THE LAUNCESTON PLANETARIUM
QUEEN VICTORIA MUSEUM

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METEORS AND METEORITES

A *meteor*, often misleadingly called a shooting star, is a streak of light in the sky that is produced by an object called a *meteoroid* entering Earth's atmosphere at a speed between 11 and 72 kilometres per second. Few ever reach the ground; a typical meteor is caused by a tiny meteoroid at most a few millimetres across and with a mass well under 1 gram, which is destroyed during its fiery passage.

The vast majority of meteors seen in the night sky are caused by tiny pieces of debris from comets, while the larger and more solid objects, some of which reach Earth intact, are mostly related to asteroids. Some have also been identified as having come from the Moon and Mars.

Unless a meteor shower (see below) is in progress, an attentive observer away from city lights will notice, on average, about four or five meteors each hour in the evening. About twice as many are seen in the pre-twilight morning hours because then, the observer is on the 'leading' side of Earth in its motion around the Sun, and this part of Earth encounters more meteoroids.

This typical background rate of a few meteors per hour is made up of *sporadic* meteors, having apparently random paths across the sky. However, very detailed studies have shown that there are

A bright meteor. The many short trails are stars, which appear that way because of the motion of Earth during the time exposure.

some preferred directions for sporadic meteors and that the rate varies over the course of the year.

Meteors have a large brightness range, but the majority that are seen are about as bright as an 'average' star, such as Ginan, the fifth star in the Southern Cross. The brighter the meteor, the less commonly they are seen. Fainter meteors are seen less frequently, too, as their light is closer to the limit of naked-eye visibility.

Very occasionally, we see a *fireball*, which has at least the brightness of the planet Venus. A fireball of Venus' brightness will be seen, on average, only about once per 20 hours of continuous observing of the sky, and brighter ones are even less common. They can even be more brilliant than the Moon, although this is very rare. Generally, the brighter object, the larger and more massive it is. A fireball of the same brightness as the Moon when it is full would be caused by an object about the size of a soccer ball. For the more solid objects, it can happen that the object (or, more commonly, fragments of it after it has broken up in the atmosphere), survives its passage to the surface. (See 'METEORITES' on next page.) The phenomenon may be accompanied by noises: a thundery noise called a sonic boom, or an explosive noise indicating that the object has broken up. In the last few moments of its journey to the ground, it has been slowed down a great deal by its passage through Earth's atmosphere, from a speed of at least 11 kilometres per second on entry down to only a few hundred metres per second. Even if found immediately, the object is quite dark, not 'red hot'.

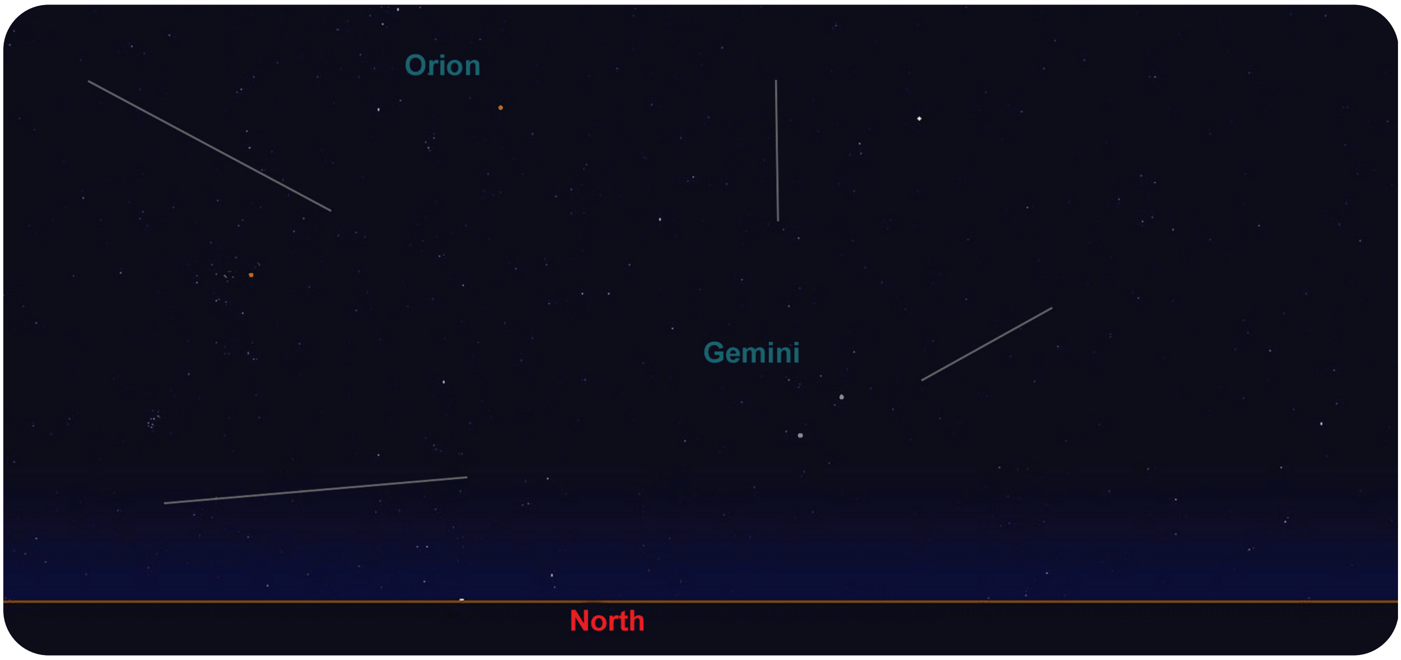
In addition to natural objects colliding with Earth, we also sometimes see artificial objects re-entering the atmosphere. These may be rocket fragments or 'dead' satellites, and can also be quite spectacular.

METEOR SHOWERS

In addition to the sporadic ('random') meteors, meteor activity increases dramatically for a few days or weeks at certain times of the year when Earth passes through the orbit of a comet – or, in the case of the Geminid shower, with an unusual asteroidal object. Then, an increased number of them will appear to come from a particular direction in the sky known as the *radiant*. This is purely a perspective effect, just as parallel railway tracks seem to come from a point in the far distance.

Even in more impressive meteor showers, we see only about one per minute, in seeming contradiction to the word *shower*. However, on rare occasions, thousands per hour have been seen, as happened in the great meteor storm of 1833.

There are many annual meteor showers, although the activity of each varies from year to year. The level of activity from a particular place depends on the angle of the radiant direction above the observer's local horizon, with the maximum activity taking place when the radiant is overhead.



Simulation of meteor paths in the Geminid meteor shower, which appears in December. The star positions are shown at 2 a.m. (Summer Time) in mid-December each year as seen from Tasmania. An unusual feature of this shower is that it is associated with the object called 3200 Phaethon, which is classed as an asteroid, rather than a comet.

METEORITES

A *meteorite* is a rocky object that has survived its passage through the atmosphere and has reached the ground. Generally, an object needs to be about 1-2 centimetres across to survive its fiery passage. Identifying a meteorite is not always easy, as many look like ordinary rocks. Even finding one that has been observed to fall can be quite difficult, unless there are many observers who can provide accurate directional information. Meteorites are normally quite dark: a stony meteorite will have a thin shell of blackish material due to its passage through the atmosphere, and an iron meteorite will be a blackish-brown. Another indication is their weight: iron meteorites are very heavy indeed, and even stony ones are rather heavy for their size. Another thing to remember is that they cannot contain shells or fossils, for obvious reasons! If you have an object that you strongly suspect is a meteorite, you may like to take it to a geologist for examination. Many museums are interested in this field.

The famous Ensisheim meteorite, which fell near the city of Ensisheim, Alsace (in what is now eastern France), in 1492. It was photographed while on display in the local museum. Image: Martin George

A stony-iron meteorite on display in the Southern Skies exhibition at the Launceston Planetarium, Queen Victoria Museum, Launceston, Tasmania. Image: QVMAG.

THE CLASSIFICATION OF METEORITES

Meteorites are classed in three general categories: *iron*, *stony* and *stony-iron*. It is estimated that about 92% of meteorites are stony, 7% iron, and 1% stony-iron. However, among those found, iron meteorites form a larger proportion than 7% because they are easier to identify.

Iron meteorites are divided into three main subclasses: *hexahedrites*, *octahedrites* and *ataxites*, in order of increasing nickel content. The first two, when sliced, polished and treated with dilute nitric acid, reveal *Neumann lines* in the case of hexahedrites and a *Widmannstatten pattern* in the case of octahedrites. The patterns are related to the crystalline structure of the meteorites.

The main subdivisions of stony meteorites are *chondrites* and *achondrites*. Chondrites contain chondrules — tiny, round grains of olivine and pyroxene — whereas the achondrites do not. Each subclass is further divided into particular types.

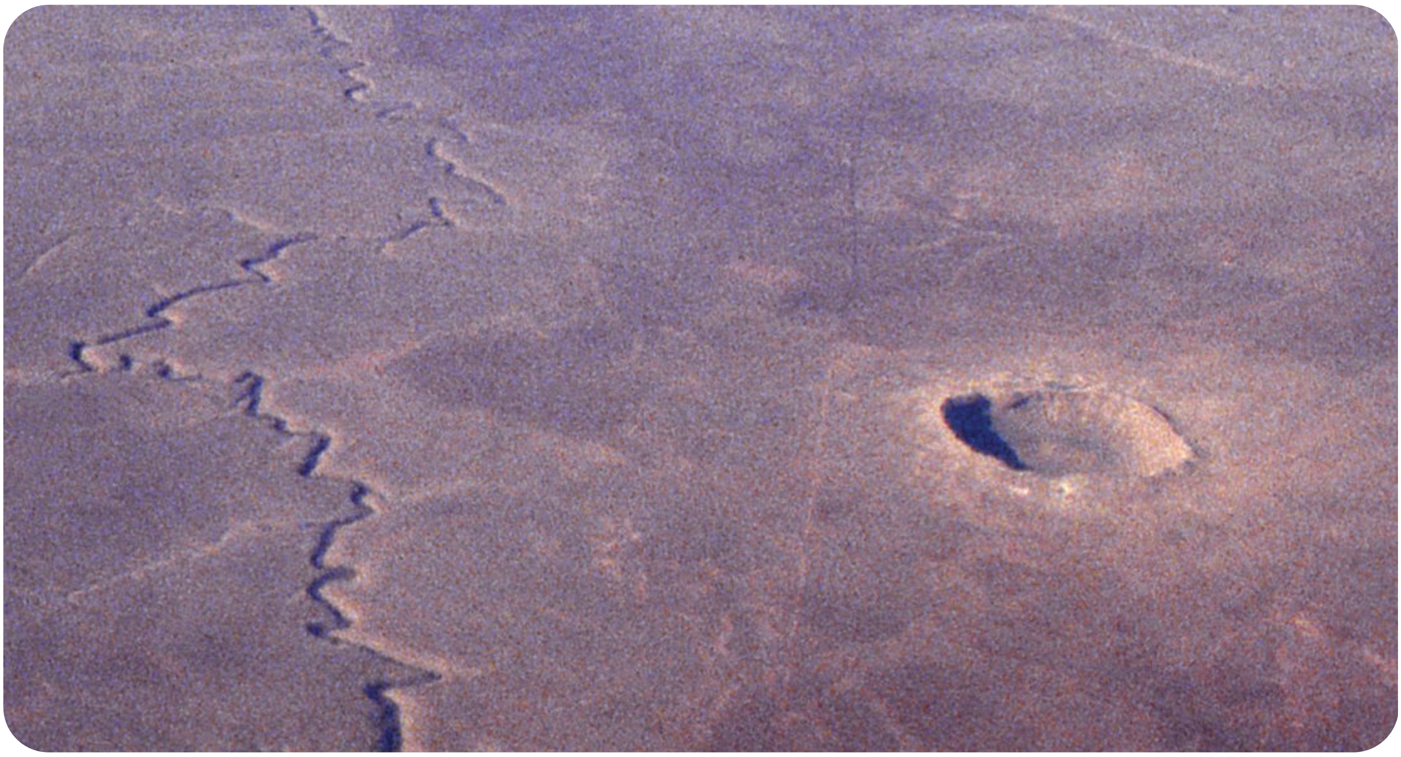
Stony-iron meteorites which, as their name suggests, contain some similarities to both stones and irons, are divided into four subclasses that reflect their different compositions.

ARE WE AT RISK?

There are no definite cases of anyone being killed by a meteorite. The only confirmed case of a person being struck was that of a woman in Alabama, USA, being hit by one in 1954 after it crashed through the roof of her house. Among several other possibilities, plausible reports indicated that a young girl was hit by a very small one in Japan in 1927, and that a boy in Germany was struck in 2009. It was also reported that a small dog was hit and killed by a meteorite in Egypt in 1911.

There are many confirmed cases of cars and buildings being struck and damaged. Among many known incidents, a stony meteorite of mass nearly 800 grams fell through the roof of a hotel in Wales in September 1949, and the town of Wethersfield, Connecticut in the USA had two incidents (in 1971 and 1982) of meteorites crashing into houses. In early 2013 a meteoroid about 17 metres across exploded in the atmosphere above the city of Chelyabinsk, Russia. This damaged many buildings, and about a thousand injuries were reported, mainly caused by broken glass. It was the most significant incident since an event in 1908 that devastated a large part of the Tunguska region of Siberia. That event was probably caused by an object exploding in the atmosphere, although a modern (2020) theory is that an object made of iron passed through our atmosphere without colliding but released enough energy to have caused the devastation.

Occasionally, an object will reach the ground and leave a noticeable crater much larger than the object's size. There are many examples around the world, including several in Australia. An object of at least one to two kilometres in diameter — in other words, a small asteroid — is large enough to cause considerable global devastation, as it could start global fires and would throw so much material into the atmosphere that sunlight would then be blocked off from the surface for months or years. This is the leading theory as to how the dinosaurs (and many other species) were wiped out about 65 million years ago.



Barringer Crater in Arizona, USA (aerial photograph). A famous tourist feature also known as Meteor Crater, this one-kilometre-wide crater was formed when a 50-metre-wide object fell to Earth about 50,000 years ago. Image: Martin George

The study of meteorites is very important. They are 'free samples' of extraterrestrial material, and can tell us much about the history of the Solar System. The chondrites, for example, are thought to represent the basic building blocks from which the planets were formed. Iron meteorites originated in the interiors of asteroids where thermal processes formed iron cores long ago; study of these gives us important clues as to the processes that formed Earth's own core. There are several examples of achondrites that come from the Moon, and some that have been identified as coming from Mars.

There are undoubtedly very many meteorites on the ground all over the world waiting to be found. There are many finds in Antarctica, where they can tend to collect in one place due to the movement of the ice, and stand out well against the white background. The first lunar meteorite — assumed to have been removed from the Moon by an earlier impact — was found in this way in 1982.