Introduction to Meteorites - KS4-5

Learning Objectives	Curriculum Links – KS4	Curriculum Links – KS5
A meteorite is a rock from space that landed on the Earth. It is different from a meteor (which is the light phenomenon that happens when a rock enters the atmosphere, also known as a 'shooting star') or an asteroid (a small rocky body in space, which most meteorites come from). Meteorites can come from all over the Solar System! Some meteorites come from asteroids, but some also come from the Moon and Mars.	Geology (Planetary Geology) Physics (Space physics)	Geology (Earth structure; Minerals and Rocks) Physics (Astrophysics/Space Physics)
Describing meteorites uses the same principles as describing rocks – they can be described based on their colours, textures, whether they contain grains or crystals, and the size of the grains or crystals present.	Geography (Rocks) Geology (Minerals and Rocks) Science (Working scientifically)	Geology (Minerals and Rocks)
To recognise a meteorite, there are a few features we can look for: a meteorite is often unusually heavy, with a pitted outside appearance, and covered in a dark glassy crust.	Geography (Rocks) Geology (Minerals and Rocks, Planetary Geology) Science (Working scientifically)	Geology (Minerals and Rocks)
There are 3 main types of meteorites, based on what they are made of: stony, iron, and stony-iron meteorites. Stony meteorites are further classified into chondrites (meteorites that were never melted) and achondrites (meteorites which come from the crust or mantle of a rocky body). Iron meteorites form in the cores of rocky bodies, and stony-iron meteorites form when impacts mix together core and crust material.	Geography (Rocks) Geology (Minerals and Rocks, Planetary Geology, Plate tectonics)	Geography (Plate tectonics) Geology (Minerals and Rocks, Earth structure)
Instead of waiting for a meteorite to fall on Earth to study them, we can study space rocks by sending a rocket to an asteroid to pick up some samples and bring them back. These are called sample return missions.	Geology (Planetary Geology) Physics (Space physics)	Physics (Astrophysics/Space Physics)

Materials needed:

- Meteorite samples, to pass around: pallasite (sample 11), lunar (sample 12), Martian (sample 13)
- Meteorite samples, for activity: iron meteorite (samples 9, 10), achondrite (sample 14), chondrites (samples 15, 16)
- Terrestrial samples: anorthosite (sample 17), basalt (sample 18), haematite (sample 20)
- Hand lenses
- Worksheets

Lesson length: 50 minutes (including optional ~5 min module)

Lesson Plan

Type/ Slide	Geology	Teaching/Learning activity	Time
Core / 1 - 2	**Meteorite** = a rock from space that landed on the Earth. **Meteor** = the light phenomenon that happens when a rock enters the Earth's atmosphere. Also known as a 'shooting star'. **Asteroid** = a small rocky body orbiting the Sun. **Meteoroid** = loose rock fragments (usually, fragments of asteroids) that haven't entered the Earth's atmosphere, and which are not in a fixed orbit.	***Ask students what is a meteorite?*** *Discuss different terminology.*	5 mins
Core / 3	We have meteorites from the Moon and Mars, which were separated from their parent bodies due to large collisions and made their way to the Earth. They are both too small and fragile to be handled outside of their boxes. Pallasites are made of metal (the shiny, metallic, opaque part) and olivines (yellow-green, transparent, glass-like).	***Pass around some meteorites (lunar, Martian, pallasite) for the students to look at. Remind them not to open the boxes!***	5 mins

Core / 4 - 7	Introduce types of meteorites (**stony, iron, stony-iron**) and how they form (**on the surface or in middle of an asteroid, or something in between**). This is because some asteroids are layered (crust, mantle and core), just like the Earth is.
	- **Stony** = majority or entirely silicate minerals. They usually come from the surface of a rocky body. Some of these come from the surface of the Moon and Mars!
	  o The ones that are made up of entirely silicate minerals are called **achondrites** and they come from the crust or mantle of a rocky body. Some of these come from the surface of the Moon and Mars!
	  o The ones that contain tiny metal grains and small circular crystals are called **chondrites**. Chondrites come from rocky bodies which never differentiated into mantle, crust and core, which means that their composition mirrors that of the entire solar system! We don't have anything like them on the Earth, so they are very unique rocks.
	- **Iron** = majority or entirely metal. They come from the core of a rocky body. We can never reach the core of the Earth, so these rocks are the closest we can get to our own core!
	- **Stony-iron** = approximately 50-50 silicate minerals and metal (note that achondrites will still have some tiny metal grains, but those don't count as stony-iron because the metal grains are rare). They form when achondrites and iron meteorites get mixed up, because asteroids collide with each other a lot.
	Another way to classify meteorites is based on whether they're from differentiated (layered) or undifferentiated asteroids. Chondrites are undifferentiated, while all the others (iron, stony-iron and achondrites) are differentiated.
		Introduce types of meteorites *and how they formed, within the context of planetary differentiation.*
		
		Ask students how do we know that iron meteorites come from the middle of an asteroid?
		They may remember that iron meteorites are very heavy, so it's because iron is relatively heavy, and it sunk to the centre.
			10 mins

Core / 8	Rocks can be described based on their physical characteristics, including: - Colour(s) - Does it contain grains or crystals? - Does it contain metal? - Does the inside look different from the outside? How? - Does it feel unusually heavy, unusually light, or just right? - Any other features? Don't forget to look closely using hand lenses! **Differentiation suggestion:** if you need to run the activity with fewer samples, we recommend including the rocks on station 2 (iron meteorite), 3 (basalt) and 5 (stony meteorite) as shown on the accompanying PowerPoint.	***Activity 1: Describing rock and mineral samples*** *Ask students to visit each of the 7 sample stations and make rock observations. They can start at any station, so they should spread out.* ***Ask students to write down their observations in the worksheets.*** *Circulate the room and give pointers.*	15 mins
Core / 9 - 17	In this activity, students will learn how to distinguish meteorites from Earth rocks (meteor-wrongs). 1. Is it unusually heavy? 2. Does it have a dark outside crust? 3. Does the outside have an irregular shape, with fingerprint-sized pits? (note for later: these are called regmaglypts) 4. Can you see metal? Not all answers have to be 'yes' for a rock to be a meteorite, but the more 'yes's, the more confident we can be that we found a meteorite!	***Activity 2: Meteorite detectives (distinguish meteorites from meteor-wrongs)*** *Using their observations from before, they can now have a go at finding the meteorites using some questions that we provide.* *If they need to quickly go back to the rocks they can, but they should hopefully already have the right observations and will just need to tick the boxes!* *This could be combined with the previous activity.* ***Give answers.*** *For each slide, go through each question and reveal if it's a meteorite.*	10 mins

Optional / 18	Instead of waiting for space rocks to fall on Earth, we can instead go and collect them ourselves. There are several recent sample return missions that space agencies have done, to asteroids Itokawa, Ryugu and Bennu. We also have returned Moon samples from the Apollo missions. **Pros**: - When a meteorite lands on Earth, it's extremely hard to find out which asteroid it came from originally. If we collect samples from asteroids and they have the same composition, we can be very sure that a meteorite came from that asteroid! - Meteorites burn as they fall through the Earth's atmosphere, which can change their composition. That's not a concern with samples that have come from asteroids. **Cons**: - Sample return missions are very expensive! - The missions are also high risk, so they can fail, costing a lot of time and money. - In the unlikely event of finding microbial life on an extraterrestrial body, we have to be very careful not to introduce the microbes to the Earth because no living creature is immune to them, so they could potentially be dangerous.	***Ask students if they can think of another way to get our hands on space rocks?*** *Introduce asteroid sample return missions.* ***Ask students what are the pros and cons of going to an asteroid and bringing back samples?***	5 mins