Call for More Cooperation To Protect the Earth

by Caroline Hartmann

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Feb. 27—In addition to averting the danger of world war, and fighting poverty and hunger, protection against a possibly devastating impact of a foreign celestial body on Earth is one of the most important problems facing humanity today. This is by no means science fiction, because countless dangerous hunks of rock, called asteroids, from the time of the formation of our planetary system, have been orbiting the Sun, buzzing around in space. Asteroid impacts on our planet are a regular occurrence, and again and again these missiles come dangerously close to the Earth. Impacts of this type have often brought decades of cold and darkness, and led to mass extinctions of sometimes up to 95% of all living things on land and sea. Researchers today are certain that the path of our Solar System through the Milky Way galaxy is the reason why the Earth regularly passes through very dense asteroid clusters and unprotected radiation-intensive areas. Right now, Earth is approaching such a dangerous zone again.

According to estimates by the U.S. space agency NASA, there are about 11.5 million near-Earth asteroids with a diameter of less than 30 meters, and about 600,000 with a diameter between 30 and 100 meters. More than 20,000 are so-called Near-Earth Objects (NEO), whose orbits intersect our Earth's orbit. Researchers at the Faculty of Celestial Mechanics at St. Petersburg State University in Russia reported that the orbit of the 340-meter-wide asteroid Apophis will pass close to Earth in 2029, 2036 and 2068, and in 2029 it will be just a tenth of the distance between Earth and our Moon.

Two drastic events show what such chunks can do: On June 30, 1908, the shock wave of an asteroid explosion knocked down millions of trees in Tunguska in Siberia in an area almost the size of Saarland. It is estimated that this explosion took place in the atmosphere at an altitude of 8–12 km, and impacted an area of 50 km in circumference. It unleashed energies equivalent to an incredible 15–20 megatons of TNT. Just for comparison: The highly enriched uranium bomb detonated over Hiroshima August 6, 1945 had a yield of 15,000 tons of TNT. In 2016, to commemorate Tunguska, the United Nations General Assembly proclaimed June 30 International Asteroid Day.

Wikipedia

The so-called "Tunguska event" in 1908, felled 80 million trees in an area in Siberia that roughly corresponds to that of Saarland (about the size of Delaware in the U.S.). The photo dates from 1927.

After 1994, when amateur astronomers documented the huge impact of the Shoemaker-Levy 9 comet on Jupiter, and their impressive images showed "live" what effects such an event could have on Earth, the American Congress felt compelled to act. NASA was given the task of cataloging all NEOs that could pose a threat to Earth and subjecting them to intensive observation through telescopes and radar instruments.

When, in February 2013, an asteroid of about 20 m in size and travelling at about 66,000 km per hour exploded over the Russian city of Chelyabinsk, its shockwave injured more than 1,500 people with flying shards of glass and other debris, and damaged thousands of buildings, that was a further impetus for asteroid research to protect our planet from great death and damage. For the impact in the Urals came without warning; the meteor was sighted only after it had already entered Earth's atmosphere. Its explosive energy was equivalent to about 600 kilotons of TNT.


NASA/ESA

Dark cloud from explosions in Jupiter's atmosphere after the impact of debris from Comet Shoemaker-Levy.

Leading scientists explained that protecting Earth from asteroids and comets must become a common task for all mankind, since dangers from the area around our planet are far more common than most people realize. Alexey Pushkov, then chairman of the Foreign Affairs Committee, demanded:

> Instead of fighting each other on Earth, people should build a European space defense system. The United States should join us and China in creating the AADS—the Asteroid Defense System.

The European Space Agency (ESA) also became active through its Space Situational Awareness Program. The main aim is to collect data from unknown NEOs in order to explore their trajectories and nature, and thus be able to make predictions about possible impacts and consequences.

The focus must therefore be a worldwide coordination of constant observation, characterization and data systematization of asteroids and other bodies that are close to us, whereby projectiles with a diameter of as little as 10–100 m, which are difficult to identify—such as the Chelyabinsk chunk—must be detected. Meteors of this size hit Earth much more frequently than the huge asteroids that really endanger civilization.

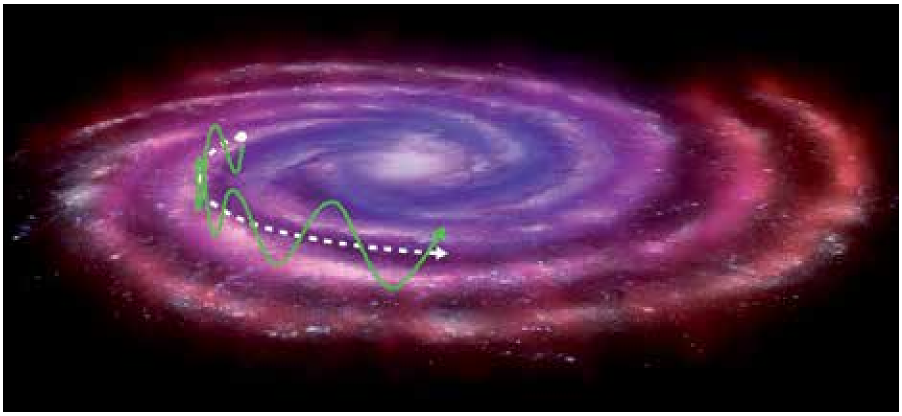
The Reasons for Previous Mass Extinctions

Until now, it was thought that our Solar System's orbit around the core of the Milky Way every 200–250 million years was circular. New research shows our Solar System actually moving in a dangerous odyssey from close to the heart of the Milky Way to its outer arms. Astronomer Rok Roskar of the University of Zurich has performed simulations showing that our Sun formed much closer to the galactic center—only about 10,000 light-years away. Today our Solar System is about 27,000 light years away from the center. In addition, Roskar was also able to show that it performs an oscillating movement on its way, so that our Solar System repeatedly oscillates between the upper and lower "surfaces" of the galactic disk, which is only about 3,000 light years thick, in an interval of about 60 million years. Roskar makes a very worldly comparison:

> It's like surfers on the ocean: if they paddle too fast or too slow, they'll get nowhere.... They have to get the speed of the wave exactly, then they can ride it.

In this way, our Solar System has often either gotten caught in the "ray shower" of a dying star, or has regularly passed through regions of high matter density, where a "hit" is much more likely. This has always had catastrophic consequences for life on Earth. On the one hand, the hard X-rays from very close supernovae have often destroyed the protective ozone layer in Earth's stratosphere, allowing the Sun's UV radiation to penetrate unhindered to the surface. In addition, high-energy protons reached Earth as cosmic radiation, damaging or killing all living beings on the ground and in the seas.

Ten years ago, a German research group found traces of the radioactive isotope iron-60 (^{60}Fe) in sediments of the South Pacific, which supports the hypothesis of a supernova explosion. It decays with a half-life of 2.6 million years. It is only present in trace amounts on Earth, but is produced in large quantities in supernova explosions.


NASA

The Solar System bobs up and down within the thickness of the galactic disk as it orbits the galactic center.

Until now, one could not explain the regularity of the mass extinction; it was speculated that it was related to the motion of the Solar System in the disk of the Milky Way. But that didn't seem plausible. It takes Earth about 200–250 million years to make one orbit of the galaxy, not 60 million years, the time between mass extinctions. In addition to Roskar, Mikhail Medvedev from the University of Kansas in Lawrence has also presented a theory to explain the cycle at the annual meeting of American physicists in Florida. He says it's cosmic rays that cause species extinction:

> Earth is always moving up and down within the disk of the galaxy. As it rises, the distance to the "surface" of the galaxy becomes smaller and smaller. Then more cosmic rays reach the Earth. This ebb and flow of the solar system lasts 62 million years, plus or minus three million.

Within the Milky Way's disk, then, Earth is shielded from dangerous cosmic rays by the galaxy's magnetic field. However, as the planet moves toward either surface of the galactic disk, the magnetic shield thins.

But that's not all: another enormous danger looms during the passages of the Solar System through the mid-plane of the galactic disk: The density of matter is highest there, and many asteroids can be thrown out of their orbits and sent toward our planet, with the well-known predictable, catastrophic consequences. Our Moon's surface also shows evidence of regular impacts, as does the large impact on Jupiter observed from Earth in 1994.

Cardiff University astrobiologists William Napier and Janaki Wickramasinghe have calculated that as our planetary system gradually approaches the danger zone again, Earth's risk of being hit by a comet or asteroid the size of the one that extinguished the dinosaurs is increases tenfold. The researchers emphasize:

> A tenfold increase from a very small risk may not sound like much. But, when it comes to the extinction of many species or even humanity, the number seems more impressive.

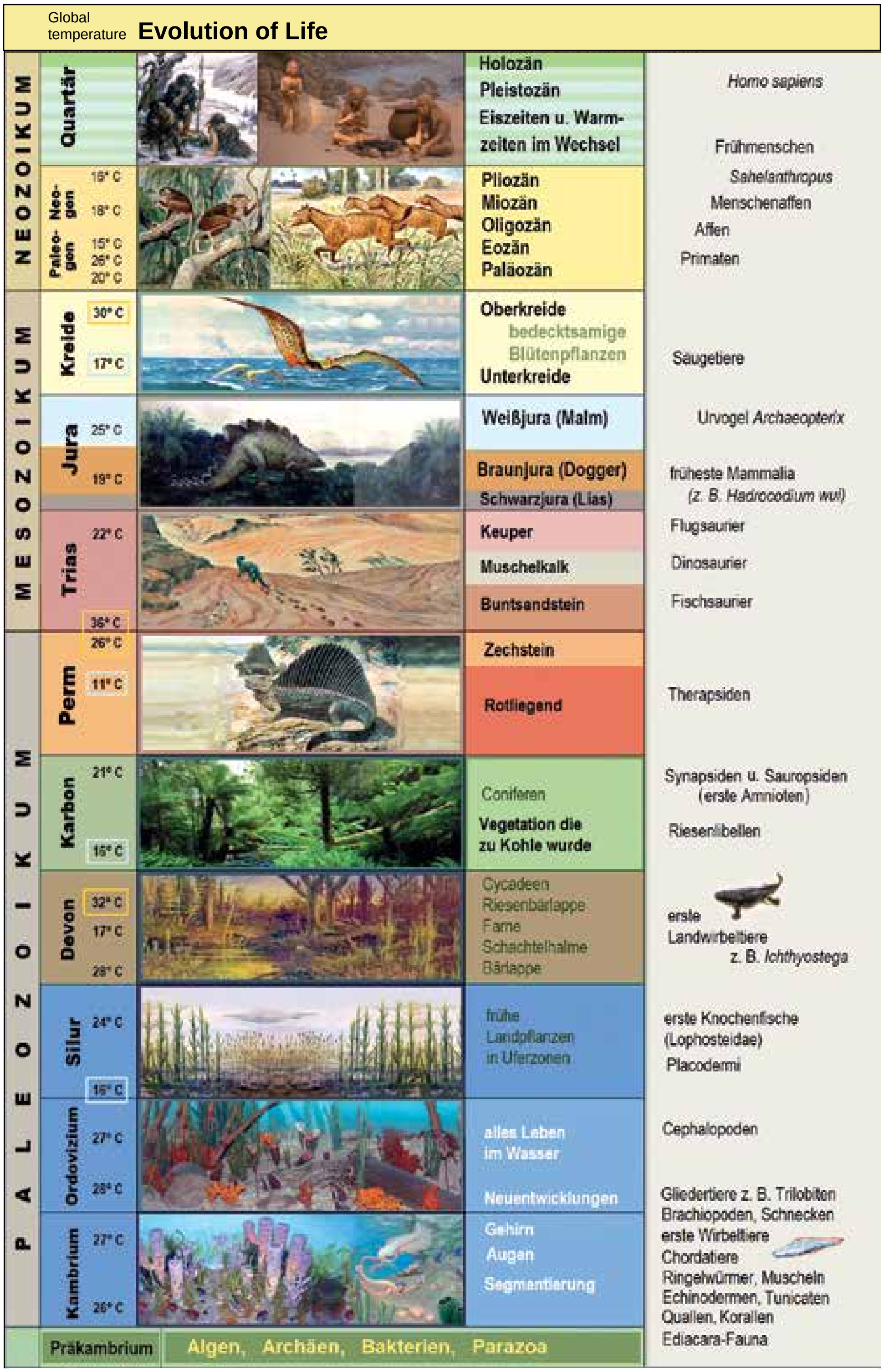
Earth's Wild History

In the 4.6 billion years of Earth's history, devastating impacts have occurred more frequently than commonly thought. There are now known to have been about half a dozen mass extinction events in Earth's history that can be linked to meteor or asteroid impacts.

At the first known major impact, there were only a few species of bacteria on Earth. It happened around 3.47 billion years ago, which geologists were able to prove from deposits of chromium and iridium, some of which were of extraterrestrial origin, in South African and Australian rock. This can also be seen in the so-called "spherules," which are molten rock droplets that rise into the atmosphere when a meteor hits, and then rain down on the Earth again. Researchers believe that this gigantic impact of a celestial body 20 km in diameter, 3.47 billion years ago, split Earth's surface into its present tectonic plates. The average temperature of Earth at that time is estimated to have been 85° Celsius.

The next known devastating meteor impact is estimated to have occurred some 380 million years ago. It triggered a mass extinction of the living beings that existed at that time, which consisted mainly of marine life.

In 2001, geologists found evidence of another serious meteor impact, in the form of extraterrestrial gases trapped in rocks 250 million years old in China and Japan. Further investigation revealed that about 90% of all marine species and 70% of all land vertebrates were wiped out. The impact, they say, was responsible for the most devastating catastrophe in the history of the planet. A huge piece of rock from space with an estimated diameter of 5–11 km was responsible for this great extinction, which must have taken place within a very short time.



R. Pott 2005, nach Verlag Dr. F. Pfeil, © Wissenschaftlicher Verlag, München

This sudden mass extinction can be dated very precisely by fossils and investigations of the corresponding layers of the Earth—for example with drill core studies. It marks the boundary between the Permian and Triassic, the so-called P/T boundary, and the beginning of the Mesozoic. What is meant by this is not just a short-lived moment, but a complete period of transition, in which an entire sequence of events and environmental consequences probably fundamentally changed the living conditions on Earth and thus also the diversity of species.

During the Permian Period preceding this impact—which must have initiated decades of cold and darkness—the land and water was richly populated. There were reptiles, ancestors of dinosaurs, and sharks and trilobites lived in the seas. In addition, there was lush vegetation. Their extinction marked the end of that age, and the beginning of the Triassic Period, in which the dinosaurs came into existence.

But the dinosaurs also

met their end when an asteroid hit them. With a diameter of 14 km, it crashed in the area of today's Yucatán Peninsula in Mexico slightly over 66 million years ago at such a fatal angle, and with such force, that the top 10 km of Earth's crust was pulverized, liquefied, or vaporized, and thrown into the upper layers of the atmosphere. The deeper layers of earth were driven downward by a distance of up to 20 km, but then bounced back up. The asteroid itself evaporated completely. The associated Chicxulub impact crater, about 180 km in diameter, was found in the early 1990s; it is half under water.

As a result of this impact, an enormous shockwave spread in the Earth and seabed, and probably triggered strong earthquakes worldwide. The so-called iridium anomaly layer speaks in favor of an asteroid impact as the trigger of this global catastrophe: In the layers of the Earth at the time of the mass extinction, an increased occurrence of iridium and other platinum metals has been discovered around the world. These substances are extremely rare in the upper layers of the Earth, but not on asteroids.

What was fatal for 70% of all living beings at that time, including the dinosaurs, was probably the beginning of the spread of mammals, since rat-like animals, for example, had survived the impact.

Only if we humans can develop a reliable defense against asteroids will we be the first living creatures not at the mercy of the next mass extinction.

Better Cooperation To Defend Earth

After the collapse of the Soviet Union in 1991, Russia and the U.S. held serious preliminary talks about working together to counter the very real threat of asteroid impact. The most important consultation was a 1993 conference in Erice, Italy, "Planetary Emergency: The Collision of an Asteroid or Comet with Earth." It was a continuation of the regular Erice conferences of the 1980s, chaired by Antonio Zichichi, President of the World Federation of Scientists, and involved leading nuclear physicists such as Edward Teller and Yevgeny Velikhov, who discussed the threat of nuclear war and possibilities for SDI-style missile defense technologies.

But it was only after the 2013 Chelyabinsk event beyond the Urals that future global asteroid defense options were considered. The Russian Federation announced that by the end of 2013, it would launch a research project into a possible anti-asteroid defense system. And in 2014, an international group of experts was founded at ESOC (European Space Operations Center) with the task of developing strategies against the potential threat of dangerous asteroids. To this end, experts from 13 space agencies, from countries across the globe, met at the ESA Space Operations Center in Darmstadt, Germany. Two important institutions were founded: the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG) with 26 member countries as of 2022, including China, Japan, Korea, Mexico, U.S.A., Russia, and Ukraine.

In this network, experts work together, dealing with the detection and tracking of NEOs to calculate their orbits and assess the dangers and effects of impacts; IAWN also cooperates with the relevant civil protection authorities.

So, the first steps have been taken. NEOShield Project Coordinator Alan Harris from the German Aerospace Center (DLR), also a participant in the Darmstadt meeting, is looking far ahead:

> If you could travel 500 years into the future and then look back, you would easily see the importance of founding SMPAG. What was started here has the potential to save millions of lives.... The problem here is, it's about more than one person; it's about our civilization. In the last few hundred years the Earth has become much more densely populated, we have an insanely complicated networked infrastructure with the internet and all that goes with it, and if any part of that infrastructure breaks, entire branches of human lives have major problems, which could really lead to a disruption in the normal functioning of our society.

In September 2022, ESA, NASA and other organizations conducted a joint asteroid defense mission called AIDA (Asteroid Impact Deflection Assessment). The target was the double asteroid Didymos, which is around 11 million km from Earth and consists of the approximately 750 meter chondrite Didymos and its approximately 160 meter companion Dimorphos. This small satellite orbits Didymos in approximately 12 hours at an altitude of 1.1 km.

NASA's DART probe ("Dual Asteroid Redirection Test"), launched Nov. 24, 2021, impacted Dimorphos Sept. 26, 2022. NASA then checked to see how much the orbit of Dimorphos around its parent asteroid had changed as a result. On Oct. 11, 2022, NASA announced that the maneuver had reduced the orbital period of Dimorphos by 32 minutes, from 11 hours 55 minutes, to 11 hours 23 minutes, bringing the smaller asteroid closer to Didymos. The impact also ejected a large amount of debris, forming a comet-like tail some 10,000 km long. The moment of impact was recorded by a small Italian-made CubeSat called LICIACube.

China's space agency CNSA is also working on a defense plan for Earth and will conduct technical studies and research to counteract threats from near-Earth asteroids, Yanhua Wu, Deputy Director of CNSA, said on Chinese state television. China's first test missions to deflect an asteroid are planned for 2025 or 2026. The missions will take close-up images of a selected, potentially dangerous object, the very small asteroid 469219 Kamoʻoalewa, after which the probe will impact the target to change its course, similar to NASA and ESA's AIDA and DART missions. In addition, China plans on setting up an early warning system, developing computer software to simulate measures against potentially threatening asteroids, and testing and verifying basic procedures.

China is working as well on plans for a defense system against Near Earth Objects. The resources for observing, cataloging, and early detection of such .NEOs, along with reactions to them, are to be further expanded in the years to 2025.

In addition to China's plans and NASA's DART mission, the European Space Agency also has an asteroid program. In 2020, ESA launched an asteroid defense project named after the Greek goddess Hera. The aim is to examine how the impact of the NASA probe on the asteroid affected it. ESA's Hera mission vehicle is scheduled to arrive at the binary asteroid in 2027 and study the system in more detail for structure, dimensions and composition, as well as the effects of the DART impact. The mission will provide valuable data on the stability of asteroids.

However, the war in Europe is a terrible example of how quickly international cooperation in important areas can be sabotaged, how quickly scientific organizations can be drawn into the hostile frenzy between nations. Despite, or precisely because of the current war scenarios, which are becoming more and more hardened by the international climate, the decisive step that can save us from a possible destruction of the planet must be taken right now: all space organizations, as in the SMPAG (Space Mission Planning Advisory Group), must come together and coordinate their projects. We finally have to think bigger and face the really important challenges.

Earth Is Approaching the Danger Zone Again

Many near-impacts of celestial objects on Earth have been documented in recent years. Even if there was no immediate danger, the following overview of a selection of objects that are or will be very close to Earth shows impressively how precarious it is for us:

- The object with the closest approach so far is called FU162. On March 31, 2004, it passed Earth at a distance of just 6,500 km, a little over the radius of Earth. However, with an estimated size of six m in diameter, it did not pose a major threat to Earth.
- On March 18, 2004, asteroid 2004 FH, a rock about 30 m in diameter, passed Earth over the southern Atlantic at a distance of only 43,000 km.
- On March 2 and March 18, 2009, asteroids 2009 DD45 (21–47 m in diameter) and 2009 FH (13–29 m in diameter) passed Earth at distances of only 70,000 and 80,000 km, respectively. Both asteroids were only discovered a day earlier.
- On October 12, 2010, asteroid 2010 TD54 (5–10 m in diameter) made its closest approach to Earth at approximately 45,000 km.
- And on April 13, 2029, the 340 meter Apophis will make a close encounter with Earth at a distance of about 30,000 km, less than one-twelfth of the distance to the Moon.

Earth has also received actual hits in recent years, which fortunately did not cause any damage. A well-documented impact took place Sept. 15, 2007 in Peru, near the village of Carancas, just 70 km from the capital La Paz. A meteor entered Earth's atmosphere and resulted in a meteorite fall, leaving a 14-meter crater. More meteorite fragments were found in the area.

And on October 6, 2008, asteroid 2008 TC3 was spotted just 20 hours before it collided with Earth. Luckily it was very small, measuring 4 m in diameter and weighing around 80 tons. It was not until December 2008 that its fragments were found in Sudan.