COMETS, METEORS, AND METEORITES

★

By CHESTER A. REEDS
CURATOR OF GEOLOGY AND INVERTEBRATE PALAEONTOLOGY

AHNIGHITO, A CAPE YORK, GREENLAND METEORITE

Reprinted from Natural History Magazine for May-June, 1933

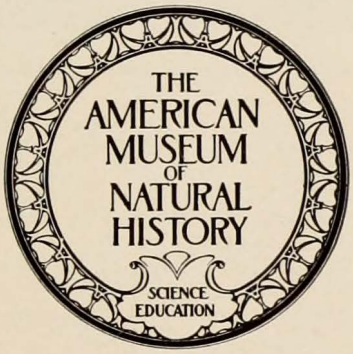
★

GUIDE LEAFLET SERIES, No. 77

THE AMERICAN MUSEUM OF NATURAL HISTORY
NEW YORK, 1933

COMETS, METEORS, AND METEORITES

By CHESTER A. REEDS
CURATOR OF GEOLOGY AND INVERTEBRATE PALAEONTOLOGY



Reprinted from Natural History Magazine
for May-June, 1933

GUIDE LEAFLET SERIES, No. 77

THE AMERICAN MUSEUM OF NATURAL HISTORY
NEW YORK, 1933

Artist's Sketch of Successive Explosions of a Meteor. By T. W. Voter

COMETS, METEORS, AND METEORITES

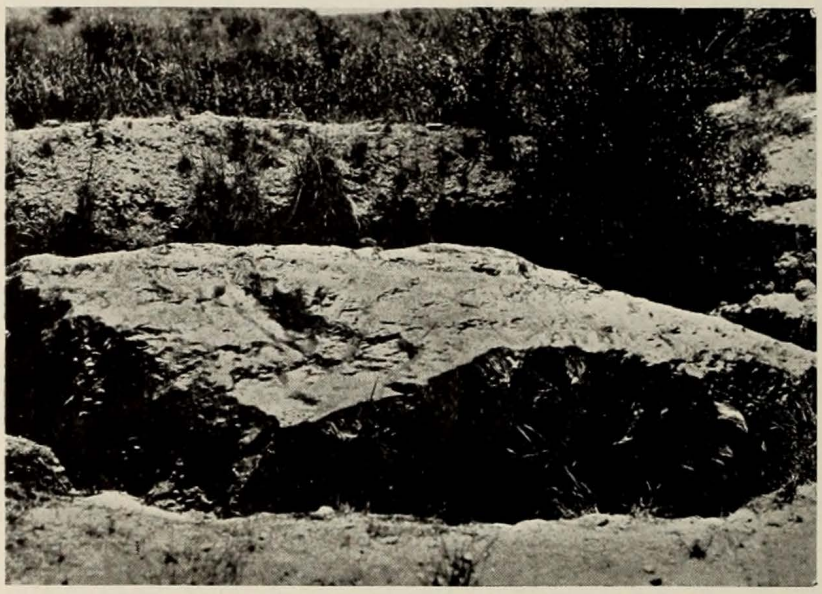
Mysterious Travelers of the Sky—Their Origin, Action, and Composition

By CHESTER A. REEDS

Curator of Geology and Invertebrate Palæontology, American Museum of Natural History

COMETS, meteors, and meteorites are usually regarded as three distinct cosmic phenomena. They seem to be connected, however, by relations of origin and association founded upon well authenticated observational evidence. These phenomena appear but occasionally and are singular and mysterious in aspect. In appearance comets and meteors resemble one another, for they both have luminous heads and nebulous tails, but as far as space relations are concerned they are separated by millions of miles. Comets, which are the most distant, are those erratic members of the solar system which move in elongated orbits about the sun. Their masses are exceedingly small when compared to their size, for they are generally surrounded by hazy or nebulous envelopes. Meteors, on the other hand, are transient cosmical bodies which enter the earth's atmosphere from without and become luminous as they shoot across the sky. Meteorites are masses of matter from outer space which have fallen upon the earth's surface. They consist usually of stony matter with varying amounts of metallic iron and nickel; more rarely of nickeliferous iron and much more rarely of stony matter with little or no metal.

For untold centuries man has looked at the starry canopy of the heavens at night and marveled at the wondrous display of the moon, the planets, and the multitude of stars set in constellations or in the Milky Way. During the day this same canopy impresses him in a different manner, for, due to the strong light from the sun, the zenith appears to be sky-blue and a sense of emptiness and vacancy is in evidence everywhere except for the clouds that may form in the lower levels of the



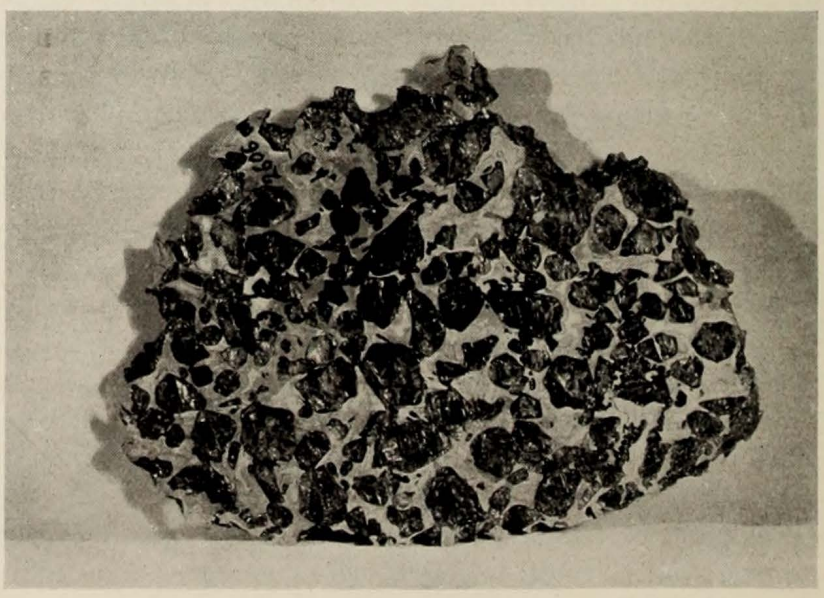
HOBA WEST SIDERITE
This fell near Grootfontein, Southwest Africa. This find (1920) is reported to be the largest single mass of meteoric iron known (3×9×9.67 feet) 60 metric tons, 132,300 lbs. Iron 83.44%, nickel 16.24%. It shows no lines—an ataxite

atmosphere called the troposphere. The stars and planets which are prominent on clear nights can seldom be seen in the daytime except from the depths of a well, a cave, a cañon or through a telescope.

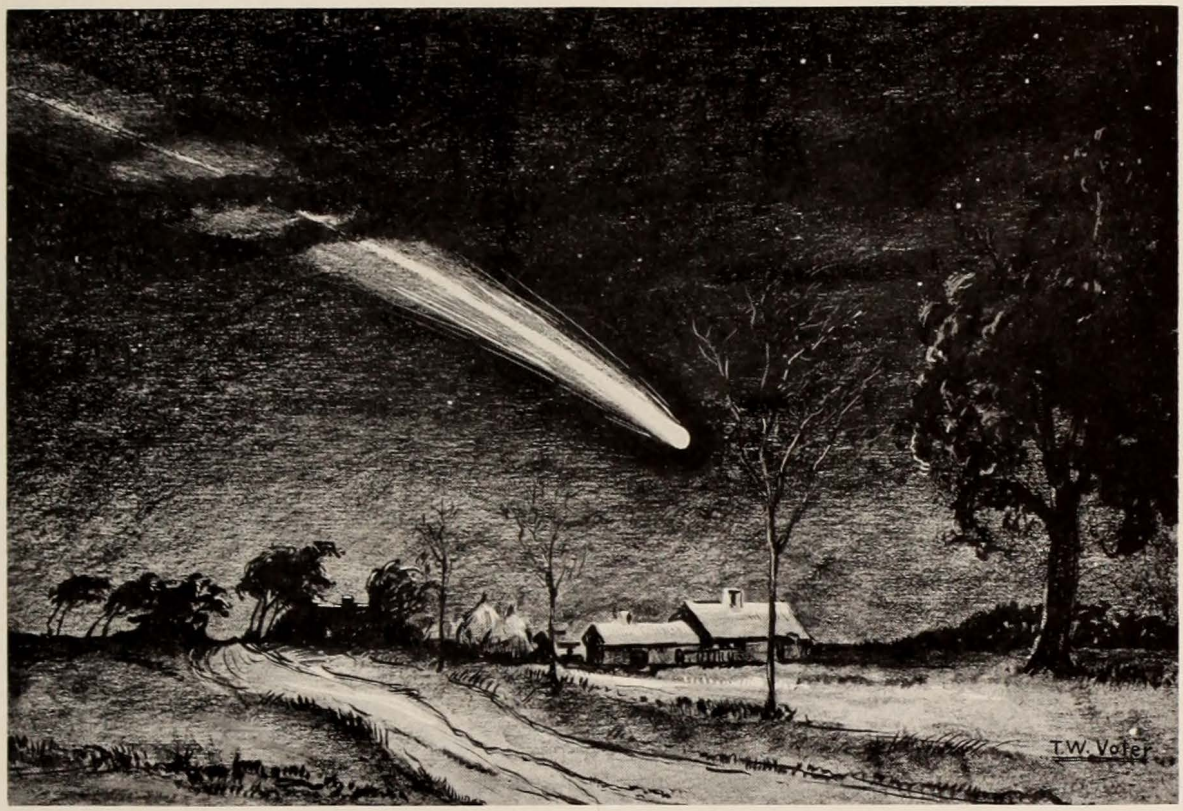
Man has discovered from such observations spread over many centuries that these various celestial objects have regular yearly movements, that they are governed in their course by definite physical laws, and consequently he has grown accustomed to their regular movements, for he sets his clocks and watches by sidereal time, predicts the time of eclipses to within a few seconds of their happening, plants and harvests his crops according to the seasons, makes his home on the earth and plans his business undertakings for the coming year with full confidence that these bodies will continue their accustomed movements and functions.

On the other hand it has been more difficult for man to visualize the daily and yearly movements of the earth, as one of the planets of the solar system, for he, with his buildings, railroads and other works, is carried along unconsciously with the earth as the entire solar system moves through space towards the star Vega. The earth rotates on its axis at the rate of 17.28 miles a minute at the equator and travels at a speed of more than 1000 miles a minute along its path around the sun.

While these celestial and terrestrial phenomena are profound and have engaged the attention of scientific men and philosophers for more than two millenia, the occasional appearance of comets, and the not infrequent flight of meteors and meteorites have aroused special attention, for these phenomena are as yet not fully understood. Comets, meteors, and meteorites appear by day or by night. They are seen in flight more clearly by



OLLAQUE SIDEROLITE, OLLAQUE, BOLIVIA
The polished surface shows olivine masses filling meshes of nickel-iron network

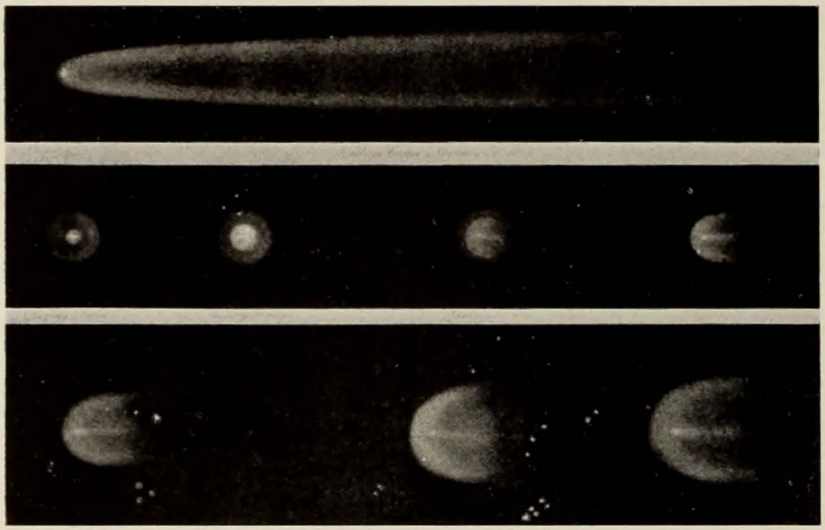


ARTIST'S SKETCH OF METEOR FALLING AT NIGHT. BY T. W. VOTER
Meteors pass through the atmosphere at speeds varying from eight to fifty miles per second

night than during the day for at night their light is apparently stronger.

Comets are rarely conspicuous, for less than ten per cent of the several hundred thousand in the solar system can be seen with the naked eye. They vary considerably in size, some of the smallest have approximately the diameter of the earth; while the Great Comet of 1811 exceeded the size of the sun and had a diameter of fully 1,000,000 miles. The average size of many of them is 80,000 miles. Comets, which move in highly elliptical orbits of great extent are, according to Kepler's laws, much more rapid in their motion when near the sun than when far away. Moreover, since most of them are illuminated only during the short interval when they are near the sun, they travel most of the time in the cold realms of space as dark objects or faintly luminous bodies.

Comets usually have a brilliant head and tail when seen near the sun. The long tail, if present, generally streams across the sky for millions of miles in directions away from the sun. The brilliant head is hazy and nebulous in appearance and may change in size when swinging through that portion of its elliptical orbit nearest the sun, called perihelion. Although the head may be great in size its mass is exceedingly small, being less than that of the major planets. Within the head a sharply defined star-like nucleus is usually visible. This nucleus is generally believed to be composed of a swarm of meteors and meteorites, whereas spectrum analyses show that the outer portion of the head consists of the extremely rarefied gases cyanogen and carbon monoxide. The tail is not in evidence when the comet is far from the sun, but, as the sun is approached, an atomic activity is set up within the head and electrons are driven off into space to form the tail. Some force, perhaps the sun's light pressure, radiation pressure or electrical repulsion within the comet's



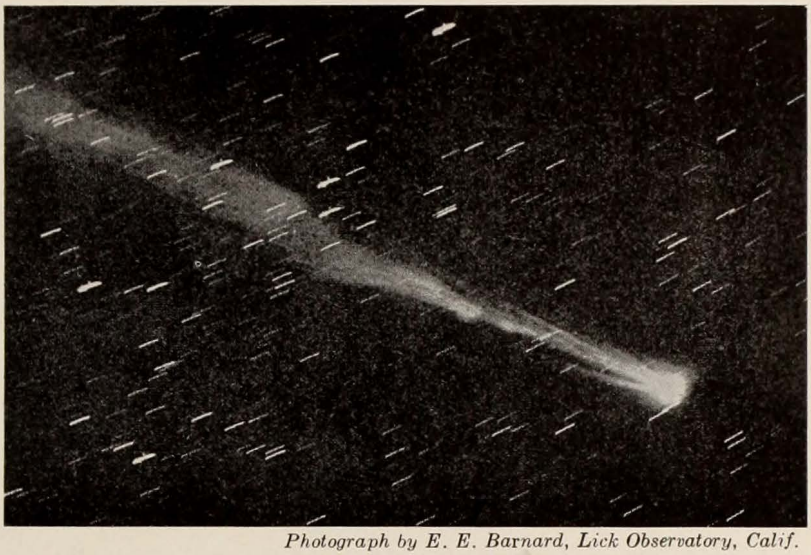
HALLEY'S COMET
C. P. Smyth's drawings of Halley's comet, 1835–1836. From Chamber's *Story of the Comets*

head, is responsible for the lighted tail. As shown by an accompanying drawing, the tail points away from the sun even after the comet has passed around the sun and starts on its return trip. Then the tail precedes the body of the comet. At various times the tail has been observed to consist of various streamers emanating from the head.

It would seem that those particles of matter which are driven out of the head to form the tail are lost and must be constantly renewed, for it has been noted that comets whose orbits are small and pass frequently about the sun are relatively faint and often devoid of a tail. May it not be that their frequent passage about the sun has deprived them of the gaseous tail-forming material?

Comets or at least some of them follow regular orbits. Newton, in studying the comet of 1680, ascertained that, according to the laws of gravitation, the path of a comet should be an elongated curve, and represented the course of such a body mathematically. Halley, in 1704, collected the observations on 24 comets, calculated their orbits, and found that the comet of 1682 had a path round the sun similar to that of the comets of 1456, 1531, and 1607. He recognized them as recurrences of the same comet and, although their periods were not exactly equal, due to interference by the planets Jupiter and Saturn, he predicted that this comet would return, subject to the influences of the planets, about 1758. Other astronomers took up the calculations of the algebraical and numerical formulæ and determined that Saturn would delay the return of Halley's comet 100 days and Jupiter 518 days, a total of 618 days. The comet was observed to pass perihelion on March 12, 1759. It returned again on November 15, 1835, after completing its course in 28,006 days. In 1873 it reached aphelion and returned once more in 1910. Halley's comet thus has an average period of about

Photograph by Max Wolf
COMET MOREHOUSE (1908 III)
Discovered November, 1908, by D. W. Morehouse at Yerkes Observatory, Wisconsin. A series of parabolic hoods enclose the head of the comet. From *Handbuch der Astrophysik*, Band IV

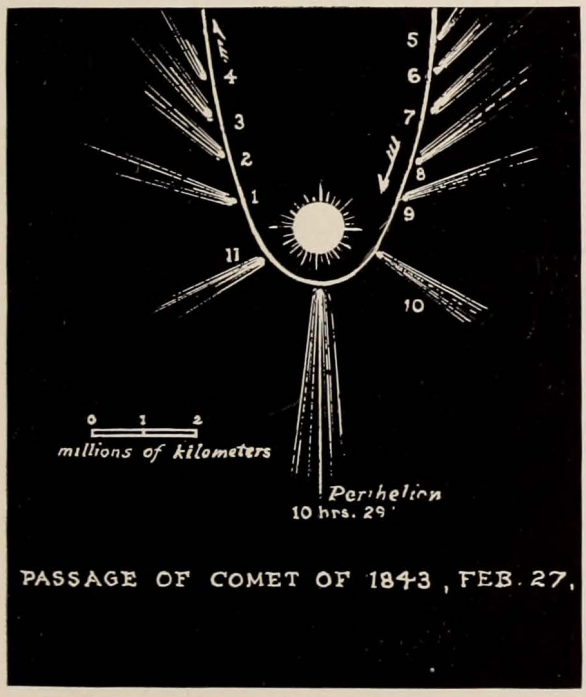


COMET RORDAME
July, 13, 1893. The camera moved with the comet, hence, the stationary stars show as short white lines

Photograph by E. E. Barnard, Lick Observatory, Calif.

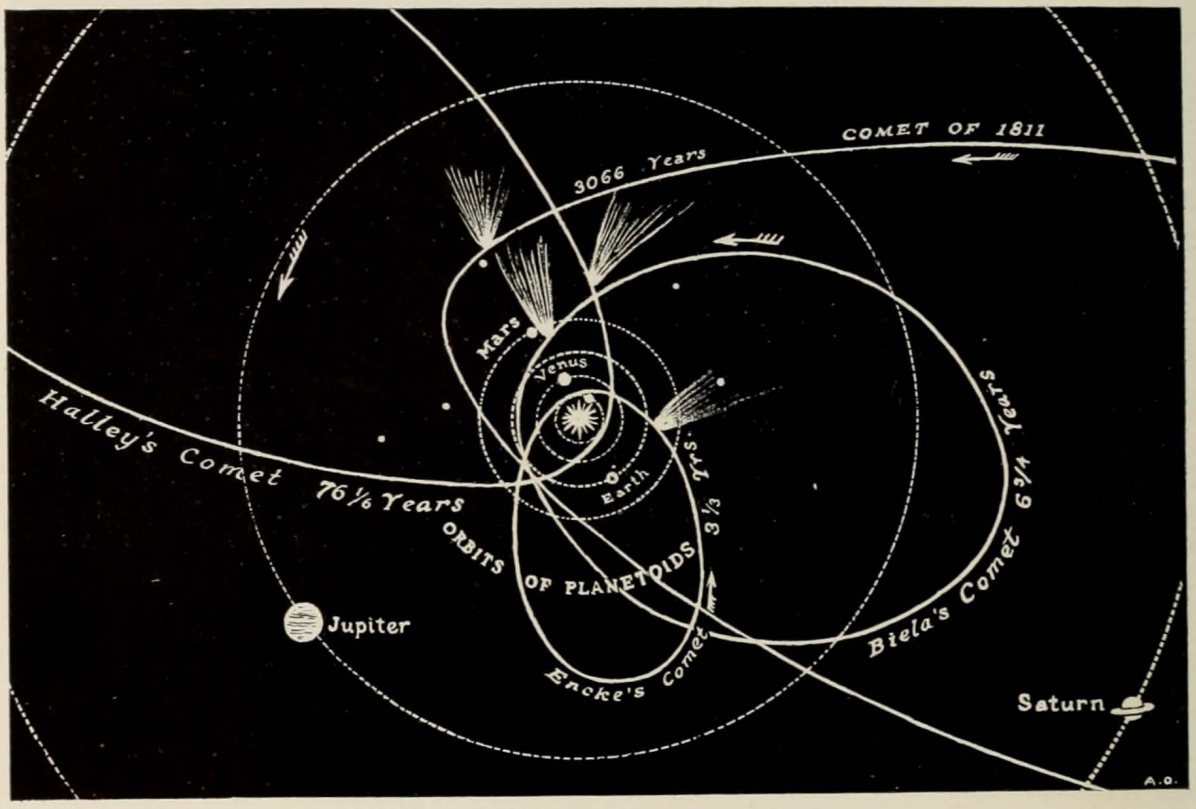
76⅛ years. These calculations and observations removed comets from the domain of legend and established them as part of our solar system.

The periodicity of a considerable number of comets has been confirmed. Of these Encke's comet, discovered November 26, 1818, is the "Mercury of Comets." It completes its elliptical orbit of 2,324,060,000 miles in 3.3 years. It is brightly lit up when it passes within 31 million miles of the sun and may then be readily seen with a telescope. In its revolutions it is also affected by planetary disturbances as are some 60 other comets with known periods of less than 80 years. Astronomers divide this assemblage of comets into four groups and name them after the four major planets, Jupiter, Saturn, Uranus, and Neptune. Jupiter's family, the largest, has some fifty members including Encke's comet, with periods 3.3 to 8.9 years; Saturn's family has four members with periods 13.1 to 17.7 years; Uranus has two with an average period of 36.6 years; Neptune's family has nine members including Halley's comet with a mean period of 70.0 years. The influence of Jupiter on the first group has been for the most part established, but the connection of other planets with their assigned members is not universally recognized.



SECTION OF A COMET'S PATH
Passage of the comet 1843 about the sun. This comet covered the perihelion portion of its orbit, twelve million kilometers, in ten hours. The tail pointed away from the sun

There are a number of instances on record which show that not only the orbits, but also the comets themselves, may be considerably affected by passing near the planet Jupiter. For instance, the orbit of Lexell's comet of 1770 was so changed in 1779 that it could not be seen. In 1770 it passed within one and a half million miles of the earth. Changes have also been noted in d'Arrest's comet 1860, Brook's 1886, Wolf's 1875 and 1922. The 1922 perturbations of Wolf's comet modified the orbit to such an extent that it took a course nearly the reverse of that of 1875. Biela's comet whose period of 6.75 years was established in 1826 had been seen in 1772 and 1805. Its orbit



ORBITS OF SOME COMETS AND PLANETS

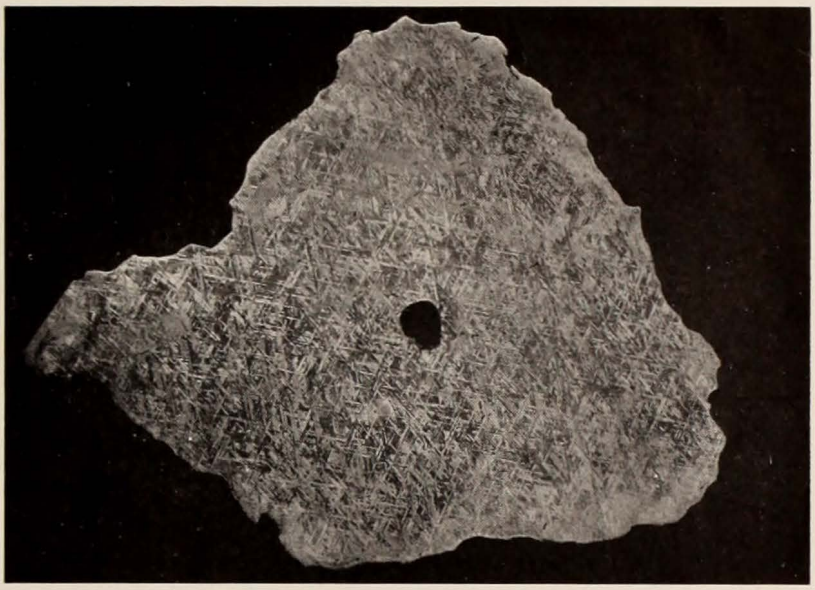
While the earth encircles the sun in one year, Encke's comet takes three and one-third years, and other comets a longer period. Most comets have paths which do not lie in the plane of the earth's orbit

was found to intersect that of the earth's, and in 1832, when it returned, there were many needless apprehensions. It was not seen in 1839, but in 1846 it was found to have split into two comets, which travelled side by side. In 1852 it reappeared with the two comets farther apart. It was not seen in 1859 or in 1866, and for the years 1872, 1885, 1892 and 1898, there was no comet, but instead brilliant showers of meteors. Other known comets have also disappeared, namely: Brorsen and Temple I, in 1879. The Pons-Winnecke comet with a period of 5.6 years has also attracted considerable attention because of irregularities in its orbit and its period. Discovered in 1819, its perihelion distance, although changed every alternate revolution by Jupiter, remained within the earth's orbit up to 1915, when it went outside. In June, 1916, and June, 1927, there were meteoric showers, which were associated with this comet. Some astronomers would also connect this comet with the great meteoric fall, which crashed into an uninhabited region of central Siberia in 1908, where, after the reported appearance of a great light followed by many detonations, an area of some 1,000 square miles, was completely devastated.

The most prominent member of Saturn's family is Tuttle's comet, discovered in 1858, with a period of 13½ years. It has been seen at every return since 1858.

Temple's comet, discovered in 1866, is the more notable of the two comets of Uranus. Its period of 33 years and its orbit coincides with that of the Leonid meteors with brilliant displays in November, 1833, 1866, and less so in 1899, since perturbations of Jupiter had changed its course. Its motion is retrograde to that of the planets. Stephan's comet seen 1867, but not since, is the other member.

Of Neptune's nine comets five have been seen a second time. Halley's is the best known. It has been traced back to



IRON METEORITE FROM GIBEON, SOUTHWEST AFRICA

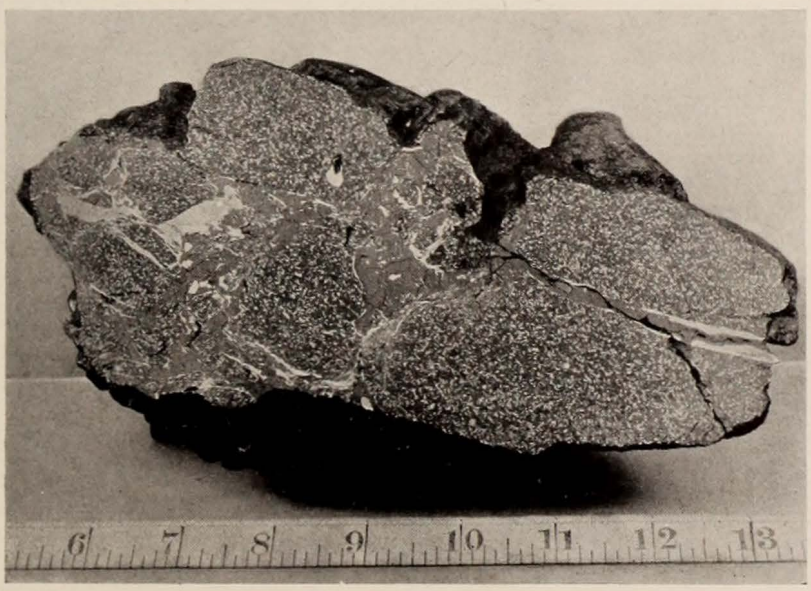
A black carbon nodule appears near the center of the polished and etched surface; Widmanstätten figures cover the remaining portion of the slice

240 B.C. On various occasions it has approached near enough to the earth to give meteor showers. It was observed in 467, 1066, 1456, 1531, 1607, 1759, 1835 and 1910. It crossed the sun in 1910, but since it was then invisible, it demonstrates the very small amount of matter remaining in it.

Other comets with periods ranging from 119 to 165 years have been observed, and one with a period of 335 years suggests a family belonging to an extra Neptune planet.

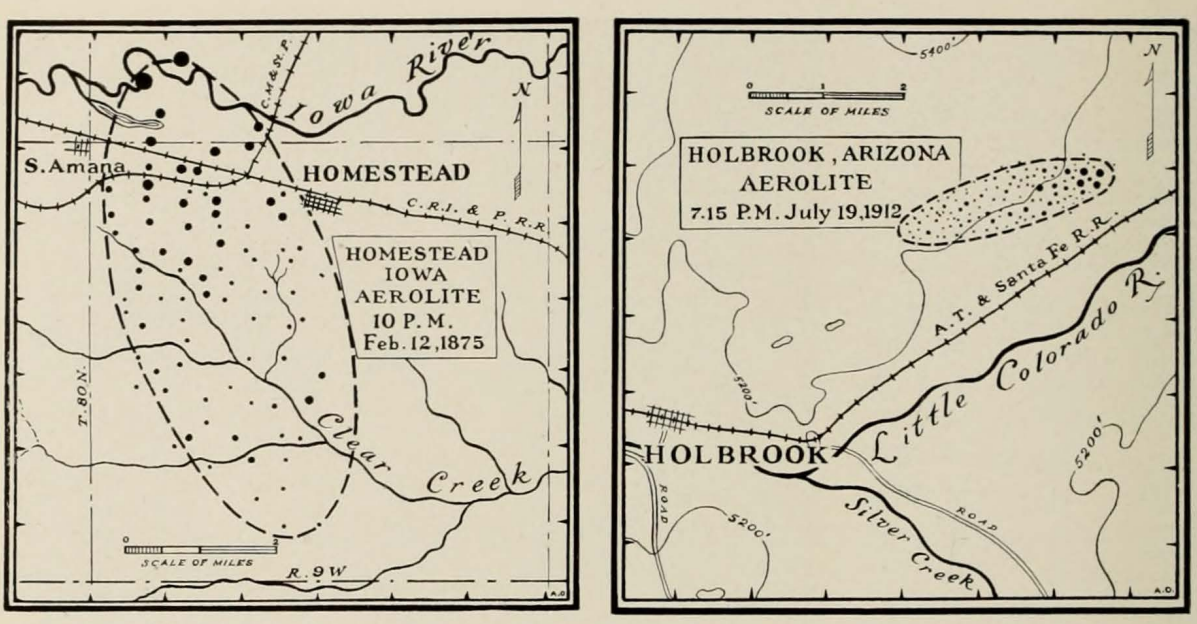
In this connection it should be stated that while comets may be seen at various times as they pass about the sun, meteors can be seen only when they enter the earth's atmosphere. In various instances it has been noted that where comets approach or cross the orbit of the earth, or disintegrate, meteoric displays have been observed.

Not infrequently on clear nights faint moving sparks of light may be seen to emanate sporadically from the starry canopy and increase in brightness as they move rapidly towards the earth, but seldom reach it before quickly and silently disappearing. Such objects are called "shooting stars" or small meteors. Occasionally, a brilliant streak of light with a more or less well-defined head called a "fireball" or "bolide," accompanied by a hissing sound and detonations, will light the sky momentarily and strike the earth at a place near or beyond the range of vision of the observer. These are also meteors, but of a larger size than the shooting star type. Perhaps a cloud of dust will be seen to rise from the place where it struck and its lodgment can be definitely located. When the spot is approached, there may be seen a newly made hole, one or more feet in



A PORTION OF THE ROSE CITY, MICHIGAN, METEORITE

Composed of a network of stone and metallic masses with a black crust appearing on the upper and lower margins



(*Left*) THE HOMESTEAD, IOWA, SHOWER.—Showing a characteristic ellipsoidal area, 3×6 miles. Pieces weighing 32 kilograms were found along the northern margin. (*Right*) THE HOLBROOK, ARIZONA, SHOWER.—The ellipsoidal area is 1×3 miles in extent. Many thousands of small fragments have been recovered

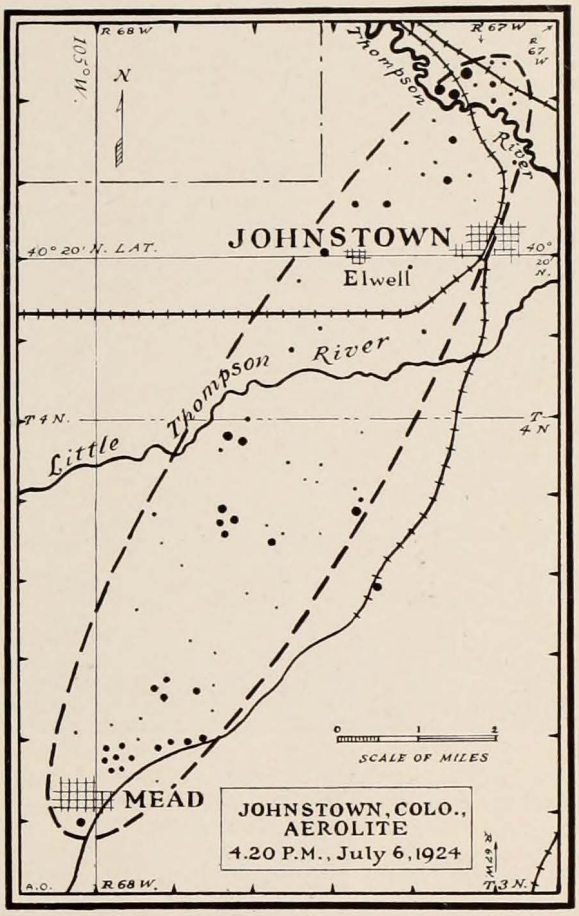
depth with an object in the bottom of it. The object may be either a stone with a blackened surface or an irregular mass of metal marked on the front or "brustseite" with shallow furrows and subconical pits, and on the rear side with depressions called thumb-marks or "piezoglyphs." Sometimes the thumb-marks are found on all surfaces. These markings are due to superficial heating produced by friction with the air. Whether the object has a stony or metallic aspect its appearance will be unlike any terrestrial rock or stone and may be called a meteorite.

Stony meteorites often fall as showers due to the fact that the original mass explodes or bursts one or more times before reaching the earth. The areal distribution of the stony fragments on the surface of the ground usually assumes the form of an ellipse varying in size from one-half mile in width to three in length as in the 1912 Holbrook, Arizona, fall, or three by six miles as in the 1875 Homestead, Iowa, fall, or three by ten miles as in the 1924 Johnstown, Colorado, fall, as shown diagrammatically in this article. The individuals of a shower are distributed according to their momentum, those of small size with less momentum will reach the ground first, while those of large size and greater momentum will be carried farther. This fact affords corroborative evidence in determining the direction of the path of the meteor. A comparison of the diagrams will show that the Homestead meteor traveled in a N.N.W. direction, the Holbrook in an E.N.E. direction and the Johnstown in a N.E. direction.

Nickel-iron meteorites are often found in single masses, yet in the case of the Cape York, Greenland, irons two large masses were found on one island, and one each on two near-by islands, suggesting a single fall. The large mass, Ahnighito, 36½ tons, the Woman, 3 tons, and the Dog, 960 pounds, are in the American Museum. The other piece, 3.4 metric tons, is in the Royal Museum at Copenhagen, Denmark. The Bethany irons in southwest Africa have been found singly in rather widely separated areas, yet when their distribution is plotted it suggests a shower. The most recent find in this region is that of Hoba West iron near Grootfontein, Southwest Africa. It is estimated to weigh 60

metric tons and is reported to be the largest single mass known.

Mr. Hirn, writing in *L'Astronomie*, June, 1883, calculated that a bolide entering the upper regions of the atmosphere with a relative velocity of 18.64 miles per second, compressed the air in front of its path from one-hundredth of an atmosphere on entering to 56 atmospheres at a height of 23 miles. He also determined that with increase of pressure there is an increase of heat and a rise of temperature on the exterior surface to points higher than can be produced in the laboratory. The temperature of space is 273° below zero Centigrade. It is assumed that the bolide had this temperature before entering the earth's atmosphere. If so, then its surficial temperature was raised from —273° C. to 3,340° C. in the few seconds of is flight. If this calculation be true it is readily understood why a meteor becomes visible on account of this transformation of its motion into heat and light. Neither is it difficult to perceive why the small masses of "shooting stars" are consumed, why the larger stony masses with low conductivity are rent into fragments by explosions, and why the more tenaceous irons usually remain intact and have irregular outlines and pitted surfaces.



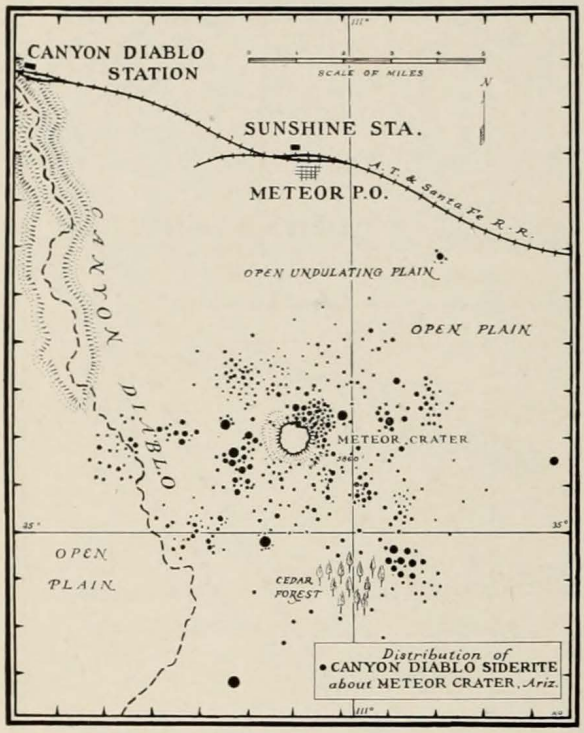
THE JOHNSTOWN, COLORADO, SHOWER

Four terrific explosions were heard accompanied by "smoke" puffs, before the fragments were spread over an ellipsoidal area some 3×10 miles in extent

It is also known that the greater the air pressure the more the velocity of the meteor is checked. This fact would explain the shallow depth of the holes made in the ground by most meteorites. The height at which some meteorites lose their initial velocity is quite variable. On the basis of some nine, which have been studied, it varies between 2 and

THE JOHNSTOWN, COLORADO, AËROLITE

One of the thirteen pieces found showing a thin black crust and a gray stony interior. Rounded and angular particles of greenish-gray pyroxene are in evidence in the gray field

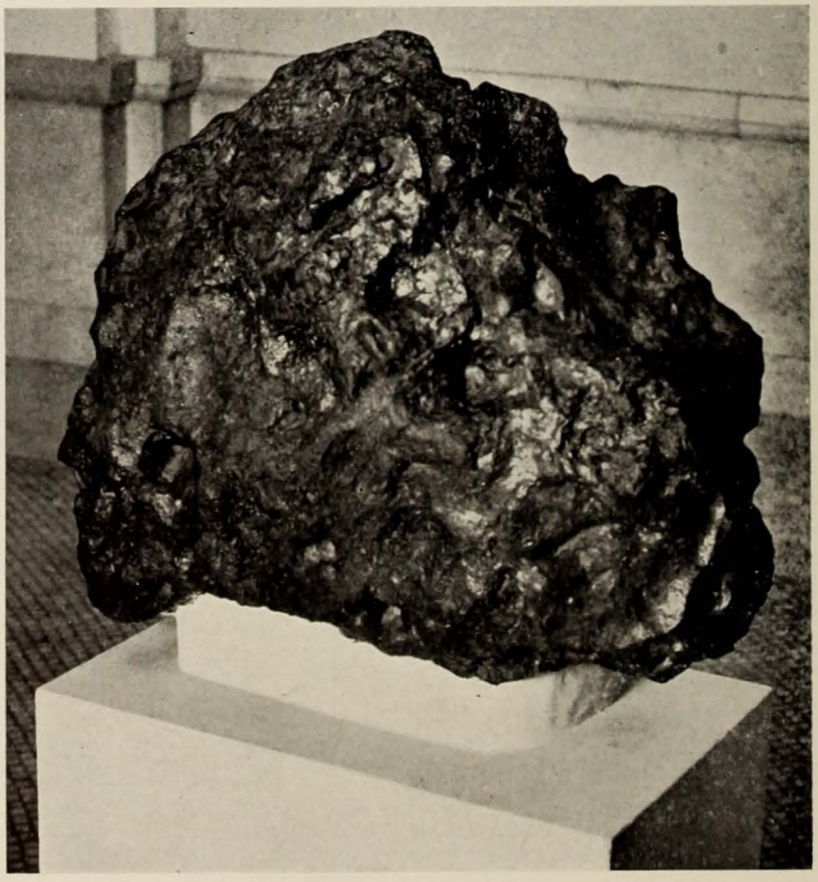


SKETCH MAP
Showing position of Meteor Crater and the Canyon Diablo Meteorites

29 miles above the surface of the earth. Some few meteors, however, have made great holes in the ground.

The most remarkable occurrence of iron meteorites associated with a meteor crater is in Yavapai County, Arizona, near the intersection of the 111th meridian and 35th parallel. The meteorite, which is called Canyon Diablo, after a near-by erosion feature, consists of thousands of pieces of variable sizes scattered over an oval area about nine miles in diameter. A depression known as Meteor Crater lies in the center of the meteorite field. This crater is quite large being 4150 feet in diameter and 570 feet deep. It is surrounded by a parapet 150 feet in height composed of rock débris thrown out of the crater. The crater has been studied at various times from different standpoints and the present general consensus of opinion is that it was formed by the impact of a great meteor or comet with the earth some 50,000 years ago, and that immediately following the impact there was a tremendous explosion which not only scattered the meteorites and rock débris over the surrounding plain, but gouged out the crater pit and greatly disturbed the normal disposition of the thick limestone and sandstone beds in the margins of the crater. Borings have been made within and about the margins of the crater in an endeavor to locate a possible larger meteoric mass, but so far they have yielded only inconclusive results.

Other meteor craters and associated

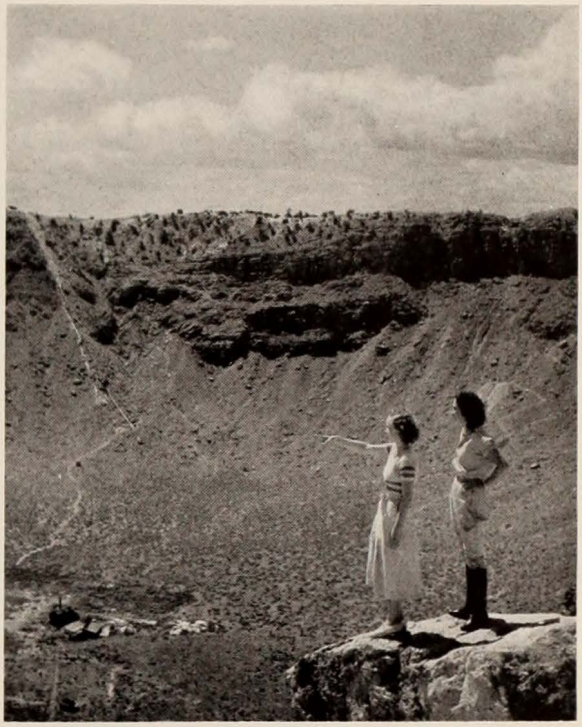


THE CANYON DIABLO METEORITE
A large mass of the Canyon Diablo siderite in the American Museum. Total weight of fall unknown; six tons preserved in collections

meteoric material have recently been found at Henbury, Australia and Odessa, Texas. No meteorite fragments, however, have been found near the meteor craters of Tunguska, Siberia, and Kaali, Esthonia.

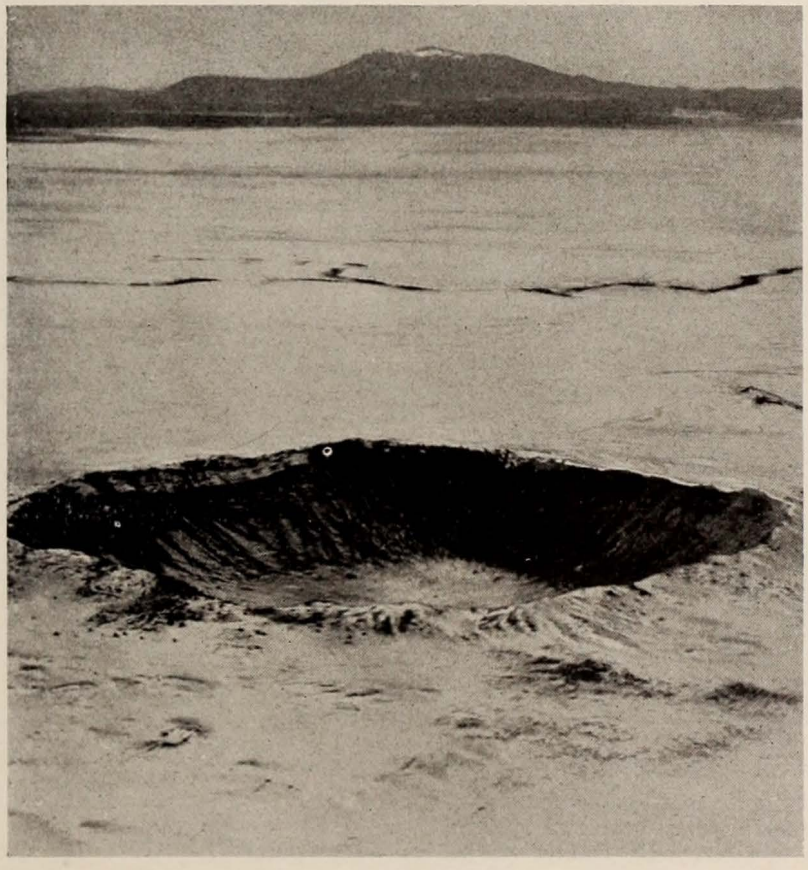
So seldom are meteorites seen to fall that it is not strange that such phenomena should attract widespread attention whenever and wherever they occur. Neither is it strange that skepticism should arise in the minds of non-witnesses regarding the existence of objects which are reported to have fallen from the heavens.

Early records show that meteoric showers were regarded as supernatural. According to the late G. P. Merrill of the Smithsonian Institution, such phenomena are referred to in Revelations VI, 13; VIII, 10; and XII, 3, 4. E. F. F. Chladin in 1819 stated that one of the oldest meteoric falls on record is that of Crete, 1478 B.C. Pliny in his second book, *Naturale Histoire*, mentions that in 468 B.C. a Greek philosopher, Anaxagoras Clazomenius, foretold that with the appearance of a comet a stone should fall from the sun. Such a stone did fall at Abydos and was held in great reverence. Records also show that at 11:30 P.M., on November 7, 1492, a meteorite fell at Ensisheim in Ober-Elsass, Germany. This stone was regarded as a miracle of God and by order of King Maximilian the main mass, weighing 260 pounds, was placed in the church at Ensisheim. This meteorite is of interest in that it constitutes



Photograph by Clyde Fisher

METEOR CRATER, ARIZONA, FROM THE RIM
Looking across the crater pit, 570 feet deep and 4150 feet in diameter



AIRPLANE VIEW OF METEOR CRATER, ARIZONA
Taken by Clyde Fisher, January 12, 1933, with snow on the ground. Canyon Diablo and the San Francisco Mountains in the background

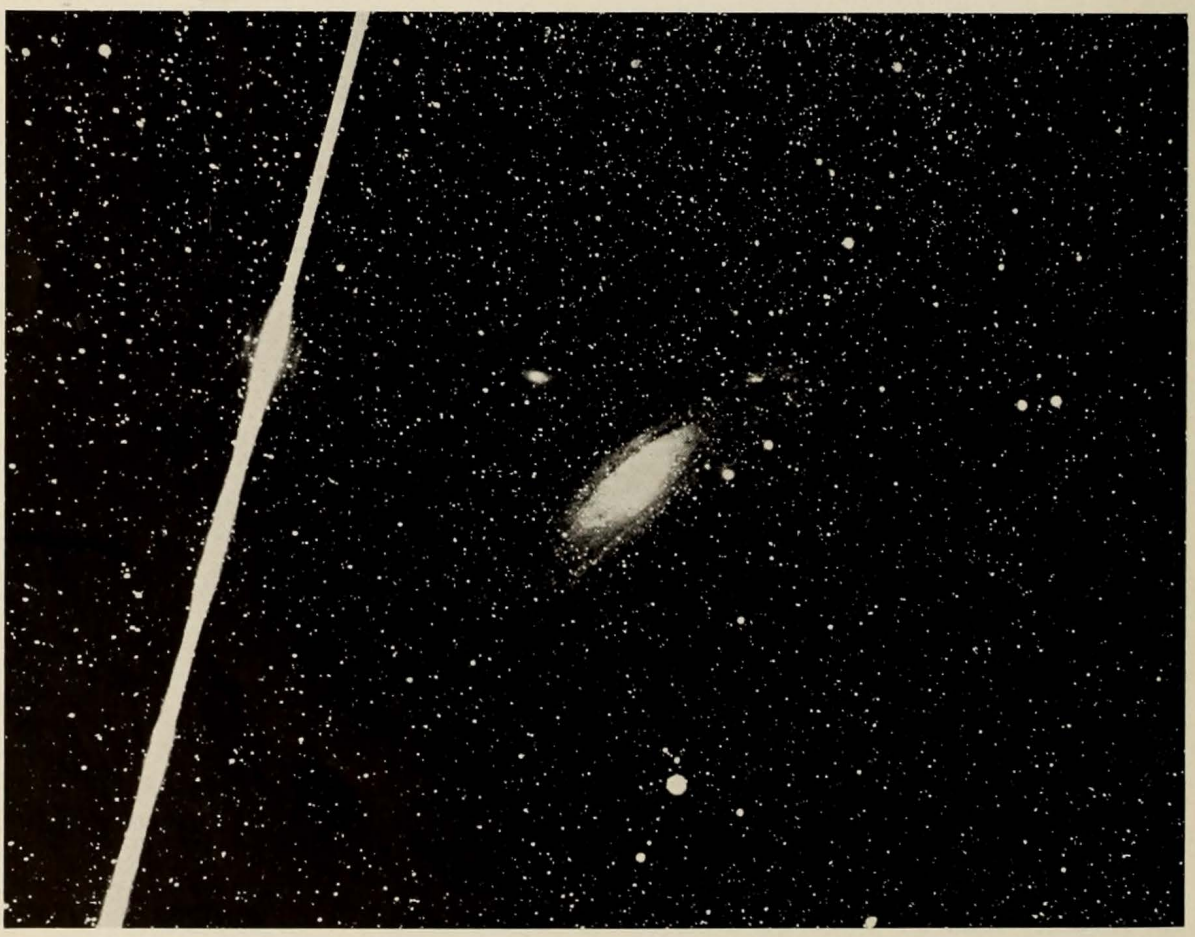
the oldest known fall of which samples of the specimen have been preserved.

As noted by Dr. O. C. Farrington, 1915, the first stony meteorite observed to fall in America, and which was described, was that of Weston, which fell 6:30 A.M., December 14, 1807, in Fairfield County, Connecticut. In commenting upon this fall Thomas Jefferson, President of the United States, expressed the prevailing opinion in regard to meteorites when he said that it was easier to believe that Yankee professors would lie than to believe that stones would fall from heaven.

The brilliant display in November, 1833, of shooting stars, later known as Leonid meteors, associated with Temple's comet, brought forth a decided change in the general attitude of the public in regard to meteoric phenomena.

With this change in attitude it is interesting to note by centuries the record of meteorites which were seen to fall and portions of which have been preserved. Referring to G. P. Merrill's 1929 list of 482 falls, we note that for the 15th and 16th Centuries there is one each; for the 17th, three; for the 18th, nineteen; for the 19th, three hundred forty-two; and for the first third of the 20th, one hundred sixteen. This shows quite conclusively that during the centuries when meteorites were regarded as being supernatural, few specimens were found, and that during the 19th and 20th Centuries, when they received attention, many were recovered.

Out of a total of 482 seen to fall, 458



A GREAT BOLIDE OR METEOR, AS SEEN THROUGH A TELESCOPE

Photograph by Josef Klepesta at the Prague Observatory, September 12, 1923. The white spots are stars. The bolide is the white streak of varying width. It crossed the field of the camera as the great spiral nebulæ in Andromeda (center) was being photographed

SHOOTING STAR AS SEEN THROUGH A TELESCOPE

Nebulæ in Cygnus to the right. The stars show as white dots. Photograph by E. E. Barnard, Yerkes Observatory, Wisconsin, July 15, 1909

represent stony meteorites, 5 stony-irons, and 22 nickel-iron meteorites. Stony meteorites are thus seen to fall more frequently than the iron meteorites, of which 350 had been found to 1929, but only 22 seen to fall. The number of falls and finds known in 1929 was 832. The list has been considerably increased during the following four years. The American Museum Collection of meteorites (March, 1933) contained 2640 specimens, representing 569 falls and finds.

Large collections of meteorites reveal that the specimens of no two falls are exactly alike in structure or composition, yet it has been observed that they may be arranged into three principal groups or kinds, as noted by Merrill namely:

1. Aërolites, or stony meteorites, consisting essentially of silicate minerals with minor amounts of the metallic alloys and sulphides.
2. Siderolites or stony-iron meteorites, consisting of an extremely variable network or sponge of metal, the interstices of which are occupied by one or more silicate minerals.
3. Siderites or iron meteorites, consisting essentially of an alloy of nickel-iron with iron phosphides and sulphides.

Technical students of meteorites have subdivided each of these groups. The aërolites and siderites are, however, the more common kinds. When cut, polished and etched, the siderites, or iron meteorites, usually show peculiar markings of crossed lines, and thus can be easily distinguished from the terrestrial irons.

Some siderites have the nickel-iron alloys arranged in the form of plates parallel with the faces of an octahedron. These lamellae may be of different degrees of thickness and composed of one, two or three kinds of metal. On etching with acid these metallic bands react unequally

and show characteristic figures known as Widmanstätten lines.

Another group of iron meteorites, composed of homogeneous masses of nickel-iron, show cleavage and lamellae parallel to the faces of a hexahedron. This is due to the twinning of a cube on an octahedral face. On etching with dilute nitric acid the structures show Neumann lines. Such forms are known as hexahedral irons.

A third group of irons are called massive irons or ataxites because their structure is amorphous and shows neither Neumann or Widmanstätten lines or other pronounced features.

The structure of the aërolites is quite different. They resemble the light colored felsitic rocks of the earth's crust, but they are unlike them. Aërolites may be granular, crystalline, chondritic, basaltic, tuff-like or breccia-like and with or without veins. Metallic shreds may or may not be scattered through the mass. While the color is usually light gray, it may vary through various shades of gray to black. A characteristic feature of aërolites is that while their interiors may be gray in tone, with various chondrules or mineral grains in evidence, their exterior surfaces are always coated with a thin black crust, which varies in thickness from $\frac{1}{64}$ to $\frac{1}{32}$ of an inch.

Astronomers tell us that about 400,000,000 celestial objects enter the earth's atmosphere every day, that about 20,000,000 are large enough to form shooting stars or meteors, and that of this number a minimum of but one per day is of sufficient size to reach the earth and constitute a meteorite. At first it may seem strange that so many meteors enter the atmosphere and so few reach the earth. When it is recalled, however, that meteorites vary from sizes microscopic to objects measured in tens of cubic feet, that they enter the upper rarefied layers of the earth's atmosphere at speeds varying from 8 to 50 miles per second, and that the atmosphere offers great resistance to their passage, it is not surprising that in the few seconds of their flight through the atmosphere that most of them are heated to the point of incandescence and consumed before they reach the earth.

Artist's Conception of November Meteors
November 13-14, 1866