COMETS

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The year 1986 might well be called the year of the comet. Comets have throughout history fostered mystery, fear, and scientific challenge regarding their composition, orbits, and origins. They are defined as small stray bodies in interplanetary space that are conspicuous because of gaseous emissions, a head, or coma, and a tail. The Latin word coma, meaning hair, derives from its tail. More recent findings have credited them with being the source of annihilations and world-wide trauma. But, first, let us take a look at the one that is, at present, on everyone's mind -- Halley's.

Scientists have traced the orbits of Halley's Comet for some three thousand years, and we now know that it has been making its journey around the sun regularly every seventy-six years. Until the late seventeenth century, however, astronomers thought comets did not follow regular orbits but took more or less straight-line courses until they came too close to the sun and were destroyed.

Johannes Kepler had established the law of planetary motion for orbiting the sun but did not think it applied to comets. Edmond Halley, a precocious young man, showed outstanding mathematical and scientific ability even at an early age. He graduated from Oxford with a special interest in astronomy, and while in his early twenties, was voted into the prestigeous Royal Society of London.

While studying the law of planetary movement with Professor Robert Hooke and Sir Christopher Wren in 1682, Halley proposed that the force of attraction between a planet and the sun must vary inversely with the square of its distance from the sun, but none of the three of them could work out the equasion. Halley decided to consult Sir Isaac Newton at Cambridge. H. H. Turner, a professor of astronomy at Oxford, in the early twentieth century, remarked, "When did ever an Oxford man take a journey to Cambridge that was of such vital importance to the world ! "

Halley got to the point of his visit when he asked Newton, "What would be the curve described by the planets on the supposition that gravity diminished inversely as the square of the distance?" Without hesitation Newton replied that it would be an elipse. Asked how he knew, Newton replied that he had calculated it. When Halley saw the calculations he realized that Newton had produced the concept of universal gravitation. He persuaded Newton to publish his great work which he had called Principles of Natural Philosophy. Halley worked with Newton, correcting errors and prepared the geometrical figures. Newton acknowledged his debt to Halley in the book's preface, describing him as "most acute and universally learned", adding that through his solicitation the book came to be published.

In 1695 Halley computed the course of twenty-four comets and became convinced that the comet seen in 1682, 1607 and 1531 was one and the same. He predicted its return in the year 1758. He expressed the hope that candid posterity would not refuse to acknowledge that this was first discovered by an Englishman. His wish was fulfilled as the comet now bears his name.

Professor Fred Whipple of Harvard, after years of study, has concluded that the head of a comet is composed of dirty ice, chiefly made of water combined with frozen carbon dioxide, ammonia, and other gases. No one has ever gotten a good look at the nucleus. When the comet enters the inner solar system, sunlight vaporizes the frozen gas on its surface, forming the coma that surrounds and obscures the nucleus. It is thought to be about five miles in diameter, and in its last orbit appeared to be rotating every ten hours.

As it approaches its perihelion, the gasses become luminous, forming the familiar coma and long diaphonous tail. The tail is amazingly thin though millions of miles long. It is estimated that a million miles of tail can be formed from one ounce of the frozen gas. It is so thin that photographs can be taken through it without distorting the picture. A force opposite to gravity repels the tail, making it follow the coma as the comet approaches the sun and precede it as it returns to its aphelion. The force of repulsion is not fully understood. It is due partly to radiation pressure and solar wind, with magnetic fields acting upon the ionized molecules.

People have for centures been fearful of comets. Thinking they were sent by angry gods to punish them, the Greeks thought the fiery tail would scorch the earth, bringing sickness and starvation to them. In the Iliad, Homer wrote that Achilles' helmet shone (quote) "like the red star that, from his flaming hair, shakes down disease, pestilence, and war."

As late as 1910, when Halley's Comet made its last previous visit to us, there was widespread fear. The New York Times reported on May 18, 1910 that planet Earth would, that night, travel through the million-mile-wide tail of the comet, a journey of about six hours. They were told, also, that the tail contained cyanogen gas, a gas so poisonous that one drop of it on the tongue would be fatal. Newspapers later tried to quell the panic by informing the readers that the gas in the tail of the comet is so rarefied that it would be impossible to receive any ill effects from it. Nevertheless, this proved less than convincing as a lady phoned "I have stopped up all the windows and doors in my flat to keep the gas out and all the other women in the building are doing the same thing.

Today, great preparations are being made to try to get a close look at it. An International Organization of Halley Watchers has been formed. Most of the observatories of the world are involved and several countries are sending space craft into the area.

The Soviet Union, in partnership with France, has sent two spacecraft equipped with television cameras and assorted sensing instruments to scout it. Vega I and Vega II were launched in December 1984 from the space center in Kazakhstan. They were to go first to Venus, where each was to release a smaller craft to make landings to study circulation patterns of the dense Venusian atmosphere. However, they have been re-directed to fly by Venus, using the planet's gravity to give them the boost needed to send them to the vicinity of Halley next month.

The plan is for Vega I to pass through the comet's atmosphere to within 6000 miles of its core, March 6. Vega II will follow three days later and risk an even closer approach of about 2000 miles from the nucleus. Whether the Vegas survive this close contact with the comet is problematical. The crafts' communication systems and other critical parts are shielded only against impacts of high velocity small particles. The Vegas are to transmit pictures and gather data on the size, shape, surface properties, and temperature of the comet's nucleus. They are also to check the chemical reaction and physical processes in the coma and study gas and particle composition at various distances along the tail. The dust will be studied by several instruments, such as a dust-plasma counter to measure minute particles, and a mass spectrometer to get the mass and chemical composition of dust in the coma.

Palomar Observatory in California was the first to detect the point of magnified light of Halley in photographs taken through the telescope October 16 1982. The comet, still beyond the orbit of Saturn and traveling 23,000 miles an hour, was as faint as the light from a single candle seen 27,000 miles away. Within two months it was sighted by observatories in Arizona, Hawaii and Chile. As it has drawn closer, most all the observatories and thousands of amateur astronomers have followed its orbit.

Never has a comet been the object of such scrutiny. The Europeans are aiming their spacecraft, Giotto to a point where the orbit of Halley intersects the plane in which the earth orbits. This should occur on the night of March 13-14. The Giotto is expected to pass within some three hundred miles to the sunward side of the cometary core -- dangerously close, perhaps fatally close.

A sandblasting of cometary dust is likely to destroy the craft near its closest approach. The European strategy is to get in as close as possible, immediately relay all data to Earth, and find out as much as possible before the probe dies. They hope to get information concerning the composition of the coma, the physical processes and chemical reactions in both the comet's atmosphere and ionosphere, the composition of dust particles and the ratio of dust to gas. They hope also to learn the properties of the flow of ionized gas in the vicinity of the comet and its reaction to solar wind.

Beyond the orbit of Halley, at the outer rim of our sun's gravitational system, between 30,000 and 100,000 astronomical units from the sun, orbits a great cloud of comets. Jan Oort, for whom it is named, suggested that early in the history of our solar system, a planet orbiting the sun between Mars and Jupitor, may have exploded. Such a planet, judging it to compare with Jupiter in composition, would have contained enough light-weight material to produce billions of comets, plus countless bits of heavier material surviving as asteroids.

Many of these meteors are thought to have hit other planets or burned in the sun, with more still cluttering the region between Mars and Jupiter. The lighter material formed the billions of comets that populate the Oort Cloud. Estimates of the total mass of comets in the cloud vary from two earth masses to twenty-four earth masses. Many times that amount are believed to have been thrown out into interstellar space.

These comets are classified as long-term comets taking between one-half and two million years to complete their orbits, and short-term comets that make their journies around the sun in from three to two hundred years in cigar-shaped courses.

The shape and length of the orbits are determined by the speed and the direction of the comets -- eliptical if the orbital speed is less than the speed of escape, parabolic if they are the same, and hyperbolic if the speed of escape exceeds that of the orbital speed.

Stars are thought to occasionally penetrate the Oort Cloud, scattering comets in all directions, some of which are sent into our inner solar system to become short-term comets. It is believed that either one of these comets, or one of the wandering asteroids, collided with the earth at the end of the Cretaceaus Period, causing a catastrophe of world-wide proportions.

Exciting developments that strengthen this belief are examined in a series of articles in recent scientific magazines. They have introduced new evidences of the cause of the extinction of the dinosaurs and other animals. The New York Times Magazine, Science Magazine, Nature, Time, and Newsweek have published articles within the last few months concerning this most intriguing hypothesis.

It has been established that at various internals in history, mass extinctions have occurred. It was in one of the largest of these catastrophes, some sixty-five million years age, that most of the living creatures, including the dinosaurs, abruptly vanished. Physicists have for centuries sought to find the reason with little or no success. Now within the last seven or eight years, discoveries and subsequent research have provided evidence that a natural "nuclear winter" or global blackout occurred at the same time the dinosaurs mysteriously disappeared.

In 1978, Luis Alvarez, who was the 1968 Nobel Prize winner in physics, now a professor at the University of California at Berkley, became fascinated with a piece of sixty-five million-year-old sedimentary rock from Italy. It had been given to him by his son, a geogolist at Columbia University. Trapped in the rock were many small fossils of sea creatures, but the fossils were almost exclusively in the bottom half of the rock. Something had killed virtually all microscopic life before the top half was formed. This something had occurred at the same time the dinosaurs vanished.

After weeks of searching, he was rewarded with his first real lead. Iridium, a rare metal in the platinum group, rains on the earth in minute quantities when micrometeorites vaporize upon entering our atmosphere. In analyzing the rock from Italy, Alvarez and his colleagues found, to their surprise, that the concentration of iridium rose abruptly at the time of the disaster to levels far more than could be accounted for by vaporizing micrometeorites alone. An extraterrestrial body with approximately six-mile diameter had struck the earth releasing energy equivalent to ten thousand times the combined nuclear arsenals of the United States and Russia. Dust thrown up by the impact would have blocked out the sun for months causing photosynthesis to cease and temperatures to drop drastically. The dinosaur would die from freezing and/or starvation. This impact theory was published in 1979.

David Raup and John Sepkoski, paleontologists working at the University of Chicago found evidence that mass extinctions had occurred regularly every twenty-six million years, the next one being due thirteen million years from now. This coincides with the devastation of sixty-million years ago.

As a result of this new evidence, Richard Muller, a student and later colleague of Alvarez, with the help of Marc Davis of the University of California and Piet Hut, an expert in orbital dynamics at the University at Princeton developed a challenging theory that seemed to explain the periodic extinctions. This new line of reasoning, called the Nemises Hypothesis, was published in 1984. Named after the Greek goddess who punished the excessively proud and powerful, in this case the dinosaurs, it is quite simple. The sun has a companion star orbiting it. Every twenty-six million years this star passes relatively close to a cloud of some trillion comets in the outer regions of the solar system, namely the Oort Cloud. The comets are pulled by the gravity of the orbiting star, about a billion of which are sent into the inner solar system. One or more of these comets hit the earth. Despite vigorous examination of the theory by critics, it has yet to be proven wrong. Called the Death Star, it is thought to be a red star about twenty trillian miles away, barely visible with powerful telescopes. A team of physicists and astronomers at Berkley are at present examining about five thousand candidates.

Now chemists at the University of Chicago have added still another theory to the one of comet dust. Edward Anders and his colleagues, Wendy Wolbach and Roy Lewis have reported in Science Magazine, October, 1985, that they have found evidence of a global fire storm at this time, which is at the end of the Cretaceaus period. This conflagration would have been much, much more devastating than merely the dust storm that Alvarez imagined. Hoping simply to elaborate on the hypothesis of Alvarez, they took samples of sediment of this period from Caravaca, Spain, Stevens Klint, Denmark, and Woodside Creek, New Zealand. Their aim was that by finding trace amounts of noble gases, which are gases from extra-terrestrial bodies, they might be able to identify the nature of the object -- that is, whether the meteorite was a comet or astoroid -- which had been responsible for the impact. Because noble gases collect in carbon particles, the scientists isolated the carbon in the layer. They found that all three samples of the sediment contained carbon that had been deposited ten thousand times as great as carbon in the layers above and below the layer of this period.

Also they discovered that the carbon was bunched together in fluffy patterns. When highly magnified, they appeared to be in clusters like bunches of grapes from one-tenth to one-half micrometer across. They had to be soot. Since soot forms in much greater amounts in fires where oxygen is limited, this would have been the case when Amazon-size areas were simultaneously ignited. The amount of soot found in the strata of rock in Spain, Denmark, and New Zealand suggests a world-wide fallout. This surprisingly large amount -- ten percent of the bio-mass of today's earth or four per cent of the estimated biomass of the Cretaceous Period -- implies that either virtually all vegetation burned or that substantial amounts of fossil fuels were ignited. Although fossil carbon cannot be ruled out at the present time, wild fires of vegetation seem to be the more plausable source. The size of the particles is similar to that assumed for a nuclear holocaust, but the global distribution is more uniform and the amounts much greater suggesting that soot produced by giant wild fires is about ten times more efficient than that assumed for a "nuclear winter". Thus cooling would be more pervasive and lasting.

If an object six-miles in diameter -- typical of a meteorite -- hit the earth, it would form a crater twenty-miles deep. Since no such crater of the right age has been found, some geogolists believe the impact took place in water, probably the Bering Sea. Because the oceans there are only about two miles deep, the object would have hit the sub-oceanic rock with the force of one hundred megatons. This would have vaporized it, producing a steamy, mushroom cloud. The fireball consisting of vaporized rock with a temperature of 3100 degrees Fahrenheit and traveling at the speed of sound would have incinerated animal life and ignited forests thousands of miles away. Eurasia and North America would have been well within range. The incomplete combustion of the huge fires would then have caused the tremendous amount of soot which, when joined with the impact dust in the stratosphere, would have blackened the skies around the earth. There is no other known process that would produce these irregular-shaped, fluffy clusters of speriods.

Along with the fluffy soot, there were in all three samples of rock -- that is, from Spain, Denmark, and New Zealand -- micrometic-size disc-shape particles of carbon with isotopes denoting extraterrestrial origin. The chemists at the University of Chicago analyzed six samples of the carbon for xenon, neon, and the other noble gases -- gases of an extraterrestrial body. After eliminating the atmospheric gases at eight hundred degrees, they found iridium and xenon that were released between eight hundred and two thousand degrees. Only two unvaporized materials survived: spinel, which has a melting point of 2135 degrees and graphitic carbon. This was treated to destroy the carbon and rutile remained. Thus, the sediment was proven to contain evidence of both a meteoritic impact and a world-wide conflagration.

Scientists seem to be in agreement as to the approximate size of the meteorite. Stony meteoroids, especially those of cometary origin, up to one kilometer spall and break up in the atmosphere. Larger bodies would be destroyed on impact and revert to carbon monoxide and hydrogen. Thus the estimated size is approximately ten kilometers, or six miles in diameter.

Up to the present time, no one has been able to knock down the hypothesis that approximately every 26 million years a meteorite of some description eliminated seventy per cent of the animals and plants. However, since many geogolists, astronomers, paleontologists, and statisticians have had a chance to study the theories proposed, some serious criticisms have emerged, principally concerning the cause of the entry of the comets into the inner solar system.

The theory that an unseen companion to the sun disturbs a comet cloud, as proposed by Muller, has seemingly survived the recent criticism fairly well. The major question, however, has been whether the sun could hold onto a companion, a small cool star, or a star so small that its nuclear fires were never ignited. It would be orbiting at the edge of the sun's gravitational pull at an average distance of 90,000 times that of Earth. Muller and his colleagues have assumed from the start that the companion had originally formed a smaller, more stable orbit and slowly drifted outward, due to the gravitational pull of passing stars. Hut and Muller and their fellow researchers have checked the stability of the orbit as well as the influence of passing stars and the gravity of the galaxy and maintain that although the companion might be stripped away in a million years, they find no problem earlier than that.

A quite different theory for the increase of short-term comets has not faired as well. This hypothesis is that every sixty-six million years, our sun, along with its planetary system, oscillates through the central plane of our galactic disc, disturbing the profusion of comets within it and sending a billion or so into our inner solar system. A dozen or so would probably hit the earth over a million years. The largest impact could have caused the extinctions.

Patrick Thaddeus and Gary Chanen of Columbia University have struck a serious blow to this theory, however, maintaining that clouds of comets are simply not bunched tightly enough within the plane of the galactic disc to make the near-plane encounters distinctly more numerous than those away from the plane.

Although these reasons for periodic extinctions, as well as others not examined in this paper, continue to be under attack, the analyses suggesting that extinctions have occurred approximately every twenty-six million years has stood up. Regardless of what measure is used, the same periodicity shows up. As a result, major extinctions, including the one sixty-five million years ago that took away the dinosaurs, is almost universally accepted in the scientific world.