Down to Earth
KS3

## Teachers' Guide

# Meteorite Mitigation

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Noddir gan Lywodraeth Cynulliad Cymru
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## Overview

This lesson aims to introduce pupils to the different effects of a meteorite impact and develop understanding of the various mitigation techniques for these events.

## Background

Massive impacts are devastating events. It is not only the impact itself that causes destruction, but the after effects are just as catastrophic. From geological records and accounts of recent impact events, we can build up a picture of the various resulting disasters encountered when objects collide with the Earth.

One of the first effects felt during an impact is a massive blast wave. An asteroid colliding with the Earth travels at a speed between 15 and 30 km/s when it arrives at the top of the atmosphere. A comet travels much faster, up to about 75km/s – compare this to Concorde which travels at about 0.6km/s, or a bullet at about 2-3km/s. Whether or not an object reaches the surface, its energy is released as an explosion, which causes a blast wave.
This wave represents an abrupt change in pressure that generates a high-speed wind, and it is this wind and the debris it carries which cause most destruction. These winds are much greater than hurricane force winds, which can range between 120 and 320km/h, for example, the resulting blast wave from an impact of a 10km asteroid would kill off any life over half of the world, with an air temperature of 500° and a wind speed of about 2500km/h. The airburst caused by the impact of an object of around 50m in diameter at Tunguska in Siberia in 1908 flattened some 2,000km$^2$ of forest.

If a large object were to impact the Earth on land, massive earthquakes, up to 13 on the Richter scale, would be produced, along with numerous large magnitude aftershocks. The earthquake that triggered the Boxing Day tsunami of 2004 was of Richter value 9.3.

| Earthquake energy as a function of magnitude | | |
|---|---|---|
| Magnitude | Energy in joules | Notes |
| -3.0 | 2 | 1kg dropped 20cm |
| -2.0 | 63 | |
| -1.0 | 2000 | 100kg person jumping up and down |
| 0.0 | $6.3 \times 10^4$ | |
| 1.0 | $2.0 \times 10^6$ | |
| 2.0 | $6.3 \times 10^7$ | Only felt nearby |
| 3.0 | $2.0 \times 10^9$ | Energy from 50 litres of petrol |
| 4.0 | $6.3 \times 10^{10}$ | Often felt up to 10's of miles away |
| 5.0 | $2.0 \times 10^{12}$ | Energy from 50,000 litres of petrol |
| 6.0 | $6.3 \times 10^{13}$ | 3.3 Hiroshima-size A bombs |
| 7.0 | $2.0 \times 10^{15}$ | |
| 8.0 | $6.3 \times 10^{16}$ | 1-2 earthquakes this size each year |
| 9.0 | $2.0 \times 10^{18}$ | Total annual energy use of the UK |

If the impact occurred in the oceans, huge tsunamis would be generated and the 'splash' from these could reach the height of a jet plane. For an object 10km in diameter (similar to that which caused the Vredefort crater in South Africa) the leading edge would hit the seafloor of deep ocean basins before the top of the object had even reached sea level. The immense waves resulting from such an impact are thought to reach heights of between 1 and 3km. The waves recorded in the Indian ocean tsunami of 2004 reached heights of up to 30m. These waves could easily flood the interior of continents found far from the coast. and the 'splash' from these could reach the height of a jet plane.

Another major effect of an impact on Earth are global wildfires or firestorms. Firestorms are created by massive amounts of methane gas that are released into the air from the Earth in a collision. Methane is an extremely flammable substance and therefore lightning can ignite this released gas. The fire burns close to the ground and reaches quite high up into the atmosphere. As extraordinary levels of the organic gas fuel the fire, the atmosphere itself would also be alight. The blaze would decrease $O_2$ supplies and increase the levels of $CO_2$ creating a runaway greenhouse effect.

In contrast to the greenhouse effect, wildfires could also contribute to a period of global winters. Smoke from the fires would block out solar radiation, producing a cooling effect and disrupting photosynthesis. Large quantities of dust put into the atmosphere after a collision on land would further enhance this effect. The dust would take months to settle back to the surface and so during this time the world would be in a state of continuous darkness and temperatures would drop throughout the world causing global winter-like conditions, much like the period thought to take place after a nuclear war (nuclear winter). Blockage of solar radiation would also diminish the ability for plants to photosynthesise and therefore would seriously disrupt all ecosystems as these organisms are at the base of the food chain.

If the impact were to occur in the oceans, a large steam cloud would be produced by the sudden evaporation of sea water. The water vapour would stay in the atmosphere long after the dust had settled back to the ground. $CO_2$ would also be thrown up in this blast and as both this and water vapour are greenhouse gases which scatter solar radiation, global warming would take place for many years after the impact, following the initial period of global cooling.

## Impact effects and their mitigation – Teachers' notes

**Learning Outcome(s)**
Pupils should:
- Learn the various effects of a meteorite impact
- Learn the mitigation techniques of these disasters
- Develop researching skills
- Develop presentation skills

**Context and starter (Lesson 1)**
Start with class discussion on ways in which impacts affect the Earth and how these additional effects may be dangerous or deadly.

**Main Activity (L1)**
Pupils split into groups and given their disaster to research on the internet and produce a 5min presentation on what their disaster is and ways of protecting the public against these, e.g. building re-enforcements, coastal defences etc. Disasters for each group are: Tsunami, Earthquakes, Floods, Wildfires and Hurricanes.

**Second activity (L1)**
Pupils present their findings to the rest of the class.

**Plenary (L1)**
Round up the various findings' of the pupils, perhaps asking questions to pupils of other groups topics.

**Context and Starter (Lesson 2)**
Summarise the last lesson and introduce the aim of the exercise

**Main activity (L2)**
In their groups pupils discuss the best techniques of mitigation they found for their homework and play the game as a team, trying to save as many lives as possible and making notes of the actions they have taken.

**Second activity (L2)**
Pupils give a 5min discussion to the other groups stating the methods they chose and how and why they helped.

**Plenary (L2)**
Class discussion of what is thought to be the most dangerous effect of an impact and why. Round up discussion.

**Exercise length:**
**2 hrs**
**(2 lessons of 1 hr)**

**Key Vocabulary**
- Meteorite impact
- Tsunami
- Flood
- Hurricane
- Wildfire/firestorm
- Earthquake
- Mitigation
- Disaster
- Richter

**Resources**
- Laptop/Desktop PC
- Student worksheets
- Internet access
- Flash player 7

**Differentiation**
- Less able pupils can research case studies of their given topic
- More able pupils can research the science behind their chosen topic.

**LSA deployment**
- Aid pupils with computer based research and the making of presentations.

**Homework:** play and make notes on the stop disasters game to maximise lives saved and bring notes to next lesson to aid in group activity. http://www.stopdisastersgame.org

**Homework due in:** Next lesson.