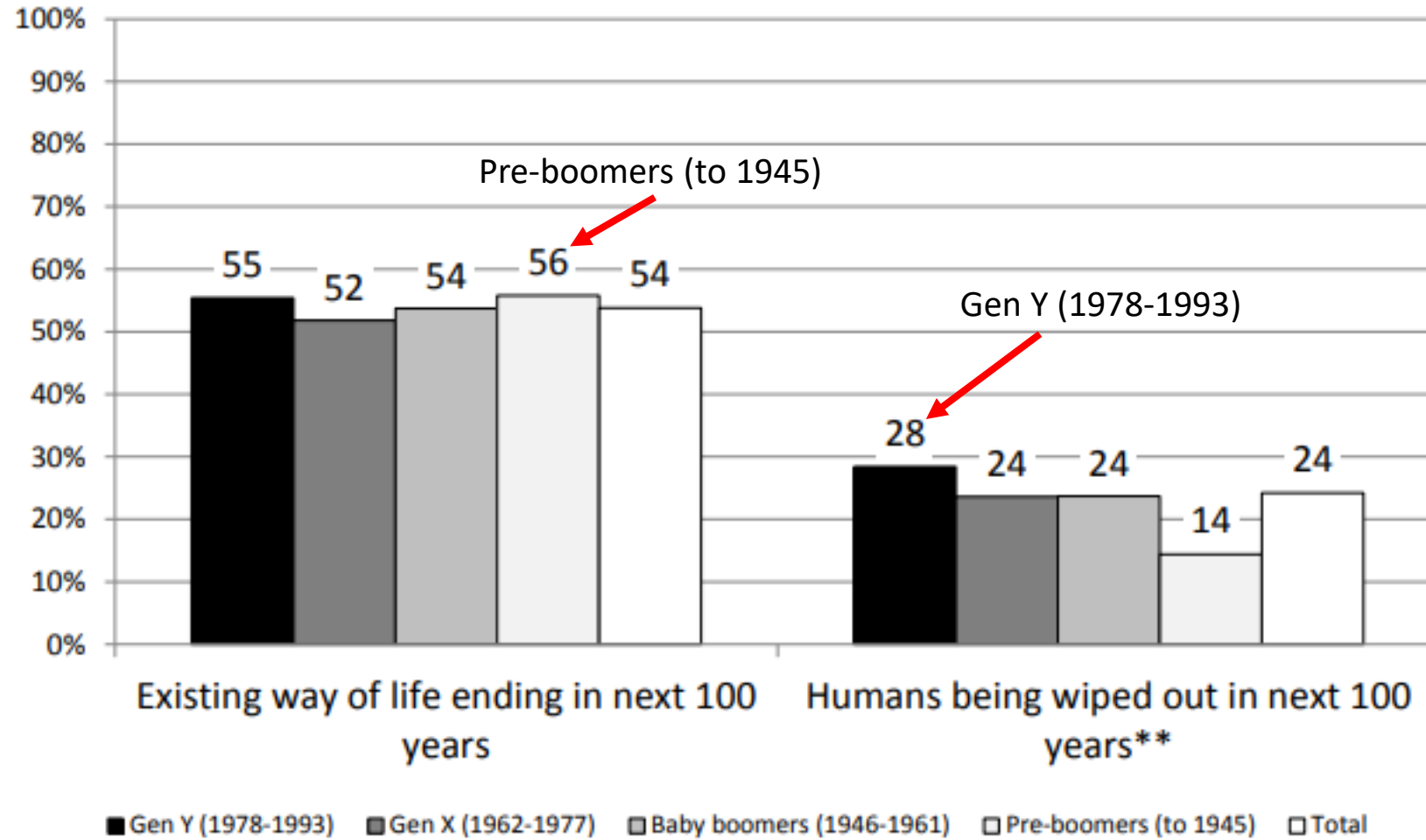
World Will End in My Lifetime



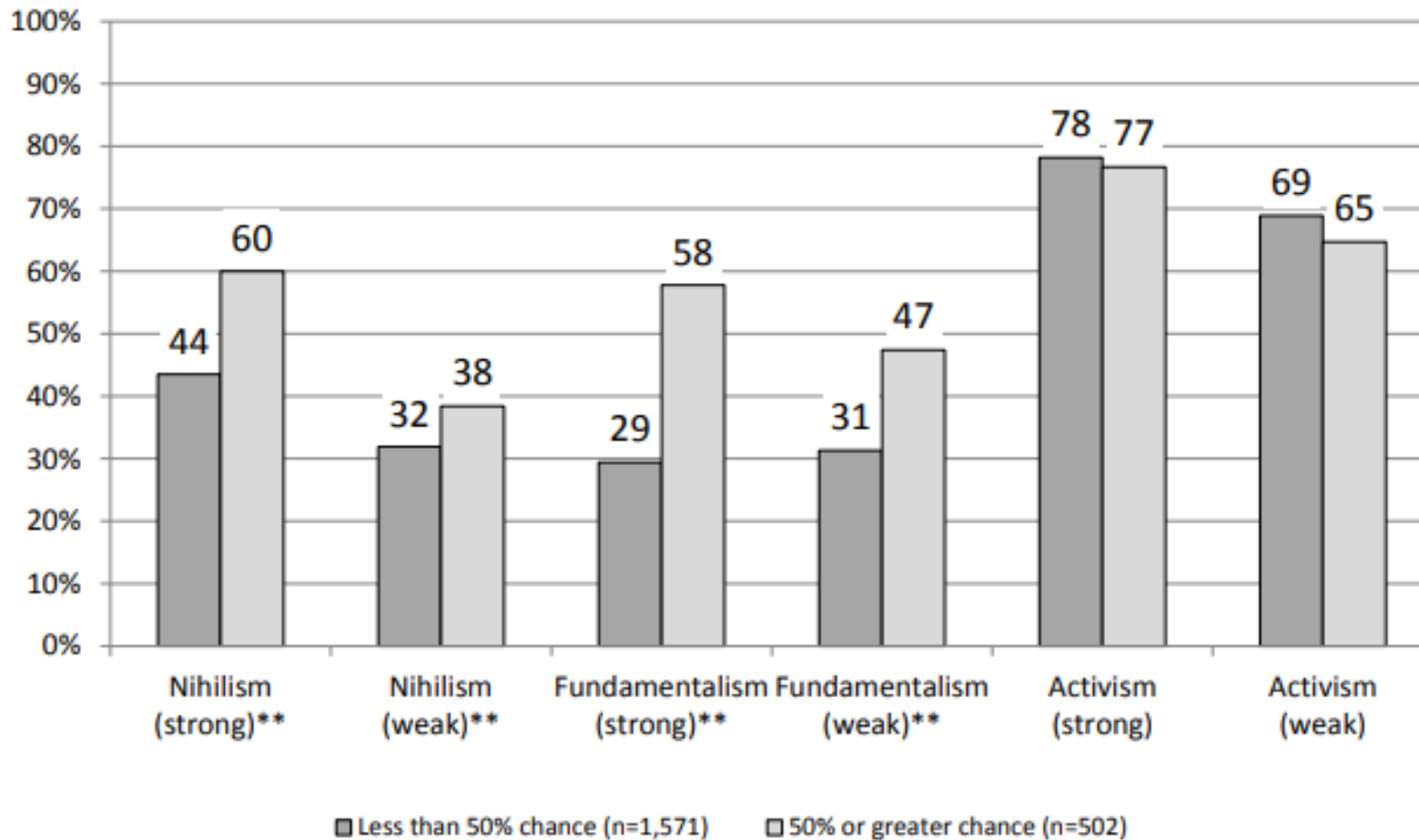
**Fig. 1: Proportion believing there is a 50% or greater chance of our way of life ending and humans being wiped out, by country**



**Fig. 2: Proportion believing there is a 50% or greater chance of our way of life ending and humans being wiped out, by generation**



**Fig. 4: Agreement with response to the future by likelihood of humans being wiped out – total sample**



**Nihilism Strong**: the world’s future looks grim so we have to focus on looking after ourselves and those we love.

**Nihilism Weak**: we should enjoy the life we have now, and not worry about what might happen to the world in the future.

**Fundamentalism Strong**: we are facing a final conflict between good and evil in the world.

**Fundamentalism Weak**: we need to return to traditional religious teachings and values to solve global problems and challenges.

**Activism Strong**: we need to transform our worldview and way of life if we are to create a better future for the world.

**Activism Weak**: hope for the future rests with a growing global movement that wants to create a more peaceful, fair and sustainable world.

As Walsh argues, many end of the world scenarios fall under the category of existential risk, which are “risks capable of putting an end to the existence of humankind, for all time. They are the mistakes we can’t recover from, the disasters that could end the human story in midsentence.”

Despite the seriousness of these risks, he argues humans as a species are poorly equipped to deal with them due to what psychologists refer to as the availability heuristic, which is the human tendency to be overly influenced by what we see and hear most often. In other words, whatever ideas are readily available to us daily—such as media stories about crime or terrorism, those common fear-inducing risks we have been exploring in recent weeks—those are the main risks we will focus our attention on.

But because these risks are most available to our mind, we tend to ignore or minimize more distant risks. Existential risks like asteroid strikes fall into this category because most people have no experience with asteroids. Humanity has never experienced a catastrophic asteroid event, so we don’t truly know the risk.

As Walsh points out, this bias towards risks we know “can also lead us to underreact to far greater dangers and threats that we’ve never experienced...These threats have no availability to us, so we treat them as unreal...Our failure to understand that the future could be radically different than the past is above all else a failure of human psychology. And that failure could prove fatal for our species.”



Humanity as a species has been incredibly lucky so far, given the fact that in the longer scope of history 99.9% of all life that has ever existed is now extinct. There have been 5 mass extinction events that wiped out all life before, leaving only a handful of species alive. Many scientists now argue we are in the middle of a Sixth Great Extinction, with species rapidly vanishing above historical baselines. While these past mass extinctions were natural, but now we have a new set of existential risks that we must worry about and which started with the first nuclear test at the Trinity Site on July 16, 1945.

“Nuclear war, though, is just the first man-made existential risk, one that has grown no less lethal even as it has receded from our attention. With every passing year, billions upon billions of tons of man-made greenhouse gas emissions are added to the atmosphere, increasing man-made climate change...Even more frightening— and far harder to predict or control— are the existential risks arising from new technologies like synthetic biology or artificial intelligence, technologies that could create threats we can hardly imagine, bombs that could explode before we even know they’re armed.”



These manmade existential risks pose a new set of challenges for humanity precisely because we have no prior experience with them to draw on, and thus our ability to evaluate their danger, and the risks they pose to our species, are underrated at best, and completely unknown at worst. This leads us to play down potential risks or decide they are mere statistical anomalies we can effectively ignore, such as estimates that humans have a 0.15 percent chance of going extinct from a natural catastrophe.

“There is a term for this, too: scope neglect, our psychological inability to scale up from the small numbers of a human-level story to the vast figures of mass death.”

Scholars trying to make sense of these challenges gave birth to the field of existential risk studies, which over the past few decades has become a growing field of inquiry spanning numerous disciplines.

One of the early sources of interest in these existential risk issues goes back to an example we already discussed, which was the Bulletin of Atomic Scientists and their creation of the Doomsday Clock in 1947. As we have discussed, the risks behind the Doomsday Clock have been shaped by two key questions:

- Is humankind safer or at greater risk this year than the last?
- Is humankind safer or at greater risk this year relative to the entire history of the clock?



PROD. *Niel deGrasse Tyson*

ROLL	SCENE	SHOT	TAKE

DIRECTOR *Elizabeth Rold*

CAMERA *Dustin Filimon* DATE *3/10*

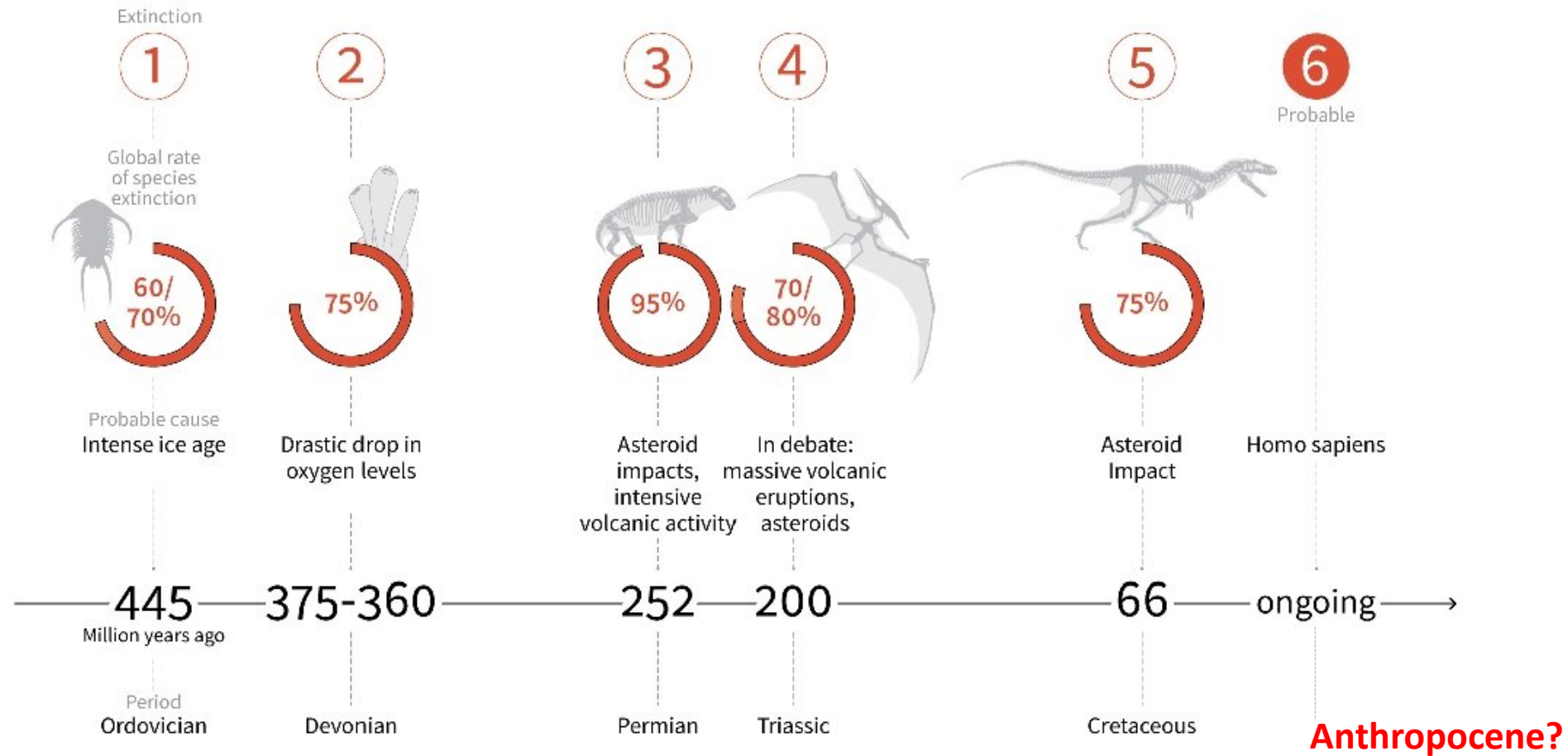
# Is the Universe Trying to Kill Us?



“This is a book about the threat of human extinction, but it’s impossible to begin the subject without considering the eradication of a group of animals that also once seemed secure in its reign over the Earth: the dinosaurs.”

# Earth's "mass extinctions"

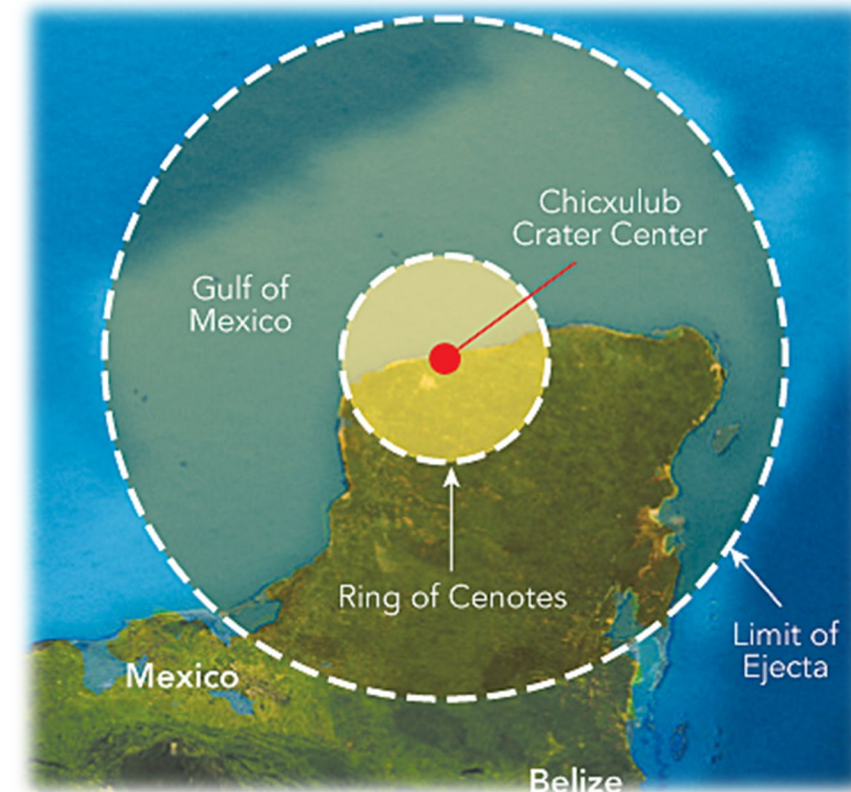
During the last 500 million years, Earth has experienced five periods when at least half the living creatures were wiped out



Arguably one of the most famous (infamous?) asteroids was the one that crashed off the coast of southern Mexico at Chicxulub and caused the end of the reign of the dinosaurs around 65 million years ago.

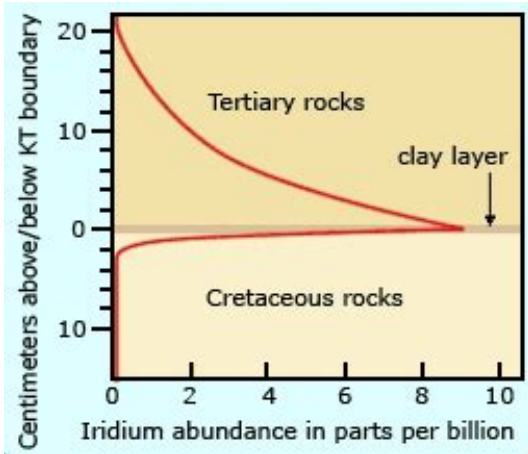
↪ (New York City to Chico, CA in 3.8 minutes)

- Approximately 6-mile-wide asteroid moving at 12.4 miles/second ↪ (2 Quadrillion – 1 Quintillion pounds!!!)
- Weight estimated between 2,204,622,621,848,800 and 1,014,126,406,050,448,000 pounds
- Created a 12-mile (20km) deep impact crater with a diameter of 93 miles (150 km)
- Impact energy around 100 million tons of TNT (6,500 x Hiroshima)
- 1,000 miles of vaporized rock shot into sky, puncturing atmosphere
- Small sand “spherules” rained down on every inch of the planet
- Thermal blast incinerates local area and caused global wildfires
- 4 inches of the ocean boiled off from the heat
- Sulfuric acid rained down on Earth from pulverized debris
- Global temperatures dropped (~50 F on land, 36 F over water)
- Up to 2 years with minimal sunlight (<1%)



But the idea of abrupt changes prior to the 1980s was not the dominant idea in geology. Rather, the leading theory was known as Uniformitarianism, the idea that evolutionary changes are gradual, a theory championed by famed British geologist James Hutton and summed up in the phrase “the present is the key to the past.” This idea has since come under question thanks to Catastrophism, the theory that the past involved a series of abrupt, radical changes that led to major shifts, such as the 5 mass extinction events mentioned earlier. Today most scientists agree that both factors played a role at different times.

The discoveries of a layer of iridium linked to the Chicxulub asteroid by father and son team Louis Alvarez and Walter Alvarez in 1980, combined with the impact crater discovery in 2001 and subsequent research, confirmed their theory of an asteroid impact as the primary cause of the K-T extinction event that wiped out the dinosaurs 65 million years ago.



Iridium layer

Starting in 1990, Congress began providing funding for NASA to study and track these Near Earth Objects and to develop contingency plans for what to do in the case of an asteroid headed for Earth, including the creation of NASA's NEO Program in 1998 and the subsequent Spaceguard Survey, whose mission was to track Potentially Hazardous Objects (PHOs) larger than 1 km (NASA has identified ~2,000 NEO so far).

**Near Earth Object (NEO)**: Asteroid that comes within 30 million miles of Earth's orbit (125 x Earth-moon)

**Potentially Hazardous Object (PHO)**: Larger asteroid that could break through atmosphere (100+ ft wide) and with an orbital path within 5 million miles of Earth.

**Asteroid**: An asteroid is a piece of rock debris floating that is orbiting the Sun. They are smaller than a planet, but larger than a meteoroid, and are found in the "asteroid belt" between Jupiter and Mars.

**Comet**: A comet is one of the smallest objects in the solar system and is made up of a mix of dust, ice, and gas orbiting the Sun. A comet heats up when traveling close to a sun, causing the ice to liquify, which is when the "tail" becomes visible. These originate in the Kuiper Belt and the Oort Cloud.

**Meteor**: A meteor is any object (comet or asteroid) that is falling through the Earth's atmosphere and is what we commonly refer to as a "shooting star," although it is not actually a star but a meteorite.

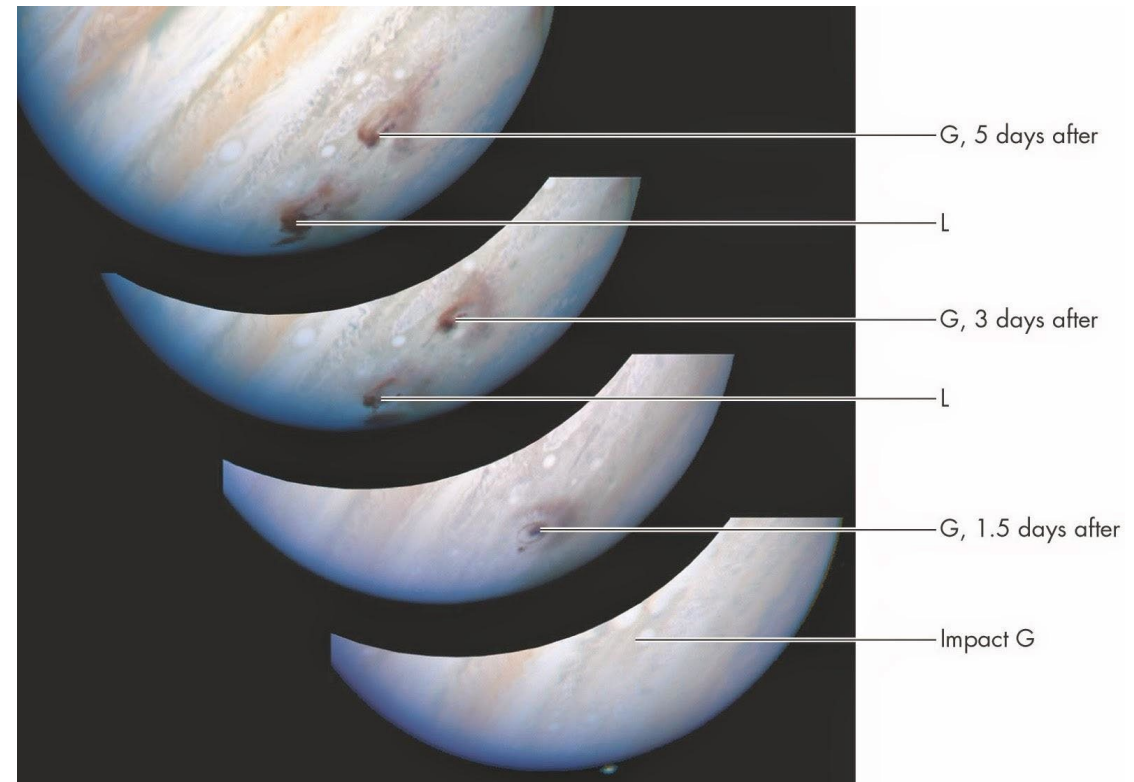


It's worth reminding ourselves that our knowledge of asteroids and other Near Earth Objects is quite recent. The first NEO was discovered in 1898, and the first positive identification of an asteroid in Earth's orbit was in 1932. Someone who is 90 today would have grown up with no basic knowledge of asteroids!

Remember the famous “one small step for man, one giant leap for mankind” moment when Neil Armstrong and Buzz Aldrin landed on the moon in 1969? That happened barely 50 years ago! .....or did it?

On March 24, 1993 astronomers Eugene Shoemaker, Carolyn Shoemaker, and David Levy were taking images of the night sky at the Palomar Observatory outside LA when they discovered an asteroid heading towards Jupiter—Shoemaker-Levy 9.

This was the first time scientists were able to directly see two space objects collide into each other. The impacts left an impression in the form of dark spots on the surface of Jupiter (~7,400 miles across) and fireballs shooting up 1,800 miles from the surface.



SCIENCE  
NASA @  
SOLAR SYSTEM

NEOs data is sent to the Minor Planet Center (MPC), the global clearinghouse for asteroid and comet data. The MPC has cataloged thousands of asteroids, including 8,000 NEOs in the 140-meter-plus category.

The largest asteroid event to date was at Tunguska, Siberia on June 30, 1908. The asteroid (~100 m/330 ft) exploded over a remote forest area with an estimated explosive power of 185-3,000 Hiroshima bombs. As Bryan Walsh notes, “The explosion annihilated more than 770 square miles of forest, pulverizing an estimated 80 million trees. It is the largest known NEO impact in recorded human history.”



**Account in *Sibir* newspaper from July 15, 1908:**

“[450 km/280 m away] peasants saw in the north-west, high above the horizon, a blindingly bright body of bluish-white color that was flying above for about 10 min...Having approached the forest the luminous body became blurred. There was an enormous mass of black smoke and a loud knocking, but not of thunder. The buildings were trembling and a fire of indefinite shape gushed out from the small dark cloud. All the village inhabitants ran from their houses in terror. Women were crying and everyone thought Armageddon had arrived.”

A more recent asteroid event, although nowhere as significant as Tunguska, occurred over Chelyabinsk, Russian in 2013. As author Bryan Walsh noted, “the Chelyabinsk meteor was the largest natural object to enter the Earth’s atmosphere since the Tunguska event, more than a century earlier. And scientists didn’t have a clue the asteroid was coming until it was too late...Chelyabinsk was a violent reminder for those in the NEO community that space can still throw things at us that we can’t see coming.”

The explosion caused over 1,500 injuries (shock waves & broken glass) and damaged over 7,200 buildings.

“The airburst from the 2013 meteor could have easily been mistaken for a nuclear strike by the United States, which was indeed the first reaction of many witnesses on the ground. Nuclear tensions between Washington and Moscow are even higher now than they were in 2013. It’s not difficult to imagine— but horrifying to picture— what a knee-jerk Russian reaction to a seeming nuclear attack could have led to.”

This is a good example of the risk of an accidentally triggered nuclear war as discussed in earlier weeks with several near-miss nuclear incidents between the US and Russia during the Cold War.



## NATIONAL NEAR-EARTH OBJECT PREPAREDNESS STRATEGY AND ACTION PLAN

A Report by the  
INTERAGENCY WORKING GROUP FOR DETECTING AND MITIGATING  
THE IMPACT OF EARTH-BOUND NEAR-EARTH OBJECTS

of the  
NATIONAL SCIENCE & TECHNOLOGY COUNCIL

JUNE 2018

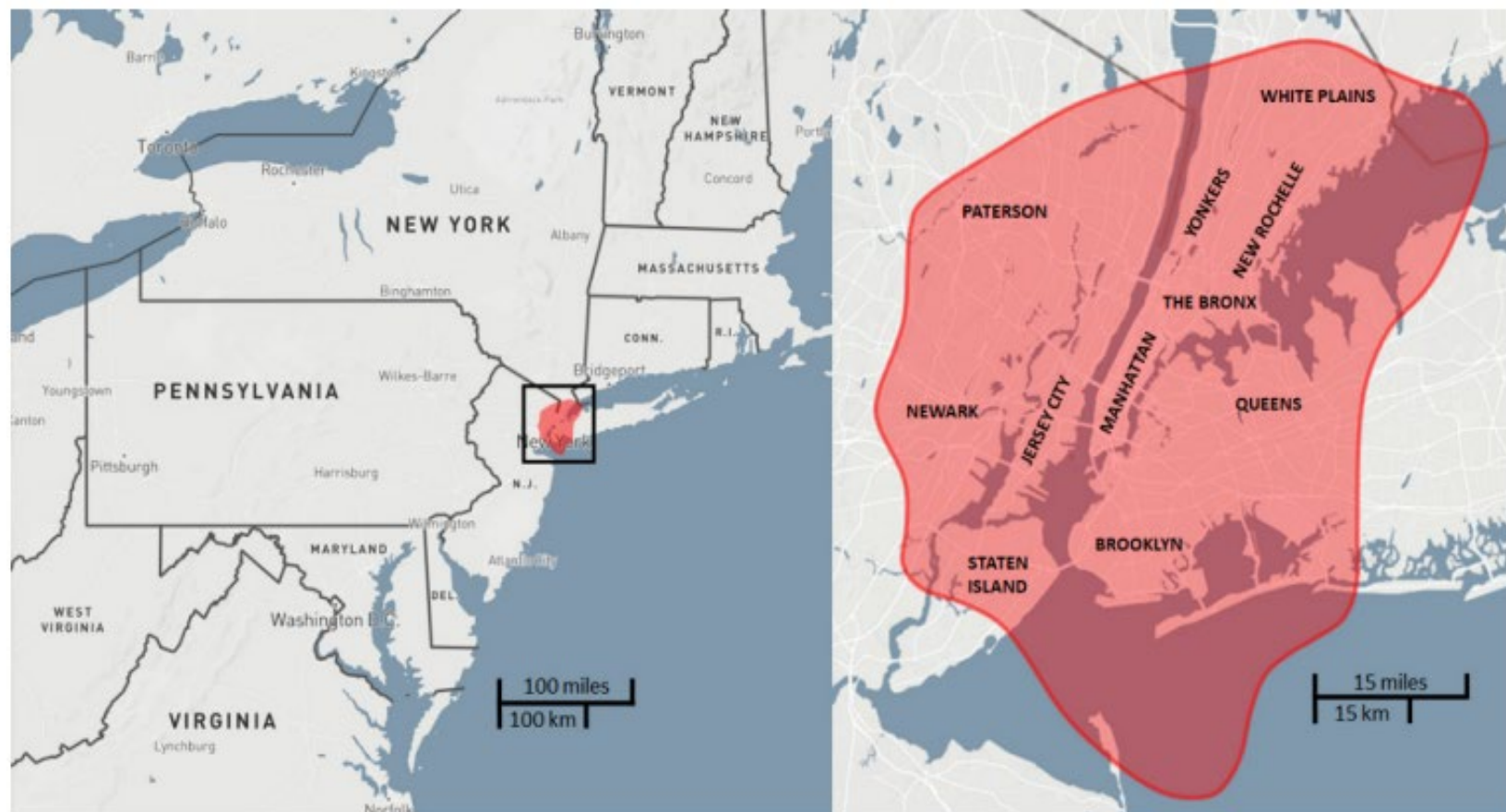


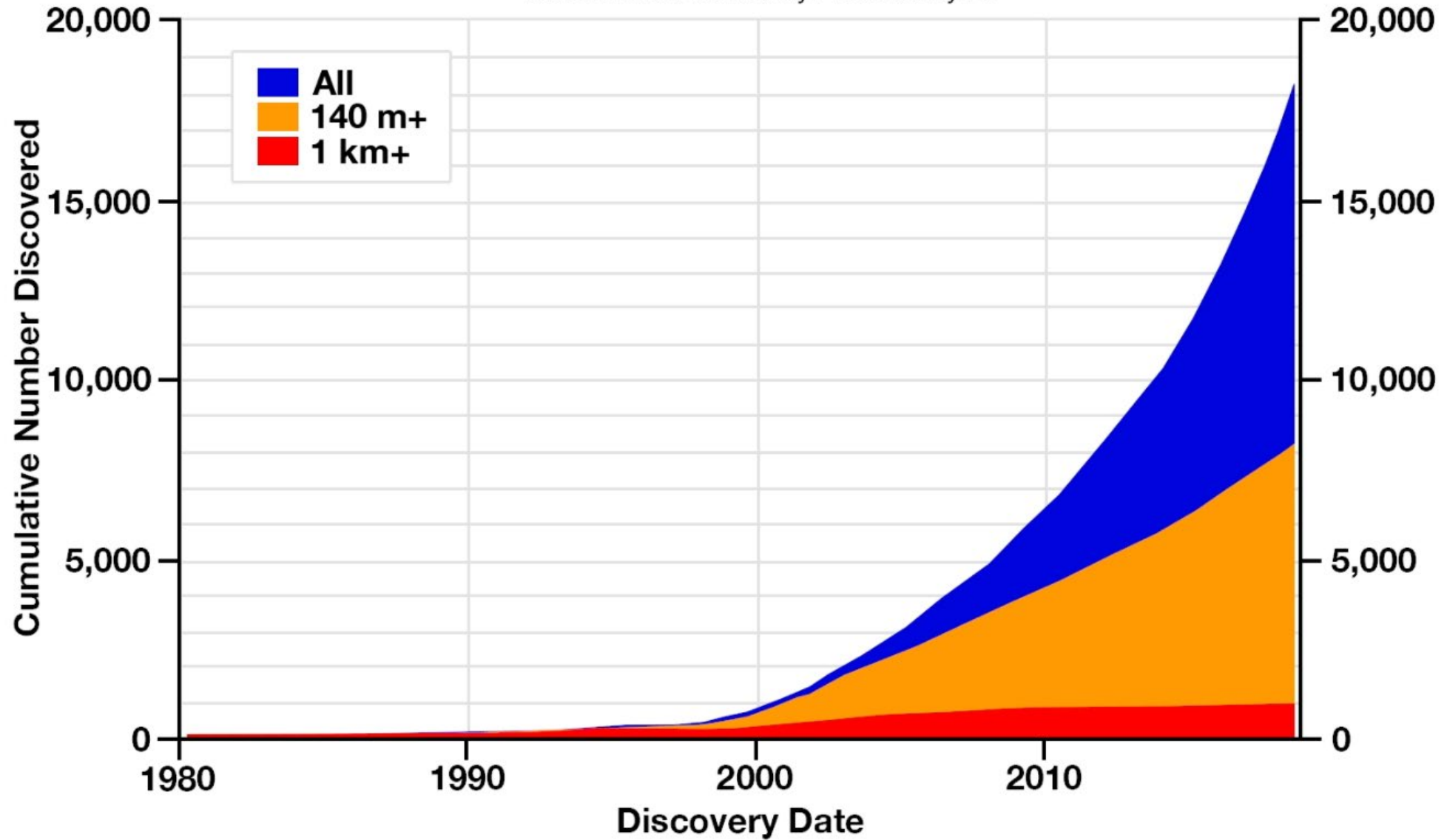
Figure 3: Equivalent area of destruction for a Tunguska-sized asteroid over New York City.

“If a similar event [to Tunguska] occurred over a major metropolitan area, it could cause millions of casualties (Figure 3). NASA estimates there are over 300,000 objects larger than 40 meters that could pose an impact hazard and would be very challenging to detect more than a few days in advance.”



# Near-Earth Asteroids Discovered

NEO Program began: 1998 July 1  
Most recent discovery: 2018 May 25



What all this suggests is that the likelihood of an extinction-level asteroid event occurring in the future is slim—once every twenty million years—but if it were to occur, it would wipe out most life on Earth.

As Bryan Walsh argues, the challenge with existential risks is that the cost of losing the world is so huge that it should justify spending any amount of money to try and fix it, but we simply don't see it that way. Instead of responding to an existential risk, we try to sweep it under the rug and minimize its chances.

**Existential Risk**: Probability of large asteroid strike minimal (0.000005 %). Global catastrophe most likely.

**Calculated Risk**: War between 2 nuclear powers predictable and preventable. Not a global catastrophe.

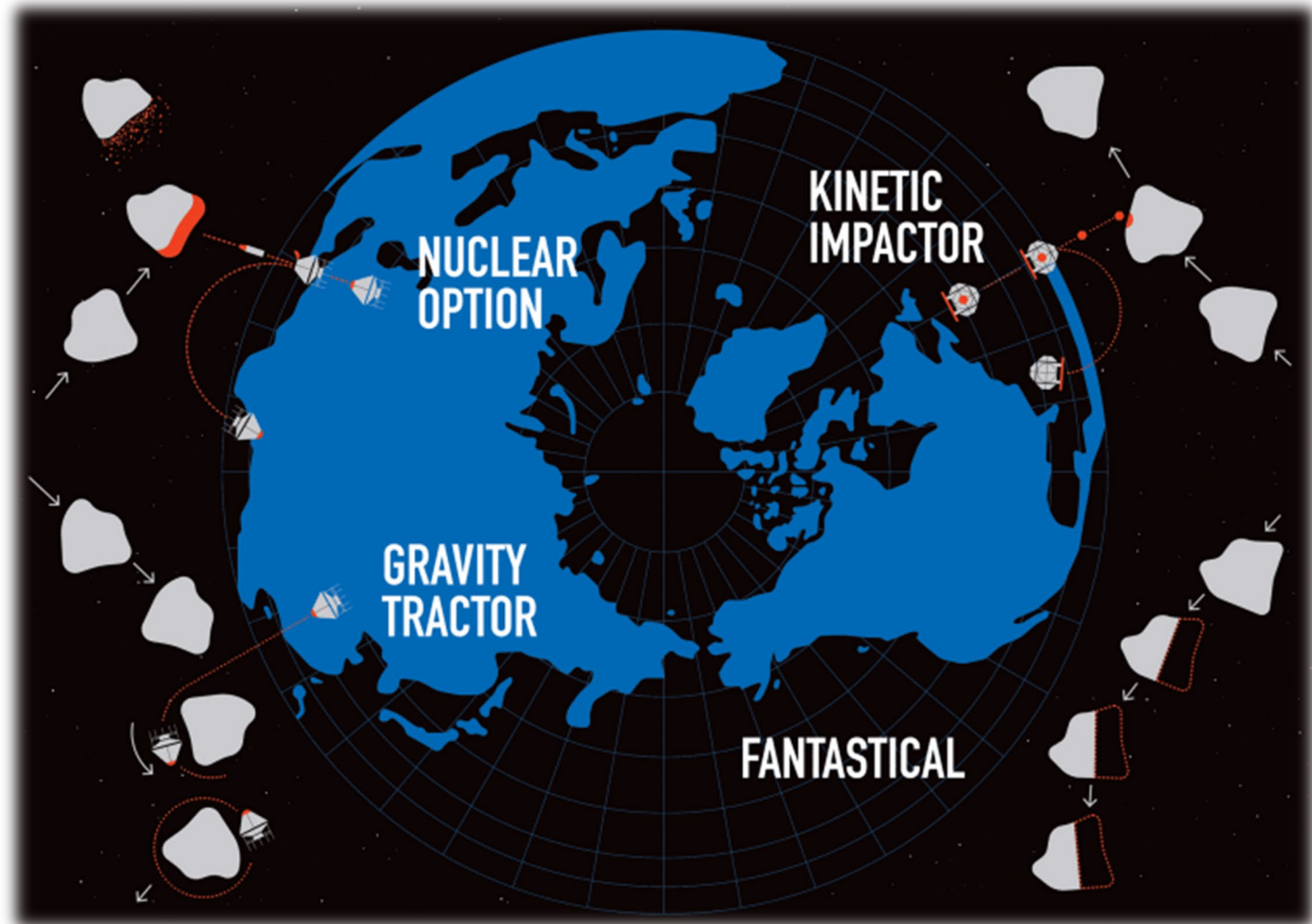
“Human beings are terrible at evaluating risk— especially existential risk. We rely on feeling rather than fact, and privilege emotional memories over hard numbers...That's how we end up ignoring risks that could wipe us off the face of the planet. Not because we're making a reasoned decision to spend money on one need over another, but because we're not being reasonable at all. That's an understandable tendency. It's also one that just may get us all killed, unless we're brave enough to come face-to-face with the end of the world.”





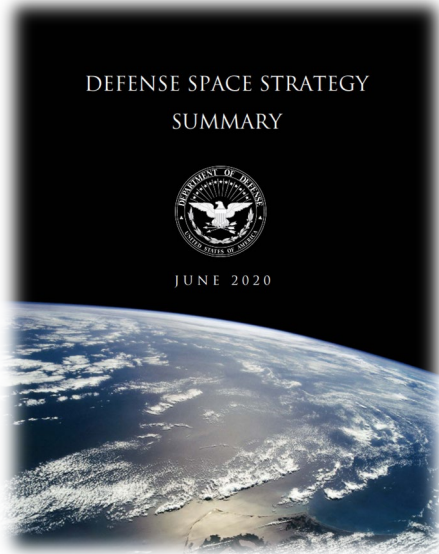
Here are some options that NASA scientists and other astronomers focused on NEOs have explored:

- **Deflection**
  - Altering speed of asteroid +/-
  - Gravity tractor with a ship
- **Ramming asteroid**
  - Kinetic impactor unmanned ship
- **Nuclear explosion**
  - Nearby explosion
  - Internal explosion
- **Orbital Laser**
  - Burn away surface materials
- **Black & White Paint job**
  - Yup, that's one fantastical idea!



In 2015 NASA created the Planetary Defense Coordination Office, followed in 2018 by the National Strategy for Space. In 2019 President Trump created Space Force, the 6th branch of the armed forces. Most recently, in June of 2020, the Department of Defense released its new Defense Space Strategy Summary.

“The Department of Defense is embarking on the most significant transformation in the history of the U.S. national security space program. Space is now a distinct warfighting domain, demanding enterprise-wide changes to policies, strategies, operations, investments, capabilities, and expertise for a new strategic environment. This strategy identifies how DoD will advance spacepower to enable the Department to compete, deter, and win in a complex security environment characterized by great power competition.”



Despite the existential risks to the planet from a Near Earth Objects, the 2020 DoD report does not mention any asteroid threats, a great example of how the “availability heuristic” leaves us blind to existential risks.



# Space Force Bible Blessing At National Cathedral Sparks Outrage

January 13, 2020 · 5:43 PM ET



DAVID WELNA



The Rev. Randolph Hollerith, dean of the Washington National Cathedral (from left); the Rt. Rev. Carl Wright, the Episcopal Church's bishop suffragan for the armed forces; and Maj. Gen. Steven Schaick, the Air Force chief of chaplains, participate in the blessing of a Bible for swearing in U.S. Space Force officials.

Danielle E. Thomas/Washington National Cathedral

As NPR reported, “The blessing of what's being called "the official Bible for the new U.S. Space Force" at the Washington National Cathedral on Sunday is drawing an outpouring of criticism on social media and condemnation from a prominent religious freedom advocacy group.”

The *AirForce Times* similarly noted that “Reaction on social media was swift, with many commenters raising concerns about the potential violation of the First Amendment’s establishment clause, which prohibits government actions favoring one particular religion over another. Some questioned whether the cathedral’s statement that the Bible will be used to swear in “all commanders” in the Space Force meant non-Christians would be excluded, even implicitly.

“So no Jews, Atheists, Muslims, Hindus, Mormons, Sikhs allowed in Space Force?” Princeton professor Steven Strauss tweeted in response.

What all this suggests is that the likelihood of an extinction-level asteroid event occurring in the future is slim—once every twenty million years. Yet even this small risk carries huge consequences, and that realization has led to more support for government efforts to address such risks.

As Bryan Walsh argues, the problem with existential risk is that the cost to the world is so huge that it should justify spending any amount of money, yet we don't see it that way. The 2020 DoD report makes Walsh's point—it only focused on perceived risks, such as a future space war against Russia or China.

“Human beings are terrible at evaluating risk— especially existential risk. We rely on feeling rather than fact, and privilege emotional memories over hard numbers...That's how we end up ignoring risks that could wipe us off the face of the planet. Not because we're making a reasoned decision to spend money on one need over another, but because we're not being reasonable at all.

That's an understandable tendency. It's also one that just may get us all killed, unless we're brave enough to come face-to-face with the end of the world.”



# Weekly Assignment Reminder

- Remember to check our class Blackboard regularly for updates, announcements, and other related class information...
- Have you done the weekly readings and watched any associated videos? Weekly readings are listed on the Class Schedule page.
- Complete the weekly discussion post response. Initial post due Wed, Oct 14 by end of the day, and peer response post due Fri Oct 16 by end of the day.



UNITED STATES  
SPACE FORCE

