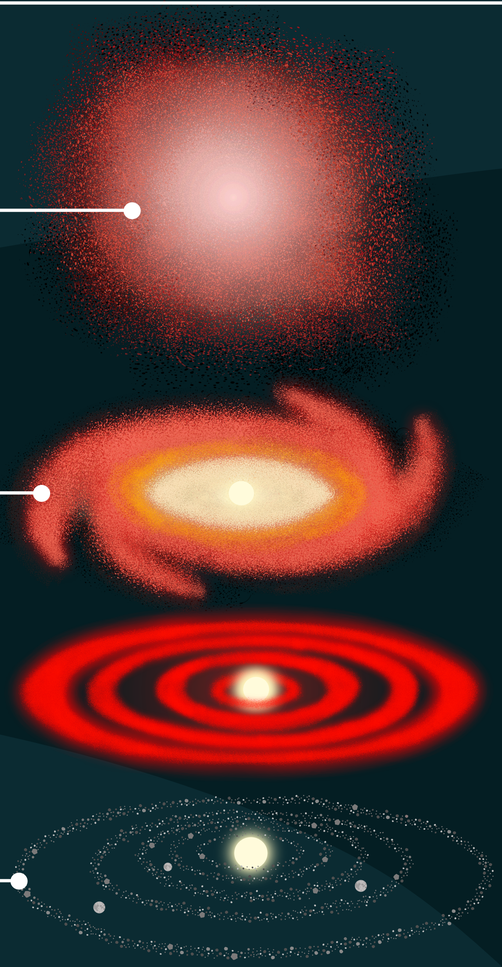
DUST TO SHOOTING STARS

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**.

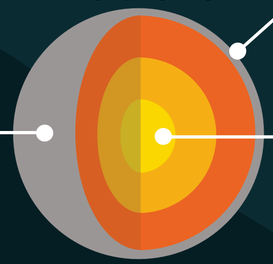


This cloud started to collapse, forming the Sun, and the rotating nebula became a disc.

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

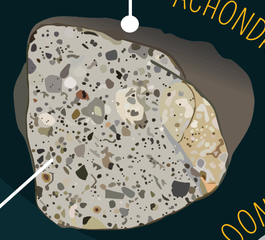
Some rocky bodies in the Solar System are layered into a crust, mantle and core (like the Earth!), which have different compositions. We call them **differentiated**. By contrast, some bodies are **undifferentiated**, because they have the same composition throughout. Parts of asteroids and planets that break off and land on Earth are called **meteorites**.

DIFFERENTIATED ASTEROIDS



The crust of an asteroid contains rocks like those on Earth, and these rocks are called **achondrites**. Achondrites are usually igneous or volcanic rocks. Did you know that we have meteorites from the **Moon** and **Mars**? They are all achondrites!

ACHONDRITE



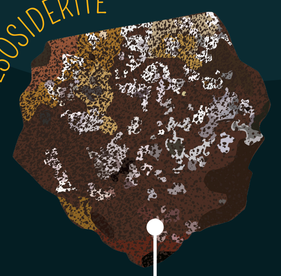
MARS

MOON

IRON METEORITE

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

MESOSIDERITE

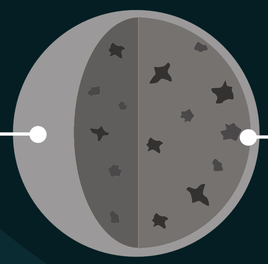


PALLASITE

Stony-iron meteorites are differentiated meteorites that contain both iron metal, and the minerals we find in achondrites. The two groups of stony-iron meteorites are called **mesosiderites** and **pallasites**.

The origin of these meteorites is debated but scientists generally think that they formed in large collisions in the early Solar System, which mixed crust, mantle and core materials in asteroids.

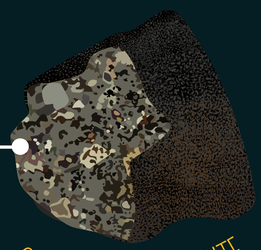
UNDIFFERENTIATED ASTEROIDS



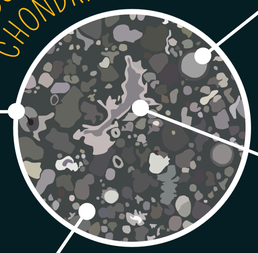
Undifferentiated asteroids are called **chondrites**. Chondrites preserve the composition of a planet before it becomes layered, so their minerals are very unique!

Carbonaceous chondrites experienced the least heating, which means they contain a lot of carbon and look a bit like charcoal. **Ordinary chondrites** experienced more heating by comparison, but still not much. Around 86% of meteorites that have fallen on Earth are ordinary chondrites!

ORDINARY CHONDRITE



CARBONACEOUS CHONDRITE



Chondrules: small (a few millimetres) igneous spherules (small spheres). They are 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 (material trapped during formation) that formed next to the Sun. They were the first things to form in the solar nebula, so are older than the Earth, and 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!

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**.

If the returned rocks match the composition of a known meteorite type, we can work out that the meteorites come from that place! This is how we know that some meteorites come from the Moon and from a few different asteroids.

Here are some example sample return missions:

Mission	Year	Destination	Meteorites that the samples were paired with
Apollo	1969 - 1972	The Moon	Lunar meteorites
Hayabusa	2003 - 2010	Asteroid Itokawa	Ordinary chondrites
OSIRIS-REx	2016 - 2023	Asteroid Bennu	Carbonaceous chondrites

DEFINITIONS

Achondrite: stony meteorite formed from 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 meteoroid enters the atmosphere and burns up (we refer to this 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.

UK SPACE AGENCY

The Geological Society