A Really Bad Day for Early Birds

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1. Introduction

No, I'm not talking about the early birds that get the worms, I'm talking about the earliest ancestors of birds. You may know them as dinosaurs.

The Cretaceous–Paleogene (K–Pg) extinction event, formerly known as the Cretaceous-Tertiary (K–T) extinction event, was a major mass extinction of three-quarters of the plant and animal species on Earth, which occurred approximately 66 million years ago. The event caused the extinction of all non-avian dinosaurs and most other tetrapods[1] weighing more than 25 kg (55 lb.), with the exception of some cold-blooded species such as sea turtles and crocodilians. It marked the end of the Cretaceous period, and with it the Mesozoic era, while heralding the beginning of the current geological era, the Cenozoic Era. In the geologic record, the K–Pg event is marked by a thin layer of sediment called the K–Pg boundary or K–T boundary, which can be found throughout the world in marine and terrestrial rocks. The boundary clay shows unusually high levels of the metal iridium, which is more common in asteroids than in the Earth's crust.

As originally proposed in 1980 by a team of scientists led by Luis Alvarez and his son Walter, it is now generally thought that the K–Pg extinction resulted from the impact of a massive asteroid 10 to 15 km (6 to 9 mi) wide, creating the Chicxulub impact crater in the Gulf of Mexico's Yucatán Peninsula in the early 1990s. This event devastated the global environment 66 million years ago, primarily through a lingering impact winter which halted photosynthesis in plants and plankton. See the image below.

[1] A majority of paleontologists use the term "tetrapod" to refer to all vertebrates with four limbs and distinct digits (fingers and toes), as well as legless vertebrates with limbed ancestors. https://en.wikipedia.org/wiki/Cretaceous%E2%80%93Paleogene_extinction_event#:~:text=The%20Cretaceous%E2%80%93Paleogene%20%28K%E2%80%93Pg%29%20extinction%20event%2C%20%5Ba%5D%20formerly%20known,%5B2%5D%5B3%5D%20which%20occurred%20approximately%2066%20million%20years%20ago.

Since there is a distinct possibility that we could get another visit from a comparable asteroid, we all should have a passing interest in the boulders from outer-space, thus I thought that my readers would be interested in some details about these bodies.

A month or two ago, as I'm starting to write this post, I found a really good article on asteroids, and I copied it a put it away for a future article. I just stumbled upon it again, and thought I'd better get busy writing this paper.

2. Asteroid Family Trees

We've all seen this happen in a science fiction movie: our plucky heroes jump into their ramshackle spaceship and escape the bad guys by flying through the treacherous asteroid belt, where huge rocks tumble and spin so close together that the crew has to constantly dodge, duck, dip and dive to avoid being smashed to atoms.

It's exciting, but it's wrong: asteroids so close together would grind one another to dust in short order, making it extremely unlikely that you'd ever find such a situation near a star. In our solar system, the odds are pretty good that you could stand on the surface of an asteroid and not even be able to see another one! Big ones tend to be many millions of kilometers apart.[2]

Yet they do interact if they are given enough time. Even in the sprawling main asteroid belt between the orbits of Mars and Jupiter, collisions are inevitable. In fact, we've managed to see some small asteroid smashups; bigger rocks are far rarer, so larger collisions are proportionally less common. But they do still happen – spacecraft reconnaissance of large asteroids shows that they are riddled with ancient impact craters. And when two space rocks go "bump" in the main belt, their high orbital speeds mean they can have collision velocities far higher than that of a rifle bullet. Shrapnel is inevitable because big impacts blow lots of asteroidal real estate out into space.

What happens to that ejected debris? In many cases, these fragments stay on much the same orbital path.as the parent asteroid, although they gradually separate from it because of slight velocity differences. After millennia the ejecta might be clear across the sun from its source. You might think this outcome must be problematic for anyone trying to track down different types of asteroids to figure out how they all fit together-and it is. But this problem of orbital mechanics provides its own solution.

That's because the chaos of collisions scarcely seeps into some parts of an asteroid's orbit; two fragments from an asteroid may end up hundreds of millions of kilometers apart, but their distance from the sun and the shape and orientation of their orbits remain similar. One of their most important characteristics is orbital inclination: changing the tilt of an object's orbit via impact is quite energy-intensive, so even after a big collision, the daughter asteroids that have been blasted into space retain a very similar inclination. Such enduring features are collectively called an asteroid's orbital elements, and they allow us to tease order out of the chaos.

[2] Phil Plait, Scientific American, January, 2026 Edition, "Inside Asteroid Family Trees." Note that this article is limited to subscribers. To Order a Copy of a Scientific American Issue: Call (800) 333-1199.

Japanese astronomer Kiyotsugu Hirayama was the first to realize, in 1918, that many more asteroids seem to share orbital elements than would be expected as a result of random chance. He called such groupings asteroid "families," the term we still use today. Families are named after the largest asteroid in the group; Hirayama initially identified three such families, belonging to the asteroids Koronis, Eos and Themis.

Today we know of more than a million asteroids in the main belt, with more found all the time-the newly commissioned Vera C. Rubin Observatory discovered more than 2,000 asteroids in its first 10 hours of observing the sky! As our catalogs swell with new-found asteroids (and as the availability requisite computing power grows), orbital patterns are getting easier to see, more families can be flagged. Astronomers currently recognize a few dozen large asteroid families, but numerous smaller ones are known as well. In a paper published in August 2025 in the journal Icarus, a research team announced that its orbital-element number crunching had revealed an amazing 63 new families.

Finding asteroid families is a boon for planetary scientists seeking shortcuts to discovery: the properties of a small asteroid may be almost entirely unknown, for instance, but if that space rock belongs to a family with bigger, better-studied members, we can more easily make a good guess about what it looks like. Confirming those guesses – making sure the objects really are related-usually requires taking spectra, the time-consuming process of breaking an object's incoming light into individual colors to reveal its composition.

Care must be taken, though. Some very large asteroids are differentiated, which means that when they formed and were still molten, heavy metals and other dense materials sank toward the center while lighter, rocky material floated nearer to the surface. A large-enough impact could excavate an asteroid's depths and shallows alike, creating a family with a mix of compositions; the Vesta family is one such example. (Vesta is the second-largest object in the main asteroid belt after Ceres, and both Vesta and Ceres are actually considered to be protoplanets by planetary astronomers.)

As a bonus, some meteorites on Earth have been identified as being from Vesta because they have very similar compositions; they probably made their way down to Earth when the gravitational effects of Jupiter dislodged them from the main belt. We can study them in detail in laboratories to gain even more insight into that family.

Another team of astronomers published a paper in August 2025 in the Planetary Science Journal on James Webb Space Telescope spectra of Polana, a 55-kilometer-wide asteroid in the main belt. The spectra show that it's the likely parent of the near-Earth asteroids Ryugu and Bennu. If those two names ring a bell, it's because both asteroids were visited by spacecraft that gathered samples and delivered them to Earth for study.

Finding-this particular branch of an asteroid family tree is more than a mere academic exercise: Both Ryugu (about one kilometer wide) and Bennu (0.5 kilometer wide) are potentially hazardous asteroids, meaning they could collide with Earth sometime in the distant future. If we know the parent bodies of such threatening asteroids, we can better understand how they find their way to the inner solar system from the main belt to pose threats in the first place, which in turn can help us defend our planet from future worrisome asteroids.

Of course, the scientific benefits to understanding asteroid families are worth the investigation, too. Asteroids are leftover rubble from the formation of the solar system itself, so studying them is quite literally studying our own family tree, with an occasional extra benefit of finding-and, we hope, avoiding-potentially apocalyptic space rocks.