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Q16

## **what are asteroids? How real is the threat of them causing extinction of life? What strategies have been developed to prevent such a catastrophe?**

UPSC Civil Services Mains 2024 · GS III · 15 marks · Indian Economy

Indian Economy and issues relating to planning, mobilization of resources, growth, development and employment.

### **Core demand of the question**

- Define asteroids
- Assess how real an extinction-level asteroid threat is
- Describe strategies developed to prevent such a catastrophe

### **Revision summary**

Asteroids are rocky, metal-rich small bodies; near-Earth objects are the ones that can meet our orbit.

An extinction-level impact is geologically real (**Chicxulub**) and very unlikely on a human calendar given current catalogues.

Smaller city-threatening objects are less fully known and are the practical hazard.

- **Planetary defence:** survey, characterise, then deflect, chiefly by kinetic impact.

NASA's DART mission in 2022 proved a spacecraft can change an asteroid moon's orbit; civil defence is the short-warning backup.

### **Introduction**

**Asteroids** are rocky leftovers of the early solar system, orbiting mainly between Mars and Jupiter, with some thrown onto paths that **cross Earth's**. A large enough impact can **end a world of species**; that is not a film line, it is the **K-Pg story**. The daily threat to a city is **much smaller**. Strategy now is to **find, track and, if needed, nudge** - not to panic.

### **Body**

#### **What asteroids are**

Asteroids are **small Solar System bodies** of rock and metal, larger than meteoroids and without a comet's routine coma. The **main belt** sits between Mars and Jupiter. **Near-Earth objects (NEOs)** are those whose orbits come close to ours. A **meteor** is the streak; a **meteorite** is what lands. Composition ranges from **rubble piles** to nickel-iron. They matter because their **kinetic energy** at closing speeds of many kilometres a second is enormous even for a modest diameter.

- **Peg:** Main-belt asteroids are the population; NEOs are the ones planetary defence cares about.

- **Peg:** **Chelyabinsk (2013)** was a small airburst that still blew out windows; it was not an extinction object.

## How real is extinction?

Earth **has** taken extinction-scale impacts. The **Chicxulub** event is the standard link to the end-Cretaceous mass dying. That class of object is **very rare** on human timescales. Surveys of NEOs have already catalogued a large share of the **kilometre-class** bodies that could cause a global catastrophe; none on the public lists is on an **imminent extinction path**. Smaller objects that could **destroy a city** are more numerous and **less fully catalogued**. **So the honest answer is: extinction is real as geology, remote as this century's calendar; regional disaster** is the more practical risk. Complacency is wrong. Apocalypse as next year's policy is also wrong.

- **Peg:** Extinction-class impacts are low-probability, high-consequence; city-killers are the gap in the catalogue.
- **Peg:** NASA and other agencies publish impact-probability tables; a non-zero Palermo or Torino scale number is a watch, not a prophecy.

## Prevention strategies

- **The first strategy is** survey: optical and infrared telescopes (ground and space) to find NEOs and compute orbits decades ahead. The second is **characterisation**: radar and fly-bys to know if the body is a rubble pile. The third is **deflection**. **NASA's DART** mission (2022) hit **Dimorphos**, moon of Didymos, and **shortened its orbital period**, proving **kinetic impact**. **ESA's Hera** follows up on that system. Other paper strategies are a **gravity tractor** (a spacecraft that hovers and tugs) and, in extreme theoretical cases, **nuclear standoff blast** - politically and legally fraught. **Civil defence** (evacuate, shelter) is the last layer if warning is short, as with Chelyabinsk's incoming from the sunward sky. International coordination sits in **UNCOPUOS** and planetary-defence groups. The workable doctrine is **early find, small nudge**, years before a predicted hit.
- **Peg:** DART is the first real deflection test, not a science-fiction sketch.
- **Peg:** Time is the weapon: a millimetre-per-second change years out is a miss at Earth.

## Flow diagram

Asteroids -> NEOs  
NEOs -> Rare extinction class  
NEOs -> City-scale risk  
Survey and track -> DART kinetic nudge  
DART kinetic nudge -> Miss Earth

## Conclusion

Asteroids are rocky Solar System bodies; some are near-Earth. Extinction impacts have happened and are unlikely this century; city-scale objects are the live risk. Strategy is catalogue, track and kinetic nudge, as DART showed. Early astronomy is the defence.

## Facts & figures

**NEO**

Near-Earth object: asteroid or comet whose orbit comes close to Earth's.

**Chicxulub**

The impact linked to the mass extinction at the end of the Cretaceous.

**Chelyabinsk, 2013**

A small asteroid airburst over Russia that injured people mainly through broken glass.

**DART, 2022**

NASA's Double Asteroid Redirection Test: a kinetic impact that altered Dimorphos's orbit.

**Hera**

ESA mission to inspect the Didymos-Dimorphos system after DART.

**Gravity tractor**

A proposed slow deflection: a spacecraft uses its mass to tug an asteroid off course.

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