Creating Science – Asteroids and Craters

A world-wide devastating event may have also helped create life, and helps to recreate it too.

Suggested Outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science Inquiry Skills: Question and predict, plan and conduct, process and analyse, evaluate, communicate.

Earth and Space Sciences Year 6: Sudden geological changes or extreme weather conditions can affect Earth's surface.

Science vocabulary words

Tier 1 (Everyday words) – Comet, asteroid, meteorite,

Tier 3 (Specialised vocabulary) –KT extinction event.

Warning

- This activity involves dropping heavy weights into pans of flour. Watch for;
  - Throwing around flour – it is a choking hazard and eye irritant. Don't do it.
  - Throwing around 'asteroids' carelessly without checking for dangers. Watch out!
  - An enormous amount of mess, kids covered in flour, and choc powder all over.
  - Kids who will, inevitably want to lick the floor. Discourage this heavily *before* getting out the asteroids.

Preparation

(Taken 14 mar 18 from https://www.sciencebuddies.org/science-fair-projects/project-ideas/Astro_p010/astronomy/craters-and-meteorites#materials)

- Some 'asteroids': Different-sized objects that are nearly spherical, depending on what variables you want to test (size, speed, colour, angle of incidence, etc.). Small stones about 2cm in diameter are very good. (At least 1 per person, or one per condition of the variable.)
  - Marbles work but they make for very deep craters with less ejector. Perhaps it's their shape, or their smooth sides?
  - Tip: Solid objects may work better than hollow ones.

- Note: Smaller objects, such as marbles and beads, will not work well for this science project unless you use metal or magnetic balls and a magnet to carefully remove them.
- Ruler, metric. *Make sure you bring enough for every group*. You may need a smaller one to measure depth and crater size, and a 1.5M+ measuring tape rule to measure height and ejector trails
- Box; it should be about the size of a shoebox. If you are working outside on flat, clear ground it can be a shoebox. If you want to contain ejector trails, perhaps working inside, a moving box with a smaller box inside might be more appropriate.
- Flour – around 2kg per group
- Cocoa powder and a sieve to spread it. Around 200g per group.
- Flour sifter or sieve
- Lab notebook

- BRING A BIN – loads of flour and dust to dispose of. You probably should not eat it since it's probably been outside and full of dirty hands. But it's still biodegradable, a compost bin is ideal. Failing that, landfill, as it is quite capable of blocking the drain if poured down enmasse. Also, for the sake of the environment, do not tip it down the drain.
- Bring along any tektites, meteorites, and lunar meteorite.

As preparation, we will be doing this activity: https://youtu.be/szFYiiX-Et0 without throwing any flour around OK!? Please be sure to watch, because we need to get *experimental*!

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students questions can and should guide student learning, more material is presented for you convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

Carefully scaffold the activity so that young learners are clear on what is required.

Middle:

Police carefully so that things aren't thrown around and full power.

Help students to decide on their own variables to investigate in a guided investigation.

Teen:

Further the activity with a study of comets.

Learning Intent (student friendly)

'We are learning to' (WALT): Scientifically analyse meteorite impacts.

What I already know

Find out what students already understand about the topic by demonstrating the moon rock and tektite, and asking what they already know about comets.

Success criteria

'What I'm looking for' (WILF).

- Students to successfully measure and conclude on the influence of one variable regarding comets – such as size, weight, colour, make up, etc. Keep all other variables the same.

Student learning goals

Help students make a self-monitored learning goal for this lesson. For example;

- How does the size of a crater is related to the size of the meteorite?
- How does the speed of the meteor relate to the size and depth of the crater?
- How does the weight of the meteor relate to the size and depth of the crater?
- What is the difference between a meteor and a meteorite?
- What is a shooting star?

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations?

Engage

- ⇨ Note the Learning Intention of this lesson for students.
- ⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

Give students some various marbles and balls to play with, and allow them to throw them around with all care and caution.

Ask: How did the craters form on the moon? Why are they all different sizes?

Explore

- ⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Explain

Meteors

Most of the shooting stars we see are no bigger than a grain of sand. But they hit the air so hard that the air in front of them is compressed, and it heats up the asteroid to the point of boiling the water metals and even the entire asteroid! Usually the asteroid will then break up, and the evaporated parts blow around in the atmosphere while the smaller pieces of dust eventually float down to the ground. But for one, brief, moment they can light up the sky.

What can be really dangerous is that if the asteroid is firm or large enough, such as a solid piece of metal perhaps broken off from a larger asteroid or moon long ago, it can reach all the way to the ground before it has a chance to burn up. This can leave a smoking crater as the meteor slams into the ground at a very high speed – the explosion can be quite dangerous – but there are no reported human deaths by meteorite in human history so far.

Curiously, if the meteorite does not break up, the front end might have melted into a new shape, but the rear end of the meteorite might not have had time to heat up – it may even be covered with frozen ice!

Elaborate

- ⇨ Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

Russian meteor - 2013 Chelyabinsk meteor

Dramatic views of the Russian meteor, as well as the terror and damage of the shockwave - https://www.youtube.com/watch?v=fBLjB5qavxY

From Wikipedia:

With an estimated initial mass of about 12,000–13,000 metric tons (heavier than the Eiffel Tower), the approximately 20-metre near-Earth asteroid that entered Earth's atmosphere over Russia on 15 February 2013 … with a speed of about 20 kilometres per second (60,000km/h. …The light from the meteor was brighter than the Sun, visible up to 100 km away. It was observed over a wide area of the region and in neighbouring republics. Some eyewitnesses also felt intense heat from the fireball.

Due to its high velocity and shallow angle of atmospheric entry, the object exploded in an air burst over Chelyabinsk Oblast, at a height of around 29.7 km. The bulk of the object's energy was absorbed by the atmosphere, with a total kinetic energy before atmospheric impact estimated from infrasound and seismic measurements to be equivalent to the blast yield of a nuclear weapon in the 400–500 kiloton (about 1.4–1.8 PJ) range – 26 to 33 times as much energy as that released from the atomic bomb detonated at Hiroshima.

Its explosion created panic among local residents, and about 1,500 people were injured seriously enough to seek medical treatment. All of the injuries were due to indirect effects rather than the

meteor itself, mainly from broken glass from windows that were blown in when the shock wave arrived, minutes after the super bolide's flash. Some 7,200 buildings in six cities across the region were damaged by the explosion's shock wave, and authorities scrambled to help repair the structures in sub-freezing temperatures.

The meteor explosion produced the largest infrasounds ever to be recorded by the CTBTO infrasound monitoring system, … so great that they reverberated around the world several times, taking over a day to dissipate.

A fourth-grade teacher in Chelyabinsk, Yulia Karbysheva, was hailed as a hero after saving 44 children from imploding window glass cuts. Despite not knowing the origin of the intense flash of light, Karbysheva thought it prudent to take precautionary measures by ordering her students to stay away from the room's windows and to perform a duck and cover manoeuvre. Karbysheva, who remained standing, was seriously lacerated when the blast arrived and window glass severed a tendon in one of her arms; none of her students, whom she ordered to hide under their desks, suffered cuts.

Art

Make a landscape look like the moon using your meteorite.

(especially effective if there's extra time)

Can you make

What killed the dinosaurs? The K-T extinction event

(Taken from https://www.nationalgeographic.com/science/prehistoric-world/dinosaur-extinction/ 14 mar 2018)

The extra-terrestrial impact theory stems from the discovery that a layer of rock dated precisely to the extinction event is rich in the metal iridium. This layer is found all over the world, on land and in the oceans. Iridium is rare on Earth but it's found in meteorites at the same concentration as in this layer. This led scientists to postulate that the iridium was scattered worldwide when a comet or asteroid struck somewhere on Earth and then vaporized. A 110-mile-wide (180-kilometer-wide) crater carved out of Mexico's Yucatán Peninsula, called Chicxulub, has since been found and dated to 65 million years ago. Many scientists believe the fallout from the impact killed the dinosaurs.

But Earth's core is also rich in iridium, and the core is the source of magma that some scientists say spewed out in vast, flood like flows that piled up more than 1.5 miles (2.4 kilometres) thick over 1 million square miles (2.6 million square kilometres) of India. This bout of volcanism has also been dated to about 65 million years ago and would have spread the iridium around the world, along with sunlight-blocking dust and soot and greenhouse gases.

Both hypotheses have merit. Some scientists think both may have contributed to the extinction, and others suggest the real cause was a more gradual shift in climate and changing sea levels. Regardless of what caused the extinction, it marked the end of Tyrannosaurus rex's reign, and opened the door for mammals to rapidly diversify and evolve into newly opened niches.

Role of Asteroids

Some scientists have suggested that asteroid impact may have even been necessary for conditions on earth to have been able to create life.

- Some suggest that the base code for DNA is so complex it could not have originated by chance in the lifetime of our planet. Therefore life may have begun elsewhere and arrived here at the start of the world. Check out exobiogenesis theories, and panspermia with Fred Hoyle again!
- Some suggest the amount of water on earth is so great that it may have been augmented by ice asteroids early in the planets history.

What other scientific examples of the role that asteroids play in life on earth can you find?

What good do meteors do?

- They help the planet to grow, an estimated 200 tonnes land on earth every day.
- They bring in minerals hard to get to otherwise, some of the worlds nickel comes from a crater in Canada.
- They 'clear away' the planet to make way for new life, i.e., dinosaurs made way for mammals.
- They really are very entertaining, see the Chelyabinsk meteor above.

What future to meteors hold for humans?

If a meteor wipes out almost all life on earth every few million years or so, as what probably happened to the dinosaurs, could it happen again?

There's a lovely presentation at https://www.vox.com/a/asteroid-day you could learn about.

Things sound like they're getting very sci-fi with the planetary defence co-ordination. https://www.nasa.gov/planetarydefense/overview

What steps can be taken to avoid death-by-asteroid? Well aside from what the movies might have us think, here are some actual suggestions: https://en.wikipedia.org/wiki/Asteroid_impact_avoidance

Evaluate

- ⇨ Review with students what the felt they learnt from this unit. Did they have any questions at the start that they feel were answered?

Success criteria

- ⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- Did you achieve your learning goal?
- What did You learn?
- What worked to help you achieve it?
- What might you do better next time?
- (If needed) where can you go for extra help or information?

Assessment and Extension Ideas

Formative:

As students are learning, help them self-monitor their own learning and achievements.

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do.

Design a poster to answer the question – will asteroids strike again?

Write an essay on one of the following topics

- Did a meteorite kill off the big dinosaurs?
- How meteorites help, the basics.
- Why are there more craters on the far side of the moon than the near side?
- Find out all you can about asteroids. How big are they? How often are do they hit?
- What role does the moon (and Jupiter) play in protecting earth from asteroids?
- Try to make your own moonscape with big and small asteroids.
- What evidence is there for the KT extinction event.

So what?

Life on earth has been forged by meteorite impacts over time.

Life on earth may once again change dramatically due to meteorite impacts.

Creating science

Science content

Meteors and craters effect life on earth

Science inquiry skills

Multiple trials and careful measurement of asteroid impacts

Science as a human endeavour

Not everyone agrees that meteorites killed dinosaurs, preferring to think that volcanoes did the job. Also, there's a fair bit of debate about the future role asteroids might play in human society – will we mine them one day? Their low gravity can be very useful for mining. Or will a giant asteroid one day change the way we live on earth? Only time will tell!

Scientist Name:
Today's Date:

Making Craters - Instructions

Step 1: **Question and Predict:** Decide on a variable to test, and three conditions in that variable, for example size (small, medium, large) or height (50cm, 100cm, 150cm), weight (100g, 50g, 5g), or one of your own. Keep all other variables THE SAME. The default variable is height.

Step 1: **Plan and Conduct**. Gather the equipment. *Carefully* **test** your meteorites, one at a time, by dropping (*not throwing*) them into the flour. Make sure you record your results – photo's or diagrams can really help here! You can use the table on the next page.

Remember – "The Only Difference Between *Messing Around* and **Science** Is Writing It Down" – Mythbusters.

Step 3: **Conclude** on your results. What did you learn?

Step 4: **Evaluate** your methods, do you think that your results are accurate? Could they be better? How might a real scientist do this experiment?

Step 5: **Share** your results. Tell, describe, draw or somehow let other people know:

- What you learnt, and
- How you know it.

Remember: DO NOT THROW METEORS OR FLOUR!!!

Making Craters – Record it!

Scientist Name:

Today's Date:

Variable, condition 1:

Depth of crater:

Width of crater mouth:

Length of ejector trails: Image:

Variable, condition 3:

Depth of crater:

Width of crater mouth:

Length of ejector trails: Image:

Variable, condition 2:

Depth of crater:

Width of crater mouth:

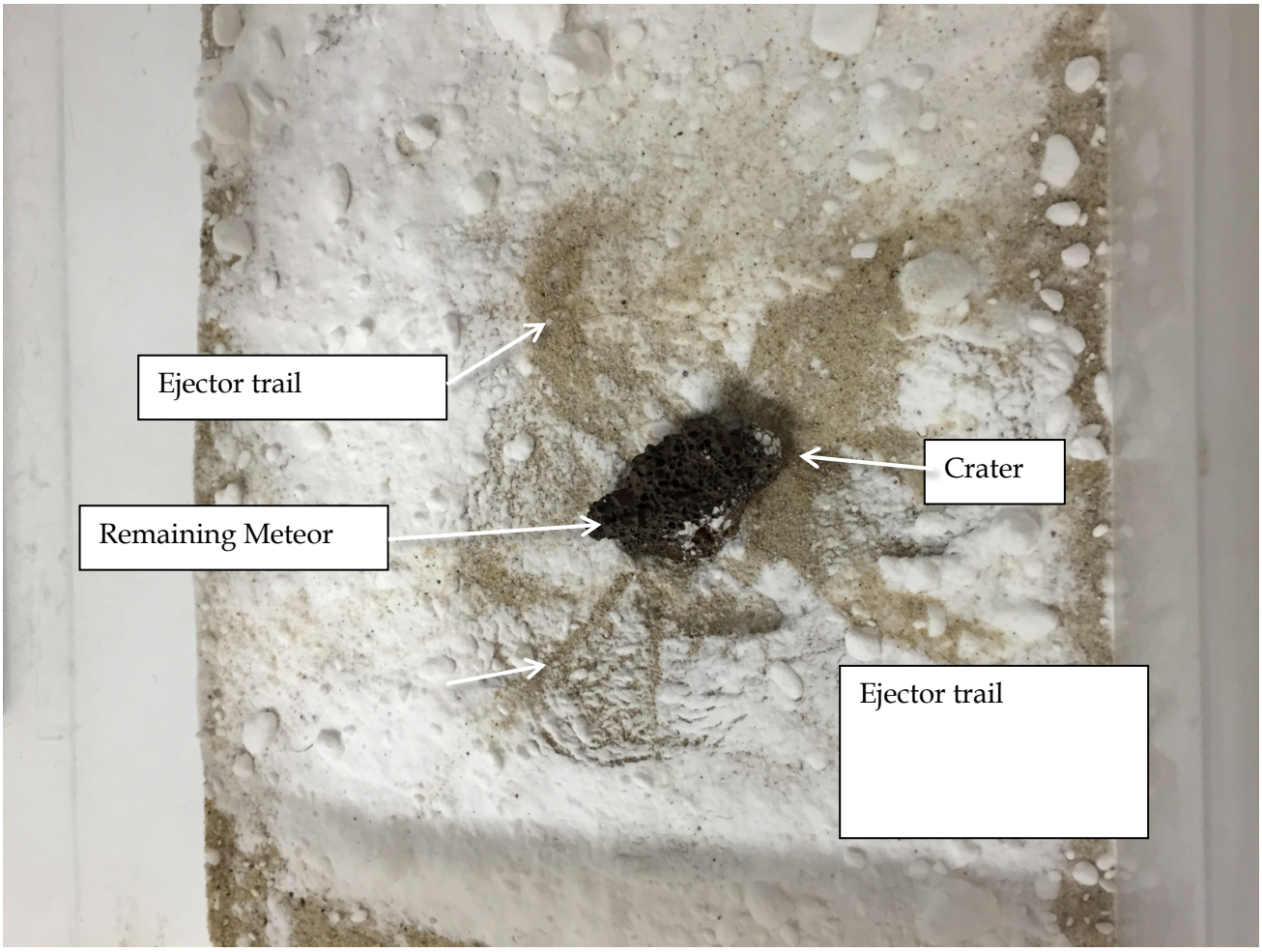
Length of ejector trails: Image:

Do this experiment as many times as you need to in order to make a clear, confident conclusion.

It's common that you learn a little extra along the way in every experiment, what extra did you see?

Appendix – anatomy of a crater

Flour on sand



Ejector trails can be quite long at times, going out of the landing zone. Use flat, clear ground if you want to measure the full length of the trail.

At 1.5 meters, trails of 30-60cm were common.

Of course, we're using small stones. If you use a 4kg brick, expect even more ridiculous results.

Appendix: Tycho

The most apparent crater on the moon, visible from earth, is at least 85 kilometres wide and almost 5 kilometres deep. Younger than most craters, it still has well defined edges.

Such a large and visible crater, with what is probably melted glass in the centre from the heat of impact. Controversy still surrounds its mysterious origin, from the mundane to the electrical. How do you think Tycho formed?