EXTINCTION EVENT FACTSHEET

Extinction events are also widely known as **mass extinctions.** During our planet's 4.6-billion-year history, **five major extinction events** are known. There have been many smaller ones, too.

At each event the fossil record shows **many species disappearing at about the same time.** The effect is a **sudden and significant reduction in the Earth's biodiversity.** That's what defines the term "extinction event." (Please be aware that "sudden" is used in the geological sense. Some of these extinction events could have gone on for a million years.)

Individual species can be wiped out much more quickly, of course. Consider that human hunters killed the world's entire population of **passenger pigeons,** over three billion birds, between 1870 and 1890, a period of just 20 years.

Here are the **Big Five** mass extinction events, listed from **oldest to youngest.** Plus a new extinction event **occurring right now,** which could become big enough to count as **number six.**

ONE

The Late Ordovician extinction event. Two pulses of rapid extinction occurred 450–440 million years ago, near and at the end of the Ordovician Period. About **85 percent** of all species were destroyed. This was the **second-greatest** extinction event known.

Probable cause: the concentration of carbon dioxide (CO_2) in the atmosphere decreased, bringing on global cooling and a **severe ice age.** At the same time, a very large continent (Gondwana, now split up) had drifted over the south pole, providing lots of land on which glaciers could grow. The ice tied up enough of the world's water to **lower the sea level** and turn to dry land much of the shallow-water marine habitat that Ordovician life—which was all marine—depended on.

TWO

The Late Devonian extinction event, 374–359 million years ago. Two to seven pulses of extinction occurred, the last one marking the end of the Devonian Period. About **75 percent** of marine species were wiped out. **Reef-building** in the sea virtually ended and did not recover for a hundred million years. There was considerable life on land at this time, and it was less affected.

Probable cause: **land plants had evolved,** and their roots were quickly breaking up the surface rock. Potassium and phosphorus, which living things need, weathered out in great quantities. Carried down the rivers and into the sea, these nutrients may have caused enormous **algal blooms** that used up much of the **oxygen dissolved in the seawater.** The lack of oxygen would have killed the reef-builders and most of the associated organisms.

THREE

The end-Permian extinction event. Sometimes called the **"Great Dying,"** this one occurred 251.4 million years ago at the end of the Paleozoic Era. It was the **most severe** extinction event known. Up to **96 percent of all sea life** and **70 percent of life on land** died out. It happened very quickly, geologically, in only 60,000 years.

Probable causes: it may have started with a huge outpouring of **lava** in Siberia, which emitted a great deal of carbon dioxide. We know that atmospheric carbon dioxide increased to about **seven times the current concentration**, acidifying the ocean and raising the average global temperature by about 8°C. The eruptions cannot account for enough CO_2 to do this, but they also released a lot of **nickel,** which helped to sustain population explosions of microbes involved in raising CO_2 levels, and **mercury,** a poisonous element. The molten rock seems to have ignited Siberian **coal beds,** which produced CO_2 as they burned, plus sunlight-blocking smoke and **toxic ash** that drifted over the oceans. This combination alone would have killed many marine organisms unable to tolerate such major environmental changes.

A sudden worldwide spike in **methane gas** (CH_4) occurred, partly brought on by **huge increases in oceanic *Methanosarcina* bacteria,** which had just acquired a gene for rapid methane production. Their numbers were boosted by the nickel infusion. Further, **methane hydrates**—natural gas held in water molecules in the chilly sediment along the edges of the continental shelves—broke down as the climate warmed and released yet more CH_4 into the atmosphere. **Methane is a potent greenhouse gas,** and the resulting runaway global warming may have upset the atmosphere's carbon cycle enough to rob the oceans of much of their dissolved oxygen. This would have killed most marine life. At the same time, **bacteria not dependent on oxygen would have flourished,** releasing a great deal of poisonous **hydrogen sulphide gas** (H_2S) into the upper ocean, a further deadly blow—and into the atmosphere as well. This was the end for most species of land animals.

FOUR

The end-Triassic extinction event has been accurately dated to 201,564,000 years ago at the end of the Triassic Period. Taking place over **less than 10,000 years,** this event killed off at least **50 percent** of Earth's species. The survivors included the **dinosaurs,** which filled empty ecological niches and took over the world.

Possible cause: this is the least understood of the big-five extinctions, but like the end-Permian event the evidence points to **rapid global warming,** perhaps mainly from the breakdown of methane hydrates and release of CH_4 greenhouse gas, leading to another **anoxic episode** in the sea and more poisoning by H_2S. The trigger seems to have been very large **volcanic eruptions** from the **Central-Atlantic Magmatic Province (CAMP),** the major rift zone that widened into the Atlantic Ocean during the breakup of **Pangea** about 200 million years ago.

FIVE

The end-Cretaceous extinction event (also called the **Cretaceous-Tertiary**, **K-T** and **K-Pg** extinction event), occurred 65.5 million years ago at the end of the Cretaceous Period, also marking the end of the Mesozoic Era. In this event, about **75 percent** of species died out. All the dinosaurs except the flying theropods—the **birds**—perished.

Cause: the trigger for this event and its effects are well known. An **asteroid 10–15 km in diameter struck the Earth.** The point of impact has been found: the **Chicxulub** ("CHEEK-shuh-loob" **Crater,** at least 180 km across, which lies along the northern coast of the Yucatan Peninsula in Mexico. It has been dated to the time of the extinction.

Worldwide, wherever sedimentary rock of that age exists it includes a layer enriched with **iridium.** This is a common element in asteroids and some meteorites, but it is rare on Earth. Particles of **shocked quartz**—formed only under severe impact—are also found in this layer, plus **tektites:** molten bits of rock that have been lofted into space and drifted back down.

The energy released in the impact has been estimated as being equivalent to **100,000 billion tonnes of TNT.** (The largest nuclear bomb ever exploded was equivalent to 50 million tonnes.) This generated an extremely powerful shock wave and a flash of intense heat that spread in all directions.

It was North America that suffered the most. The asteroid came in from the **southeast** at an **angle of 20–30 degrees,** which sent a wall of red-hot dust and debris racing northward across the Gulf of Mexico and into the U.S. and Canada. **Anything living between the Appalachians and the Pacific probably would have been killed outright.** As the seismic wave spread around the world, it would have triggered many **earthquakes** and **volcanic eruptions**. **Tsunami waves over a kilometre high** would have struck the northern Gulf coast.

The world's ecosystem could have rebounded from this, because the initial destruction was limited mainly to one continent. But planet-wide ecosystem killers came next.

Earth was swathed in a **dust cloud** dense enough to keep all sunlight from reaching the surface for about a year, followed by ten years of greatly reduced solar heating and light. The impact generated **global acid rain.**

The acidity, the darkness and the long **"impact winter"** caused the death of **most land plants** and the ocean's **photosynthesizing plankton.** Organisms that ate these foods soon starved, then the creatures that hunted them.

The number of **dinosaur** species in North America may have been dwindling before the asteroid struck, perhaps indicating that a minor extinction event was already underway. But the asteroid-induced event clearly wiped out the world's remaining big reptiles and other large animals. Probably nothing larger than a housecat was able to live and reproduce.

Of the survivors, **mammals and birds** did the best. Like the dinosaurs before them, they radiated into the many newly opened ecological niches. After a few million years of diversification, mammals came to dominate the planet. Also like the dinosaurs, mammals increased in size.

Today, material ejected from the impact makes up a **"boundary claystone"** layer found from Texas to Alberta along a path 200–300 km wide. It is easy to identify (if you're a geologist) and provides a very accurate time-line in the rock.

SIX?

The Holocene[1] extinction event, the most recent mass extinction, has been occurring since the end of the Ice Ages and is accelerating today. It may or may not turn out to be the sixth great mass extinction, but the current estimated rate of species loss—up to 140,000 per year—is on par with the previous five. The cause is obvious: **activities of our own species.**

The human population has grown explosively. We have become very numerous on every continent except Antarctica. We are taking over more and more of the world's land and turning its food-production potential and habitat to our own use. In the process, natural ecosystems are being depleted, air and water are being polluted and biodiversity is being reduced on both land and sea.

Perhaps most disturbing is the **global warming** we are causing by burning so much fossil fuel so quickly. Global warming is strongly associated with two of the Big Five extinction events.

— Ben Gadd, 2015

[1] As of 2012, the new term **Anthropocene** (pronounced "ANN-throw-po-seen" or "Ann-THROW-po-seen") is becoming a popular alternative to "Holocene." It occupies a similar time slot, from roughly 14,000 calendar years ago (12,000 radiocarbon years ago) to the present. The Anthropocene denotes the portion of the geological record in which humans have become numerous enough and powerful enough to affect the climate, geology and biology of the planet.