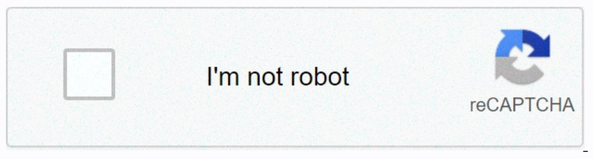

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Asteroid impact on earth video

Collision of two astronomical objects with measurable results A major impact event releases the energy of several million nuclear weapons that are launched simultaneously when an asteroid a few kilometres in diameter collides with a larger body such as Earth (image: artist's impression). An impact event is a collision between astronomical objects that causes measurable results.[1] Impact events have physical consequences and have been found to occur regularly in planetary systems, although most often they include asteroids, comets or meteoroids and have minimal effect. When large objects affect terrestrial planets such as Earth, there can be significant physical and biospherical effects, although atmospheres mitigate many effects on the surface through atmospheric input. Craters and impact structures are dominant forms of soil in many of the Solar System's solid objects and present the strongest empirical evidence of their frequency and scale. Impact events seem to have played an important role in the evolution of the solar system since its formation. Major impact events have significantly shaped the earth's history, and have been involved in the formation of the Earth-Moon system, the evolutionary history of life, the origin of water on Earth and several mass extinctions. The prehistoric impact of Chicxulub, 66 million years ago, is believed to be the cause of the Cretaceous-Paleogene extinction event.[2] Throughout recorded history, hundreds of earthly impacts (and explosive bolids) have been reported, with some incidents causing deaths, injuries, property damage or other significant local consequences.[3] One of the most well-known recorded events in modern times was the Tunguska event, which occurred in Siberia, Russia, in 1908. The 2013 Chelyabinsk meteorite event is the only known such incident in modern times to lead to numerous injuries. Its meteorite is the largest recorded object to have encountered Earth since the Tunguska event. The Comet Shoemaker-Levy 9 impact provided the first direct observation of an alien collision of the solar system's objects when the comet broke apart and collided with Jupiter in July 1994. An extra-sun impact was observed in 2013, when a huge impact on the terrestrial planet around star ID8 was detected in the NGC 2547 star cluster by NASA's Spitzer Space Telescope and confirmed by ground observations.[4] Impact events were a plot and background element in science fiction. In April 2018, the B612 Foundation reported It is 100 percent that we'll be hit [by a catastrophic asteroid], but we're not 100 percent sure when.[5] [6] Also in 2018, physicist Stephen Hawking, in his latest book Short Answers to The Big Questions, considered asteroid impact to be the greatest threat to the planet.[7] [8] [9] In June 2018, the US National Science and Technology Council warned that America America for an asteroid impact event, and has developed and released the National Action Plan for Object Readiness near Earth for better preparation.[10] [11] [12] [13] [14] According to expert testimony to the United States Congress in 2013, NASA would require at least five years of preparation before a mission to intercept an asteroid could begin.[15] The impact and global map of the Earth on the equirectagular projection of craters in the Earth's impact database from November 2017 (in the SVG file, hovering over a crater to show its details) See also: List of impact craters on Earth Major impact events have significantly shaped the earth's history, having been involved in the formation of the Earth-Moon system , the evolutionary history of life, the origin of water on Earth, and several mass extinctions. Impact structures are the result of impact events on solid objects and, as dominant forms of soil in many of the solid objects of the System, present the most solid evidence of prehistoric events. Notable impact events include the Recent Heavy Bombardment, which occurred early in the history of the Earth-Moon system, and the impact of Chicxulub, 66 million years ago, believed to be the cause of the Cretaceous-Paleogene extinction event. Frequency and danger Main article: Asteroid avoidance impact REP. STEWART: ... Are we technologically capable of launching something that could intercept [an asteroid]? ... Not. If we already had space plans on the books, that would take a year... I mean a typical little mission... it takes four years of approval to begin to begin...— Rep. Chris Stewart (R.UT) and Dr. Michael F. A'Hearn, April 10, 2013, Congress of the United States[15] Frequency of small asteroids about 1 to 20 meters in diameter that impacted the Earth's atmosphere. A bolide submitted to the atmospheric entrance Small objects often collide with The Earth. There is a reverse relationship between the size of the object and the frequency of such events. The lunar crater record shows that the frequency of impacts decreases as approximately the cube of the diameter of the resulting crater, which is on average proportional to the diameter of the impact axis.[16] Asteroids with a diameter of 1 kilometer (0.62 miles) hit Earth every 500,000 years on average.[17] [18] Large collisions – with objects of 5 kilometers (3 miles) – occur about once every twenty million years.[19] The last known impact of an object 10 km (6 mi) in diameter (6 mi) or greater was in the Cretaceous-Paleogenic extinction event 66 years ago Years.[20] The energy released by a impact axis depends on the diameter, density, speed, and angle.[19] The diameter of most asteroids near Earth that have not been studied by radar or infrared can generally only be estimated within about a factor of two, based on the brightness of the asteroid. Density is generally considered because the diameter and mass, from which the density is also generally calculated. Due to Earth's escape rate, the minimum impact speed is 11 km/s with asteroid impacts averaging about 17 km/s on Earth.[19] The most likely angle of impact is 45 degrees.[19] Impact conditions such as the size and speed of asteroids, as well as the density and angle of impact determine the kinetic energy released in an impact event. The more energy released, the more damage is likely to occur to the soil due to the environmental impacts caused by the impacts. Such effects can be shock waves, heat radiation, the formation of craters with related earthquakes, and tsunamis if water bodies are hit. Human populations are vulnerable to these effects if they live within the affected zone.[1] Large seiche waves resulting from earthquakes and large-scale deposit of debris can also occur within minutes of impact, thousands of kilometers from impact.[21] Airbursts Rocky asteroids with a diameter of 4 meters (13 feet) enter the Earth's atmosphere about once a year.[19] Asteroids with a diameter of 7 meters enter the atmosphere about every 5 years with as much kinetic energy as the atomic bomb dropped on Hiroshima (about 16 kilotons of TNT), but the air explosion decreases to just 5 kilotons.[19] These normally explode in the upper atmosphere and most or all of the solids evaporate.[22] However, asteroids with a diameter of 20 m (66 feet), and hitting Earth about twice every century, produce the strongest airlocks. The 2013 Chelyabinsk meteorite is estimated to have a diameter of about 20 meters with an air explosion of about 500 kilotons, an explosion 30 times larger than that over Hiroshima. Much larger objects can affect solid earth and create a crater. Stony asteroid impacts that generate an airburst[19] Impactordiameter Kinetic energy at Airburstaltitude Averagefrequency(years) Recorded fireballs(CNEOS)(1988-2018) atmosphericentry airburst 4 m (13 ft) 3 kt 0.75 kt 42.5 km (139,000 ft) 1.3 54 7 m (23 ft) 16 kt 5 kt 36.3 km (119,000 ft) 4.6 15 10 m (33 ft) 47 kt 19 kt 31.9 km (105,000 ft) 10 2 15 m (49 ft) 159 kt 82 kt 26.4 km (87,000 ft) 27 1 20 m (66 ft) 376 kt 230 kt 22.4 km (73,000 ft) 60 1 30 m (98 ft) 1.3 Mt 930 kt 16.5 km (54,000 ft) 185 0 50 m (160 ft) 5.9 Mt 5.2 Mt 8.7 km (29,000 ft) 764 0 70 m (230 ft) 16 Mt 15.2 Mt 3.6 km (12,000 ft) 1,900 0 85 m (279 ft) 29 Mt 28 Mt 0.58 km (1,900 ft) 3,300 0 Based on density of 2600 kg/m3 , speed 17 km/s, and an impact angle of 45° Rocky asteroids that worship sedimentary rocks and create a crater[19] Impact Energy in Crater Frequency(years) πρόσκρουση εισόδου 100 m (330 ft) 47 Mt 3,4 Mt 1,2 χιλιόμετρα (0,75 μίλια) 5.20 0 130 m (430 ft) 103 Mt 31,4 Mt 2 χιλιόμετρα (1,2 mi) 11.000 150 m (490 ft) 159 Mt 71,5 Mt 2,4 χιλιόμετρα (1,5 mi) 16,5000 m (1,5000 m (1,5 mi) 200 m (1,5 mi) 200 m (1,5000 m(s) 660 ft) 376 Mt 261 Mt 3 km (1,9 mi) 36.000 250 m (820 ft) ft) Mt 598 Mt 3.8 km (2.4 miles) 59,000 300 m (980 ft) 1270 Mt 1110 Mt 4.6 km (1980 ft) 2 .9 mi) 73,000 400 m (1,300 ft) 3010 Mt 2800 Mt 6 km (3.7 miles) 100.00 0 700 m (2,300 ft) 16100 Mt 15700 Mt 10 km (6.2 mi) 190,000 1,000 m (6.2 mi) 3 300 ft) 47000 Mt 46300 Mt 13.6 km (8.5 miles) 440,000 Based on r = 2600 kg/m3; v = 17 km/s· and an angle of 45° Objects with a diameter of less than 1 m (3.3 ft) are called meteoroids and rarely do so on the ground to become meteorites. An estimated 500 meteors reach the surface each year, but only 5 or 6 of them usually create a signature weather radar with a scattered field large enough to be recovered and known to scientists. The late Eugene Shoemaker of the U.S. Geological Survey estimated the rate of impact on Earth, concluding that an event about the size of the nuclear weapon that destroyed Hiroshima occurs about once a year. Such events seem to be spectacularly obvious, but generally go unnoticed for a number of reasons: the majority of the Earth's surface is covered by water; a good part of the earth's surface is uninhabited; and explosions generally occur at relatively high altitude, resulting in a huge flash and thunderclap, but no real damage. [referral required] Although no person is known to have been directly killed by an impact[disputed – discuss], more than 1000 people were injured in the incident of the Chelyabinsk meteor explosion over Russia in 2013.[23] In 2005 it was estimated that the probability of a single person being born today dying due to an effect is about 1 in 200,000.[24] Asteroids of magnitude two to four meters in size 2008 TC3, 2014 AA, 2018 LA, 2019 MO, and the suspected artificial satellite WT1190F are the only known objects detected before impacting on Earth.[25] [26] Geological significance The effects had, during the history of the Earth, a significant geological[27] and climatic[28] influence. The existence of the Moon is widely attributed to a huge impact on the early history of the Earth.[29] Impact events earlier in Earth's history have been credited with creative as well as catastrophic events it has been suggested that affected comets delivered Earth's water, and some have suggested that the origin of life may have been influenced by objects impacted by the introduction of organic chemicals or life forms on the Earth's surface, a theory known as exogenesis. Eugene Merle Shoemaker was the first to prove that meteor impacts have affected Earth. These altered views of Earth's history did not emerge until relatively recently, mainly due to the lack of direct observations and identification of the signs of an Earth impact due to erosion and erosion. The large-scale terrestrial impacts of the species that produced the Barringer Crater, locally known as the Meteor Crater, northeast of Flagstaff, Arizona, are rare. Instead, it was widely believed that crater was the result of the Barringer crater, for example, was attributed to a prehistoric volcanic eruption (not an unreasonable assumption, since the volcanic San Francisco Peaks stand only 48 kilometers or 30 miles to the west). Similarly, the craters on the surface of the Moon were attributed to the volcanic eruption. It wasn't until 1903-1905 that the Barringer crater was correctly identified as an impact crater, and it wasn't until 1963 that research by Eugene Merle Shoemaker definitively proved this hypothesis. The findings of space exploration in the late 20th century and the work of scientists such as Shoemaker proved that the impact crater was by far the most widespread geological process in the work on the solid bodies of the Solar System. Every researched solid body in the Solar System was found to be a crater, and there was no reason to believe that the Earth had somehow escaped bombardment from space. In the last decades of the 20th century, a large number of highly modified impact craters began to be detected. The first direct observation of a major impact event occurred in 1994: the collision of the shoemaker-Levy 9 comet with Jupiter. Based on crater formation rates determined by Earth's closest celestial companion, the Moon, astrogeologists have found that over the past 600 million years, the Earth has been hit by 60 objects 5 kilometers (3 miles) in diameter or more.[17] The smallest of these percussions would leave a crater nearly 100 km (60 miles) apart. Only three confirmed craters from that time period with that size or larger have been found: Chicxulub, Popigai, and Manicuagan, and all three are suspected of being linked to extinction events[30][31] although only Chicxulub, the largest of the three, has been consistently examined. The impact that caused the Mistastin crater caused temperatures above 2,370 °C, the highest known to have occurred on the Earth's surface.[32] In addition to the direct impact of asteroid impacts on a planet's surface topography, global climate and life, recent studies have shown that several successive impacts may have an effect on the dynamo mechanism at the core of a planet responsible for maintaining the planet's magnetic field, and may have contributed to Mars' lack of the current magnetic field.[33] An impact event can cause a crest of mands (volcanoism) at the opposite point of the collision.[34] Chicxulub's impact may have increased volcanicism on the mesoethnal ridges[35] and has been suggested to have caused flood basalt volcanoism in Deccan traps.[36] While many impact craters have been confirmed on land or in shallow over continental shelves, no impact crater in the deep ocean has been widely accepted by the scientific community.[37] The effects of projectiles as large as one kilometer in diameter are generally thought to explode before reaching the sea floor, but it is unknown what will happen a much larger impact supine hit the deep ocean. The lack of a crater, however, does not mean that an impact on the ocean would not have dangerous consequences for humanity. Some scholars have argued that an impact event on an ocean or sea can create a megatsunami, which can cause destruction both at sea and on land along the coast,[38], but this is disputed.[39] Eltanin's impact in the Pacific Ocean 2.5 Mya is thought to involve an object about 1 to 4 kilometers (0.62 to 2.49 miles) across, but remains crater-free. Biospheric effects The effect of impact events on the biosphere has been the subject of scientific debate. Several mass extinction theories related to the effects have been developed. In the last 500 million years there have been five generally accepted large mass extinctions which on average wiped out half of all species.[40] One of the largest mass extinctions that have affected life on Earth was the Permian-Triassist, which ended the Permian period 250 million years ago and killed 90 percent of all species.[41] Life on Earth took 30 million years to recover.[42] The cause of Permian-Triassic's disappearance is yet another topic of discussion the age and origin of the proposed impact craters, i.e. the Bedout High structure, supposedly associated with it, are still controversial.[43] The latest such mass extinction led to the extinction of non-bird dinosaurs and coincided with a large meteor impact. this is the Cretaceous-paleogenic extinction event (also known as the K-T or K-Pg extinction event), which occurred 66 million years ago. There is no definitive evidence of the effects that lead to the three other major mass disappearances. In 1980, physicist Luis Alvarez; his son, geologist Walter Alvarez; and nuclear chemists Frank Asaro and Helen V. Michael from the University of California, Berkeley discovered unusually high concentrations of iridium in a specific layer of rock layers in the Earth's crust. Iridium is an element that is rare on Earth but relatively abundant in many meteorites. From the amount and distribution of iridium present in the 65-million-year-old iridium layer, the Alvarez team later estimated that an asteroid 10 to 14 kilometers (6 to 9 mi) must have collided with Earth. This iridium layer on the Cretaceous-Paleogene boundary has been found around the world in 100 different locations. Multidirectively shocked quartz (coesite), which is normally associated with major impact events[44] or atomic bomb explosions, has also been found in the same layer in more than 30 areas. Soot and ash in levels thousands of times normal levels were found with the above. Anomalies in iso-local chromium ratios found within the K-T boundary layer strongly support impact theory.[45] Iso-local chromium ratios are homogeneous within the earth and, as a result, these iso-local anomalies exclude a volcanic origin, which has also been proposed as a cause for Enrichment. In addition, the iso-local chromium ratios measured at the K-T limit are similar to the iso-local chromium ratios found in carbon chondrites. Thus a possible candidate for the impact target is a carbonic asteroid, but a comet is also likely because comets are thought to consist of material similar to carbonated chondrites. Perhaps the most convincing evidence of a global disaster was the discovery of the crater that has since been named Chicxulub Crater. This crater is centered on Mexico's Yucatán Peninsula and was discovered by Tony Camargo and Glen Penfield while working as geophysicist for mexican oil company PEMEX.[46] What they referred to as a circular feature later turned out to be a crater estimated to be 180 kilometers (110 miles) in diameter. This convinced the vast majority of scientists that this extinction resulted from a point event that is most likely an alien effect rather than an increase in volcanic and climate change (which will spread its main effect over a much longer period of time). Although there is now general agreement that there was a huge effect at the end of the Cretaceous that led to the enrichment of iridium of the K-T boundary layer, remnants have been found from other, smaller impacts, some close to half the size of the Chicxulub crater, which did not lead to mass extinctions, and there is no clear link between an impact and any other mass extinction incident.[40] Paleontologists David M. Raup and Jack Sepkoski have suggested that an excess of extinction events occurs about every 26 million years (though many are relatively minor). This led physicist Richard A. Muller to suggest that these disappearances could be due to a hypothetical companion star in the Sun called Nemesis periodically disrupting the orbits of comets in the Oort cloud, leading to a large increase in the number of comets reaching the inner solar system, where they could hit Earth. Physicist Adrian Melott and paleontologist Richard Bambach most recently verified raup and Sepkoski's finding, but argue that it is not consistent with the characteristics expected of a Nemesis-type periodicity.[47] Sociological and cultural implications Main article: End of culture An impact event is usually seen as a scenario that would bring about the end of civilization. In 2000, Discover Magazine published a list of 20 possible doomsday sudden scenarios with an impact event listed as the most likely to occur.[48] A joint Pew Research Center/Smithsonian survey from April 21-26, 2010 found that 31 percent of Americans believed that a will collide with Earth by 2050. The majority (61 percent) disagreed.[49] The Earth affects the artist's depiction of a collision between two planetary bodies. Such a collision between Earth and a Mars-sized object probably formed the Moon. In the early history of the Earth (approximately four years ago), bolide effects were almost certainly common, since the solar system contained much more distinct bodies than today. Such impacts could include asteroid strikes hundreds of kilometres in diameter, with eruptions so powerful that they evaporated all of Earth's oceans. It wasn't until this heavy bombardment slakened that life seems to have begun to evolve on Earth. The main theory of the Moon's origin is the giant theory of impact, which believes that the Earth was once struck by a planetoid the size of Mars. Such a theory is able to explain the size and composition of the Moon, something not done by other theories of lunar formation.[50] Evidence of a massive impact in South Africa near a geological formation known as the Greenstone Barberton Zone was revealed by scientists in April 2014. They estimated that the impact occurred about 3.26 billion years ago and that the impactor was about 37-58 kilometers (23-36 miles) wide. The crater from this event, if it still exists, has not yet been found.[51] However, in January 2020, scientists reported that the oldest recognised asteroid impact occurred in Western Australia more than 2.2 billion years ago.[52] [53] Two asteroids of magnitude 10 kilometres are now believed to have hit Australia between 360 and 300 million years ago in the western Warburton and East Warburton basins creating a 400km impact zone. According to data found in 2015 it is the largest ever recorded.[54] A third, possible impact was also detected in 2015 to the north, in the upper Diamantina River, which is also believed to have been caused by an asteroid 10 km to about 300 million years ago, but further studies are needed to establish that this crust anomaly was indeed the result of an impact event.[55] Pleisto-New More information: Pleisto-New Aerial view of The Barringer Crater in Arizona Artifacts recovered with tectites from the 803,000-year-old Australasian strelasian event in Asia linking a Homo erectus population to a major meteor impact and its consequences.[56] [57] [58] Important examples of Pleistocan impacts include the Lonar crater lake in India, about 52,000 years old (although a study published in 2010 gives a much older age), which now has a thriving semi-tropical jungle around it. [reference required] Holocene More information: Brand new Rio Cuarto craters in Argentina were produced about 10,000 years ago, at the beginning of the Brand New. If it turns out to be impact craters, it'll be the first impact of the brand new one. In 201 del Cielo (Field of Heaven) refers to an area bordering Argentina's Chaco province, where a group of iron meteorites was found, estimated to date back to 4,000-5,000 years ago. In 1576, the Committee received the first attention from the Spanish authorities; in 2015, police arrested four alleged smugglers who were trying to steal Meteorites.[59] Henbury craters in Australia (~5,000 years old) and Kaali craters in Estonia (~2,700 years old) were apparently produced by objects dissolved before impact.[60] [reference required] The Whitecourt crater in Alberta, Canada is estimated to be between 1,080 and 1,130 years old. The crater has a diameter of about 36 meters and a depth of 9 m (30 ft), is heavily forested and was discovered in 2007 when a metal detector revealed fragments of meteorite iron scattered in the area.[61] [62] A Chinese record states that 10,000 people were killed in the 1490 Ch'ing-yang event with deaths caused by a hail of stone stones; some astronomers assume this may describe a real meteor fall, although they find the number of deaths unlikely.[63] The Kamil crater, discovered by Google Earth's image review in Egypt, 45 m (148 feet) in diameter and 10 m (33 ft) deep, is believed to have formed less than 3,500 years ago in a then uninhabited area of western Egypt. It was found February 19, 2009 by V. de Michelle in a Google Earth image of the eastern Uweinat Desert, Egypt.[64] Effects of the 20th century Trees hit by the Tunguska eruption One of the most well-known recorded effects in modern times was the Tunguska event, which occurred in Siberia, Russia, in 1908. This incident involved an explosion most likely caused by the air explosion of an asteroid or comet 5 to 10 kilometers (3.1 to 6.2 miles) above the Earth's surface, felling about 80 million trees over 2,150 km2 (830 square miles).[65] In February 1947, another large bolide affected the Earth in the Sikhote-Alin Mountains, Primorye, Soviet Union. It was during the day and witnessed by many people, which allowed V. G. Fesenkov, then chairman of the meteor committee of the USSR Academy of Sciences, to assess the trajectory of the meteoroid before encountering the Earth. Sikhote-Alin is a huge drop with the total size of the meteoroid estimated at about 90,000 kg (200,000 lbs). A more recent estimate by Tsvetkov (and others) puts the mass at about 100,000 kg (220,000 lb).[66] It was an iron meteorite belonging to chemical group IIAB and with a coarse octaedrite structure. More than 70 tons (metric tons) of material survived the collision. A case of a man injured by a space rock occurred on November 30, 1954, in Syllacauga, Alabama.[67] There a 4 kg (8.8 lb) stone chondrite crashed through a roof and hit Ann Hodges in her living room after she bounced off her radio. She was badly bruised by the shrapnel. Since then, several people have claimed to have been hit by 'meteorites', but have not verifiable meteors. A small number of meteor falls have been observed with automated cameras and have been recovered after calculating the point of impact. The first was the Pribram meteor, which fell in Czechoslovakia (now the Czech Republic) Republic) In this case, two cameras used to photograph meteorites captured images of the fireball. The images were used both to determine the position of the stones on the ground and, most importantly, to calculate for the first time an exact trajectory for a recovered meteorite. After the fall of Pribram, other nations introduced automated observation programs aimed at studying the invading meteors.[69] One of them was the Prairie Meteor Network, operated by the Smithsonian Astrophysical Observatory from 1963 to 1975 in the Midwestern USA. This program also observed a meteor fall, the Lost City coarse, allowing its recovery and a calculation of its trajectory.[70] Another project in Canada, the Meteor Observation and Rehabilitation Program, ran from 1971 to 1985. He also recovered a single meteorite, Innisfree, in 1977.[71] Finally, observations from the European Fireball Network, a descendant of the original Czech project that recovered Pribram, led to discovery and orbit calculations for the Neuschwanstein meteorite in 2002.[72] On August 10, 1972, a meteor that became known as the Great Daylight Fireball of 1972 was witnessed by many people as it moved north across the rocky mountains from the southwest of the US to Canada. It was shot by a tourist in Grand Teton National Park in Wyoming with an 8mm color camera.[73] In the size range the object was roughly between a car and a house, and while it could have ended its life in a Hiroshima-sized explosion, there was never any explosion. Analysis of the orbit showed that it never came much lower than 58 kilometers (36 miles) from the ground, and the conclusion was that it had been grazing earth's atmosphere for about 100 seconds, then bypassed behind the atmosphere to return to its orbit around the Sun. Many impact events occur without being monitored by anyone on the ground. Between 1975 and 1992, U.S. rocket early warning satellites took 136 major explosions into the upper atmosphere.[74] On November 21, 2002, edition of the journal Nature, Peter Brown of the University of Western Ontario reported on his study of U.S. early warning satellite records for the past eight years. It detected 300 flashes caused by 1 to 10 m (3 to 33 feet) meteors in this time period and estimated the rate of Tungska-sized events as once in 400 years.[75] Eugene Shoemaker estimated that an event of this magnitude occurs about once every 300 years, although later analyses have suggested that it may have been overestimated by a size class. In in the early hours of January 18, 2000, a fireball exploded over the city of Whitehorse, Yukon Territory at an altitude of about 26 kilometers (16 miles), illuminating the night like a day. The meteor that produced the fireball was estimated at about 4.6 m (15 ft) in diameter, weighing 180 tons. This explosion was also featured in the Channel Science killer series series with several witness reports from residents in Atlin, British Columbia. Effects of the 21st century Main article: List of bolids On June 7, 2006, a meteorite was observed striking Reisadalen in the municipality of Nordreisa in County Troms, Norway. Although initial witness reports indicated that the

resulting fireball was equivalent to the Hiroshima nuclear explosion, scientific analysis places the force of the explosion anywhere from 100-500 tons of TNT equivalent, about three percent of Hiroshima's yield. [76] On September 15, 2007, a chortic meteor crashed near the village of Carancas in southeastern Peru near Lake Titicaca, leaving a water-filled hole and spewing gases throughout the surrounding area. Many residents became ill, apparently from the harmful gases shortly after impact. On October 7, 2008, an asteroid about 4 meters marked 2008 TC3 was detected for 20 hours as it approached Earth and as it fell through the atmosphere and was affected in Sudan. This was the first time an object was detected before it reached the atmosphere and hundreds of pieces of the meteorite were recovered from the Nuvian desert. [77] Path left by the explosive chelyabinsk meteor as it passed over the city. On February 15, 2013, an asteroid entered earth's atmosphere over Russia as a fireball and exploded over the city of Chelyabinsk during its passage through the Uric Mountains region at 09:13 YEKT (03:13 UTC). [78] [79] The object's air explosion occurred at an altitude of between 30 and 50 kilometers (19 and 31 miles) above the ground,[80] and about 1,500 people were injured, mainly from a broken glass window shattered by the blast wave. Two were reported in serious condition. However, there were no deaths. [81] Initially about 3,000 buildings in six cities across the region were reported damaged due to the blast surge, a number that stood at more than 7,200 in the following weeks. [82] [83] The Chelyabinsk meteorite was estimated to have caused over $30 million in damage. [84] [85] It is the largest recorded object to have encountered Earth since the 1908 Tunguska event. [86] [87] The meteorite is estimated to have an initial diameter of 17-20 meters and a mass of approximately 10,000 tons. On October 16, 2013, a team from the Federal University of the Urias led by Viktor Grohowski recovered a large chunk of the meteor from the bottom of Russian Lake Chebarkul, about 80 kilometers west of the city. [88] On January 1, 2014, a 3-meter (10-foot) asteroid AA was discovered by the Lemmon Mountain survey and observed over the next hour, and was soon found to be on a collision course with Earth. The exact location was uncertain, on a line between Panama, the central Atlantic Ocean, Gambia and Ethiopia. Around the expected time (January 2, 3:06 UTC) an infrasound explosion was detected near the center of the impact range, in the middle of the Atlantic Ocean. [89] [90] This marks the second time that object was detected before impact on Earth after 2008 TC3. Nearly two years later, on October 3, WT1190F was spotted orbiting the Earth in an extremely eccentric orbit, taking it from the geocentric satellite ring almost twice the Moon's orbit. It is estimated to have been disturbed by the Moon on a collision course with Earth on November 13. With over a month of observations, as well as precovery observations found dating back to 2009, it was found to be much less dense than a natural asteroid should be, suggesting it was probably an unknown artificial satellite. As predicted, it fell over Sri Lanka at 6:18 UTC (11:48 local time). The sky in the area was very cloudy, so only an airborne observation team was able to successfully observe it fall above the clouds. It is now believed to be a remnant of the Lunar Prospector mission in 1998, and is the third time any previously unknown object - natural or artificial - has been spotted before impact. On January 22, 2018, an object, the A106fgF, was discovered by the Early Warning System (ATLAS) with a ground-impact asteroid and was identified as having little chance of impacting Earth later in the day. [91] Since it was very dim, and identified only hours before its approach, no more than the original 4 observations covering a period of 39 minutes were made of the object. It is unknown whether it affected Earth or not, but no fireball was detected in either infrared or infrared, so if it did, it would be very small, and probably near the eastern end of its possible impact area - in the western Pacific Ocean. On June 2, 2018, the Mount Lemmon survey identified 2018 LA (ZLAF9B2), a small asteroid 2-5 meters long found that further observations had an 85% chance of affecting Earth. Shortly after impact, a report from Botswana reached the American Meteor Society. Further observations with Atlas extended the observation arc from 1 hour to 4 hours and confirmed that the asteroid orbit actually acted Earth in southern Africa, completely closing the loop with fireball exposure and making this third physical object confirmed to impact Earth, and the second ashore after 2008 TC3. [92] [93] [94] On 8 March 2019, NASA announced the detection of a major air explosion occurring on 18 December 2018 at 11:48 local time off the east coast of the Kamchatka Peninsula. The Kamchatka hyperbole is estimated to have a mass of about 1600 tons, and a diameter of 9 to 14 meters depending on its density, making it the third largest asteroid to hit Earth since after the Chelyabinsk meteor and the Tunguska event. The fireball exploded in an air blast 25.6 kilometers (15.9 miles) above the Earth's surface. 2019 MO, an asteroid of about 4m, was spotted by ATLAS just hours before it crashed into the Caribbean Sea near Puerto Rico in June 2019 [2] Asteroid impact prediction Main article: Asteroid Asteroid Forecast Orbit and locations of 2018 LA and Earth, 30 days before impact. The diagram illustrates how track data can be used to predict impacts well in advance. Note that in this case the asteroid's orbit was not known until a few hours before impact. The diagram was then constructed for imaging. In the late 20th and early 21st centuries, scientists put in place measures to detect objects near Earth and predict the dates and times of asteroids that invite Earth, along with the locations they will present. The International Astronomical Union Minor Planet Center (MPC) is the global clearing desk for information on asteroid orbits. NASA's Sentry system continuously scans the MPC list of known asteroids, analyzing their orbits for any possible future impacts. [95] Currently no one is predicted (the single highest probability of impacts currently reported is ~7 m asteroid 2010 RF12, which is due to pass Earth in September 2095 with only a 5% predicted probability of impact). [96] Currently the forecast is mainly based on the cataloguing of asteroids years before they are due to impact. This works well for larger asteroids (> 1 km across) as they look easy from a long distance. More than 95% of them are already known and their orbits have been measured, so any future impacts can be predicted long before they reach their final approach to Earth. Smaller objects are too faint to observe, unless they come too close, so most cannot be observed before their final approach. The current mechanisms for detecting asteroids in the final approach are based on large-field terrestrial telescopes, such as the ATLAS system. However, today's telescopes cover only a part of the Earth and even more importantly they cannot detect asteroids on the day side of the planet, which is why so few of the smaller asteroids that usually affect Earth are detected during the few hours that will be visible. [97] So far only four impact events have been successfully predicted in advance, all from harmless asteroids 2-5m in diameter and detected a few hours in advance. Ground-based telescopes can only detect objects approaching the night side of the planet, away from the Sun. About half of the effects occur on the day side of the planet. Current response status Main article: Avoiding asteroid impacts In April 2018, the B612 Foundation reported It is 100 percent certain We'll be hit [by a catastrophic asteroid], but we're not 100 percent sure when. [5] [6] Also in 2018, physicist Stephen Hawking, in his latest book Short Answers to The Big Questions, considered asteroid impact to be the greatest threat to the planet. [7] [8] [9] In June 2018, the US National Science and Technology Council warned that America is unprepared for an asteroid impact event, and developed and released the National Action Plan for Object Readiness Near Earth for the best According to expert testimony to the United States Congress in 2013, NASA would require at least five years of preparation to launch a mission to intercept an asteroid. [15] The preferred method is to prevent rather than disturb an asteroid. [98] [99] [100] Elsewhere in the solar system Evidence of the massive impact events of the past Main article: List of largest craters in the solar system Topographic map of the South Pole-Aitken basin based on Kaguya data provides evidence of a huge impact event on the Moon about 4.3 billion years ago Impact craters provide evidence of previous impacts on other planets in the Solar System, including possible interplanetary terrestrial impacts. Without carbon dating, other benchmarks are used to estimate the time of these impact events. Mars provides some important evidence of possible interplanetary collisions. The North Polar Basin on Mars is thought by some to be evidence of a planet-sized impact on the surface of Mars 3.8 to 3.9 billion years ago, while Utopia Planitia is the largest confirmed impact and Hellas Planitia is the largest visible crater in the Solar System. The Moon provides similar evidence of huge impacts, with the South Pole-Aitken basin being the largest. The Caloris basin of mercury is another example of a crater formed by a huge impact event. Rheasilvia in Vesta is an example of a crater formed by an impact capable, based on the impact-to-size ratio, of severely distorting a planetary mass object. Impact craters on Saturn's moons, such as Engelier and Geren in Iaepeo, Mamaldy in Rhea and Ulysses in Tethyls and Herschel in Mimas form important surface features. Models developed in 2018 to explain Sky's unusual rotation support a long-standing theory that this was caused by a skewed collision with a huge object twice the size of Earth. [101] Observed events Jupiter Comet Shoemaker-Levy 9's scar on Jupiter (dark area near the edge of Jupiter) Jupiter Event Events Event Date of Event (UTC) Rough initial size (meters) Latitude (°) Longitude (°) May 2017 event[102] 2017/05/26 19:25 13 +51.2 ; Mar 2016 event[102] 2016/03/17 00:18:33 15 +4 ; Sep 2012 event[103][102] 2012/09/10 11:35:00 30 +2 345 Aug 2010 event[103][102] 2010/08/20 18:22:12 10 +11; June 2010 Jupiter impact event 2010/06/03 20:31:20 12 −16.1 342.7 Jul 2009 Jupiter impact event 2009/2009/2009 07/19 13:30 300 −57 305 Jul 1994 Comet 9 1994/07/16-22 1800 −65 ; In July 1994, Comet Shoemaker-Levy 9 was a comet that broke up and collided with Jupiter, providing the first direct observation of an alien collision of Objects of the Solar System. [104] The event served as a wake-up call, and astronomers responded by launching programs such as Lincoln's Near-Earth Asteroid Survey (LINEAR), Near-Earth Asteroid Monitoring (NEAT), the search for objects near The Lowell Observatory's Earth (LONEOS) and several others that have been increased the rate of asteroid discovery. The 2009 Jupiter impact event occurred on July 19, when a new black spot about the size of Earth was discovered in Jupiter's southern hemisphere by amateur astronomer Anthony Wesley. Thermal infrared analysis showed that they were hot and spectroscopy methods that detected ammonia. JPL scientists have confirmed that there was another impact event on Jupiter, most likely with a small unexplored comet or other icy body. [105] [106] [107] The impactor is estimated to have been approximately 200-500 metres in diameter. A 2010 Jupiter impact event occurred on June 3 involving an object estimated at 8-13 meters was recorded and first reported by Anthony Wesley. [108] [109] [110] On September 10, 2012, amateur astronomer Dan Petersen visually spotted a fireball on Jupiter that lasted 1 or 2 seconds. This was confirmed by an amateur astronomer in Texas, George Hall, who depicted the impact using a camera mounted on a 12 LX200. It is estimated that the fireball was created by a meteoroid less than 10 meters in diameter. [111] On March 17, 2016, a Jupiter impact event occurred involving an unknown object, possibly a small comet or asteroid that was initially estimated at 30-90 meters (or a few hundred feet) across. The size estimate was later corrected to 7 and 19 metres. The event was first reported by Austrian amateur astronomer Gerrit Kernbauer, and was later confirmed in telescope footage by amateur astronomer John McKeon. [102] [112] On May 26, 2017, amateur astronomer Sauveur Pedranghelu observed another glow from Corsica (France). The event was announced the next day, and was quickly confirmed by two German observers, Thomas Iessler and André Fleckstein. The impactor had an estimated size of 4 to 10 meters. [102] Other implications of Hubble 3's large-field camera clearly show the slow evolution of debris coming from asteroid P/2010 A2, supposedly due to a collision with a smaller asteroid. In 1998, two comets were seen plunging towards the Sun in close succession. The first of these was on June 1st and the second the next day. A video of this, followed by a dramatic ejection of solar gas (unrelated to impacts), can be found on NASA's website[113]. Both of these comets evaporated before coming into contact with the sun's surface. According to a theory by NASA Jet Propulsion Laboratory scientist Zdeněk Sekanina, the last impactor to actually make contact with the Sun was the Howard-Koomen-Michels supercomet on August 30, 1979. [114] [self-published source?] (See also sungrazer.) In 2010, In January and May, Hubble's Wide Field Camera 3[115] took images of an unusual X-shape created after the collision between asteroid P/2010 A2 and a smaller asteroid. Around March 27, 2012, based on the data, there were signs of impact on Mars. Images from the Mars Reconnaissance Orbiter provide fascinating from the largest impact observed to date on Mars in the form of fresh craters, the largest measurement of 48.5 by 43.5 meters. It is estimated to be caused by a shock medium of 3 to 5 metres in length. [116] On March 19, 2013, a collision occurred on the Moon that was visible from Earth when a 30-centimetre-sized boulder meteoroid hit the lunar surface at 90,000 km/h (25 km/s, 56,000 mph) creating a 20-meter crater. [117] [118] NASA has been actively monitoring lunar impacts since 2005,[119] by tracking hundreds of candidate events. [120] [121] Extra-sun impact Asteroid collision led to planet building near the star NGC 2547-ID8 (artist concept). Collisions between galaxies, or galaxy mergers, have been observed directly by space telescopes such as Hubble and Spitzer. However, collisions in planetary systems, including stellar collisions, have long been speculated, only recently began to be observed directly. In 2013, a collision between small planets around the star NGC 2547 ID 8 was detected by Spitzer and confirmed by ground observations. Computer modeling shows that the impact involved large asteroids or protoplanets similar to the events believed to have led to the formation of terrestrial planets such as Earth. [4] Popular science fiction novels Culture Main article: Asteroids in fiction § Conflicts with planets Numerous science fiction stories and novels center around an impact event. One of the first and most popular is Off on a Comet (French: Hector Servadac) by Jules Verne, published in 1877, and H. C. Wells wrote about such an event in the 1897 short story of The Star. In more modern times, perhaps the best-seller was the novel Lucifer's Hammer by Larry Niven and Jerry Pournelle. Arthur C. Clarke's novel Rendezvous with Rama opens with a major asteroid impact in northern Italy in 2077, which creates the Spaceguard Project, which later discovers the Rama spacecraft. In 1992 a U.S. congressional study led nasa to take over the Spaceguard Survey, with the novel named as an inspiration for the name for the search for Earth-affecting asteroids. [122] [best source required] This in turn inspired Clarke's 1993 novel The Hammer of God. [reference required] Robert A. Heinlein used the concept of guided meteorites in his novel The Moon is a Cruel Mistress, in which the Moon rebels use rock-filled shipping containers as a weapon against their Earth oppressors. [reference required] Cinema and TV See also: Asteroid Impact § Fantastic representations Various disaster films centering on actual or threatened impact events. Released during the turmoil of World War I, the Danish feature film The End of the World revolves around the near-miss of a comet causing fire showers and social unrest in Europe. [123] When The Worlds Collide (1951), based on a 1933 novel by Philip Wylie, deals with two planets in a collision with Earth-the smallest planet a near miss, causing extensive damage and destruction, followed by a direct hit from the larger planet. [124] See also Asteroid Capture Asteroid Avoidance Impact - Methods to Prevent Catastrophic Asteroid Hits B612 Foundation Central Top Crater Earth Impact Database Global Catastrophic Risk - Hypothetical Future Events That Could Harm Human Well-Being Globally Impacts Gardening Late Heavy Bombing – Space When a Disproportionately Large Number of Asteroids Theoretically Have Collided With Inner Planets List of bolides List of impact craters on Earth List of meteor air explosions List of possible impact structures on Earth Near Earth asteroids Near Earth object Near Earth Object Camera Palermo Technical Collision Risk Scale Pan-STARRS - Multi-telescope astronomical research Peak ring (crater) - A roughly circular ring or plateau, possibly switches, surrounds the center of the impact crater Potentially dangerous Spaceguard object - Various attempts to discover , catalog, and study asteroids that could affect the Earth Turin scale , 0 to 10

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