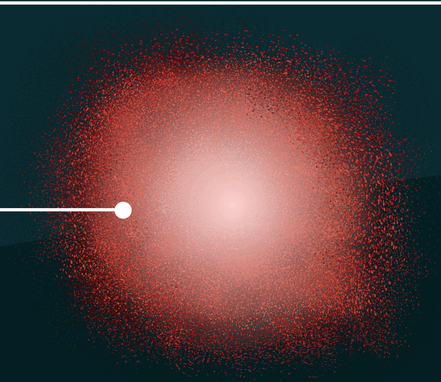
DUST TO SHOOTING STARS

WHAT ARE METEORITES AND HOW DO THEY FORM?

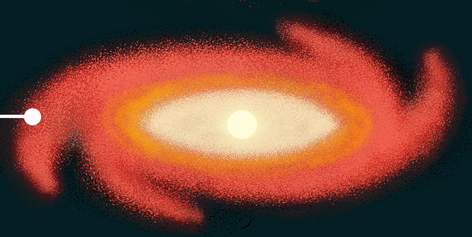
Rocks from space fall on Earth all the time, but have you ever wondered what is in them and how different they are to Earth rocks? How do they form, and why are they so important?

Let's take a short tour inside space rocks and their mysterious histories.

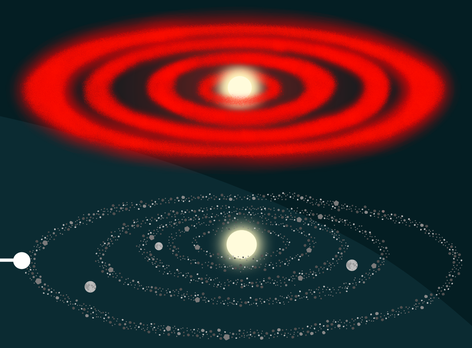
The Solar System began 4.6 billion years ago, as a giant cloud of gas and dust called a **solar nebula**.



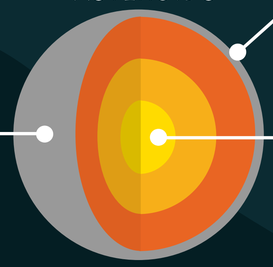
This cloud started to collapse, forming the Sun, and the rotating nebula became a disc called the **protoplanetary disc**.



Dust in the disc accumulated into larger grains, and eventually boulders and asteroids. Some (not all!) asteroids formed planets, in a process called **planetary accretion**. Today, most asteroids are found in the asteroid belt between Mars and Jupiter, and the Kuiper belt beyond Neptune.



DIFFERENTIATED ASTEROIDS

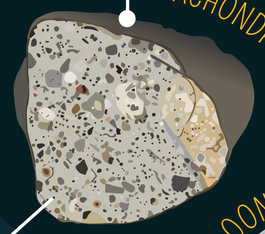


Some rocky bodies in the Solar System melt and become layered into a crust, mantle and core (like the Earth!), which have different compositions. We call them **differentiated**. Differentiated meteorites provide indirect evidence for the structure of the Earth.

By contrast, some bodies are **undifferentiated**, because they remain the same composition throughout.

The crust of an asteroid contains rocks like those on Earth. These rocks, called **achondrites**, contain a wide variety of minerals (mainly pyroxene, feldspar and olivine) and rock types (mainly volcanic). Did you know that we have meteorites from the Moon and Mars? They are all achondrites!

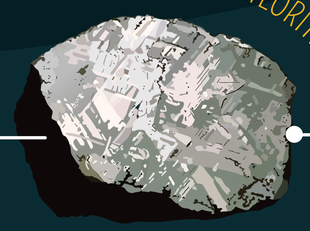
ACHONDRITE



MARS

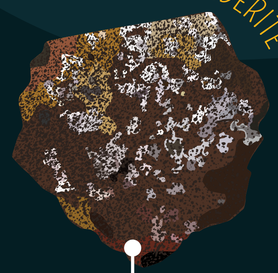
MOON

IRON METEORITE



The core of a differentiated asteroid is mostly metal, like the Earth's core. Rocks from the centre of asteroids, called **iron meteorites**, are mostly made of iron and nickel. We can never reach the Earth's core, so iron meteorites are helpful for understanding our own planet!

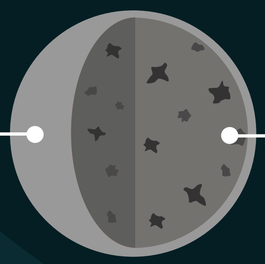
MESOSIDERITE



PALLASITE

Stony-iron meteorites are differentiated meteorites that contain both iron metal, and silicates we find in achondrites, like olivine and pyroxene. The two groups of stony-iron meteorites are **mesosiderites** and **pallasites**.

Their origin is debated, but scientists generally think that they formed in large collisions in the early Solar System, which mixed together crust, mantle and core material in differentiated asteroids.

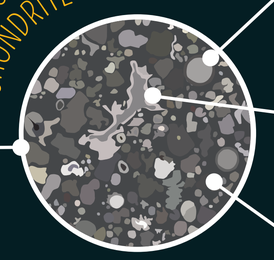


UNDIFFERENTIATED ASTEROIDS

Undifferentiated meteorites are called **chondrites**. Chondrites preserve the composition of a planet before it becomes layered, so their mineral assemblages are very unique!

Carbonaceous chondrites experienced the least heating, so they are very fresh, contain a lot of carbon, and look a bit like charcoal. **Ordinary chondrites** were heated a little, but still not much. ~86% of meteorites that have fallen on Earth are ordinary chondrites!

CARBONACEOUS CHONDRITE

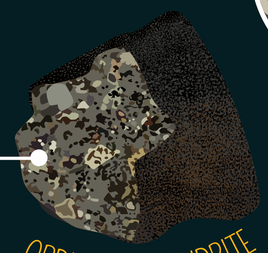


Chondrules: small (a few millimetres) igneous spherules formed in the early Solar System, from dust floating in the solar nebula. Even now, chondrule formation remains one of the most debated processes in planetary science!

Calcium-Aluminium Inclusions: irregularly-shaped inclusions that formed next to the Sun. They were the first things to form in the solar nebula, so are older than the Earth — certainly the oldest thing you can touch!

Matrix: dark in colour and very fine-grained, like a mudstone. It looks like something you might find on your BBQ!

ORDINARY CHONDRITE



SAMPLE RETURN MISSIONS

Instead of waiting for space rocks to fall on Earth, we can instead go to space to bring rocks back! These missions are called **sample return missions**.

Mission	Year	Destination	Meteorites that the samples were paired with
Apollo 11, 12, 14, 15, 16, 17	1969 - 1972	The Moon	Lunar meteorites
Luna 16, 20, 24	1970 - 1976	The Moon	Lunar meteorites
Stardust	1999 - 2006	Comet 81P/Wild	-
Hayabusa	2003 - 2010	Asteroid Itokawa	Ordinary chondrites
Hayabusa2	2014 - 2020	Asteroid Ryugu	Carbonaceous chondrites
OSIRIS-REx	2016 - 2023	Asteroid Bennu	Carbonaceous chondrites
Chang'e 5, 6	2020 - 2024	The Moon	Lunar meteorites

DEFINITIONS

Achondrite: stony meteorite formed on the surface (crust) of a differentiated asteroid
Asteroid: a small rocky body that orbits the Sun
Chondrite: stony meteorite originating from an undifferentiated asteroid
Meteor: the light phenomenon that happens when a small meteoroid enters the atmosphere and burns up (we refer to them as 'shooting stars')
Meteorite: a rock from space that landed on Earth
Meteoroid: a rock in space that has not entered the Earth's atmosphere. A meteoroid can become a meteorite if it lands on Earth, but many of them do not.

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